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IDENTIFICATION, MORPHOMETRY AND VOLUMETRIC ANALYSIS OF THE GENIAL TUBERCLES IN RADIOGRAPHIC AND TOMOGRAPHIC EXAMINATIONS

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ABSTRACT
The aim of this study was to determine the identification, morphometry, and volumetric analysis of the genial tubercles in radiographic and tomographic examinations. To do so, 15 dried human mandibles were exposed to four stages. In the initial stage, the samples were exposed to the carrying out of bidimensional radiographic examinations, digital periapical radiography in the area of the lower incisors and digital totally occlusal radiography and tridimensional image examination, cone beam computed tomography. In the second stage of the research, the same image examinations were carried out in the mandibles with the genial tubercles accentuated with barium sulphate. In stage 3, a gingival needle was inserted in the lingual foramina into the lingual canal to perform the image examinations of each one of the mandibles. In stage number 4, the genial tubercles were removed to perform the image examinations in the mandibles. The radiographies were assessed by two radiologist dental surgeons dully trained for morphological analysis. For the morphometric assessment (linear and volumetric dimensions), the ITK-snap® Version 3.6.0 software was used. As a result of the periapical radiographies, no change was observed in the initial or final images of all mandibles, showing that the radiopaque projected image does not refer to the genial tubercles but to the cortical bone of the mandible (highlighted by the needle). Besides, with the highlighting of the barium sulphate, it could be noticed that the genial tubercles increase the radiopacity of the symphysis region. In the occlusal radiographic images, changes were observed in each one of the stages, once the position of the mandible during the examination make the projections of the genial tubercles quite evident, being the bidimensional examination indicated for the assessment of these anatomical

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structures. The cone beam computed tomography presents, distinctively, the property of providing tridimensional images rich in details, without overlapping images, enabling the assessment of area, volume and shape of the genial tubercles and also differ these structures from the lingual canal and mental protuberances. Thus, it could be concluded that the periapical radiography of the lower incisors highlights the lingual canal, the occlusal radiography highlights the genial tubercles and the tomography is the examination that presents the conditions to differ these structures.

Keywords: Anatomy. Genial tubercles. Image Diagnosis.

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INTRODUCTION

The genial tubercles, also known as mental spines, are bone protuberances located in the medium mandibular line, in the lingual face, below the lower incisors and above the inferior edge of the mandible base, they are subdivided into superior and inferior tubercles (Langlais, Langland & Nortjé, 1995; Jindal *et al*., 2015; Nejaim *et al*., 2017; Kim *et al.,* 2019).

Radiographically, the genial tubercles are well observed in the total occlusal radiography of the mandible as a lingual projection in a pyramidal shape. In the periapical radiographies of the lower incisors, these structures are well observed in a varied way, from a radiopaque mass in the medium line below the lower incisors (White & Pharoah, 2014) to a radiopaque ring that surrounds the lingual foramina (Langlais, Langland & Nortjé, 1995; Nejaim *et al*., 2017). It is worth to highlight that, White & Pharoah (2014) claim that the lingual foramina is seen as a small radio-lucid image circumscribed as a defined radiopaque edge, located below the medium line under the level of the lower incisors.

Due to the limitations presented by the radiographic examination, the cone beam computed tomography (CBCT) presents the property of providing us with tridimensional images rich in details and free of the overlapping of images. Thus, we can assess the area, volume and shape of the genial tubercles in the tomographic images (Chin, 2012; Lee *et al*., 2016).

Kolsuz *et al*. (2015) performed a study aiming at assessing the morphology of the genial tubercles using images of the CBCT; using parameters like height and width of the tubercles, distance from the lower incisors until the upper limit of the upper genial tubercles, distance from the margin of the lower limit of the lower tubercle until the lower margin of the mandible and the thickness of the mandible edge.

Lee *et al*. (2017) studied the reliability of the genial tubercles through CBCT in patients who had mandible asymmetry and the use of this anatomic repair as a reference to diagnose the alteration; the results showed that the genial tubercles constitute a reliable reference for the assessment of mandible asymmetry in CBCT images.

The knowledge of morphometry and the location of the genial tubercles have a great significance in the clinical practice once they serve as guides for the evaluation of etiology, diagnosis and / or treatment of numerous clinical conditions, such as stress, mandible asymmetry – its location is used as a stable anatomic repair, mandible atrophy; besides leading the study of the skull-face anatomy and of constituting important anatomic structures in the building of a good planning and a plan of total treatment, when, for isntance, there is a referral for pre-prosthetic surgery or treatment for obstructive sleep apnea (Chin *et al*., 2012; Elizabeth *et al*., 2007; Júnior *et al*., 2007; Kolsuz *et al*., 2015; Lee *et al*., 2016; Park *et al*., 2017; Schendel, 2011; Song *et al*., 2017).

Recently, a new classification for genial tubercles was proposed based on morphometric findings obtained through cone-beam computed tomography in a Brazilian population. This study demonstrated significant anatomical variability in genial tubercles, especially regarding their size, shape, and volume, highlighting their importance as a fundamental anatomical reference for surgical and prosthetic procedures in the anterior mandibular region (Silva *et al*., 2022).

The clinical relevance of genial tubercles was highlighted in a morphological study conducted in a Saudi population using cone-beam computed tomography. The authors reported significant variations in the morphological patterns of these tubercles, emphasizing the necessity for detailed anatomical knowledge of this structure to prevent clinical complications during dental and surgical interventions involving the anterior mandibular region (Al-Amery *et al*., 2019).

Thus, the aim of this study was to determine the morphology, morphometry and identification of the genial tubercles in digital periapical radiographies of the lower incisors, total digital occlusal radiographies of the mandible and cone beam computed tomographies.

MATERIALS AND METHODS

Samples: To carry out this study 15 dried human mandibles from the skull archive of the Radiology of the Pontifícia Universidade Católica de Minas Gerais – PUC Minas – Brazil were used. The study was dully approved by the Research Ethics Committee under the number 2.704.516.

Images acquisition: In order to perform this study, digital periapical radiographies of the lower incisors, digital total occlusal radiographies of the mandible and cone beam computed tomographies of all 15 dried mandibles included in the sampling were made. The intraoral device Kodak 2200® (Eastman Kodak Company, Rochester, NY, USA) was used to obtain the periapical and occlusal radiographies, using as exposure factors 60 kV, 10 mA, the distance focus-receptor 25 cm (periapical) and 35 cm (occlusal) and 1,5 mm of aluminium filter. The exposure time was of 0,455 seconds for the periapical radiographies and 0,500 seconds for the occlusal ones. The digital phosphorus system Vista Scan Perio

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Plus® (Dürr Dental, Bietigheim-Bissingen, Germany) was used with scanning time of 10,2 seconds, using phosphorus plates (Prosphor Storage Plate - PSP) in sizes 2 (periapical) and 4 (oclusal), immediately after the exposures to the X rays. It is worth highlighting that to obtain the periapical radiographies of the lower incisors the parallel technique was used, where the central axis of the X rays incurred perpendicularly to the receptor and the teeth. So as to simulate the absorption and attenuation of the X rays by the soft tissues of the face, an acrylic plate of 20 mm thick was used between the source of the X rays and the mandible. All images were obtained by a single experienced operator, trained by a radiologist. The computed tomographies were acquired through the machine CS9000-3D® (Carestream Dental, Atlanta, USA), with 140kHz, 60 kV, 2mA, exposure time of 10,9 seconds, Voxel of 75 µm and FOV of 5,0cm x 3,7cm. All images were acquired in the DICOM format (Digital Imaging and Communication in Medicine). The mandibles were positioned in the perpendicular median sagittal plan and the occlusal plan parallel to the ground. To simulate the absorption and attenuation of the X rays, the mandible was dipped into a cubic recipient with water for 24 hours.

Study stages: The study was performed in 4 stages; in the first one the periapical radiographies of the lower incisors, total occlusal radiography of the mandible and the cone beam computed tomography were carried out in each one of the mandibles to obtain the initial images without any kind of intervention. In stage 2, the intraoral radiographies and computed tomography of the mandibles were performed with the genial tubercles highlighted with Barium Sulphate, which is a contrast material, not soluble in water, used to make the structures studied clear. Stage 3 was marked by the introduction of a gingival needle in the lingual foramina heading to the lingual canal, before the performance of the examinations, with the aim of highlighting the lingual canal. Whereas, in stage 4, the final one, all the genial tubercles were removed using a file, in order to perform the radiographies and tomographies. The anatomic structures were removed with the aid of a sheet of dry file with the grammage of 225mm x 275mm. These images were compared with the images of stage 1 to assess diameters, length, width, area, volume and shape.

Images Assessment: Two experts in Dental Radiology analysed the obtained images independently. The digital radiographic images were analysed in a flat screen monitor of 22 inches, using the s*oftware Kodak Dental Imaging*® 6.14.7. The assessors were able to use all image manipulation tools within the *software*. The computed tomographies were analysed using the *software CS 3D Imaging*® (Carestream Dental, Atlanta, USA). The

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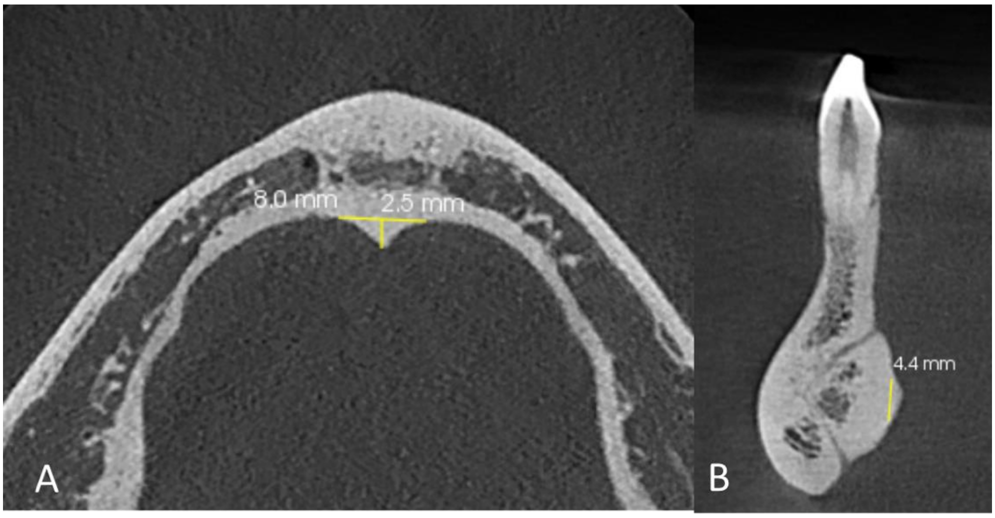
assessment consisted in highlighting the location of the genial tubercles and their morphological representation in each kind of examination. For the morphometric assessment, the initial computed tomographies of each mandible were used. With the same *software,* the assessor performed the previous-posterior, lateral and upper-lower measurements of all genial tubercles, as shown in Picture 1.

Picture 1: Axial reconstruction (A) and sagittal reconstruction (B) of the computed tomography of the mandible showing the performance of the previous-posterior, lateral and upper-lower measurements of the genial tubercles.



Source: Personal archive.

The volume analysis of the genial tubercles was performed in a semi-automatic manner of the (free) segmentation *software ITK-SNAP 3.0*® (Cognitica, Philadelphia, PA). The analyses were made by a single examiner, radiologist dental surgeon, who had previous knowledge of how the *software* worked and about tomographic anatomy.

The reconstruction of the 3D model was made by the semi-automatic segmentation of the *software*. The cortical bones of the genial tubercles were delimited by the assessor in the multi-plan reconstructions, defining the interest area using the tool Snake ROI (Region of Interest).

The segmentation of the cortical bones was performed in the *software* in 3 steps:

1st Step: Image resource selection *Region competition* to activate the evolution contour through a pre-processing of the image. To fill in the volume to be segmented, threshold parameters were established of -1000 for the minimum value and ranging from -500 to -850 the maximum value, with fixed smoking at 3,00. These parameters varied according to the density values present in the image examination of each patient. The option of combined display was used to verify the complete filling of the volumes of the genial tubercles.

2nd Step: Placing of adjustable ray bubbles along the image to initialize the active evolution contour.

3rd Step: Speed selection (fixed in 5) to fill in the volume to be segmented, with beginning and end of the filling in this same stage.

At the end of segmentation, the image of the genial tubercles volumes was reconstructed in the 3D window of the *software*. The volumes of the structures were measured by *software* itself in cubic millimetres (mm^3). As training, the assessor assessed and re-assessed a group of 20 images, different from those which composed the study sampling, obtaining similar values among the assessments.

Statistic tests: Twenty days after the conclusion of all the measurements in the genial tubercles, 100% of the sampling was re-assessed and the correlation coefficient intra-class (CCI) was calculated to determine agreement intra and inter assessors. CCI was interpreted according to the ICC foi Cicchetti categorizing system (1994), that is, <0,40 weak agreement, 0,40-0,59 moderate agreement, 0,60-0,74 good agrément and 0,75-1 excellent agreement.

RESULTS

The correlation intra-class revealed an excellent reproductability intra-observer for both assessors (ICC> 0,990, p <0,0001) regarding linear and volumetric measures. All the same, there was an excellent correlation between the assessors considering the genial tubercles for volume (0,990, p <0,0001), upper-lower (0,971, p <0,0001), previous-posterior (0,98, p <0,0001), lateral (0,950, p <0,0001). Table 1 shows the morphometric data of the genial tubercles in the tomographic examinations.

Table 1 Morphometric data of the 15 studied mandibles.

	Volume (mm^3)	*Previous-posterior measure*	*Lateral measure*	*Upper-lower measure*
AVERAGE	4,0	1,7	2,5	2,6
STANDARD DEVIATION	1,5	0,7	1,0	1,0

In the periapical radiographies of the lower incisors, no alteration in the initial and final images of all mandibles was noticed, showing that the projected radiopaque image does not refer to the genial tubercle but to the cortical bone of the lingual canal of the

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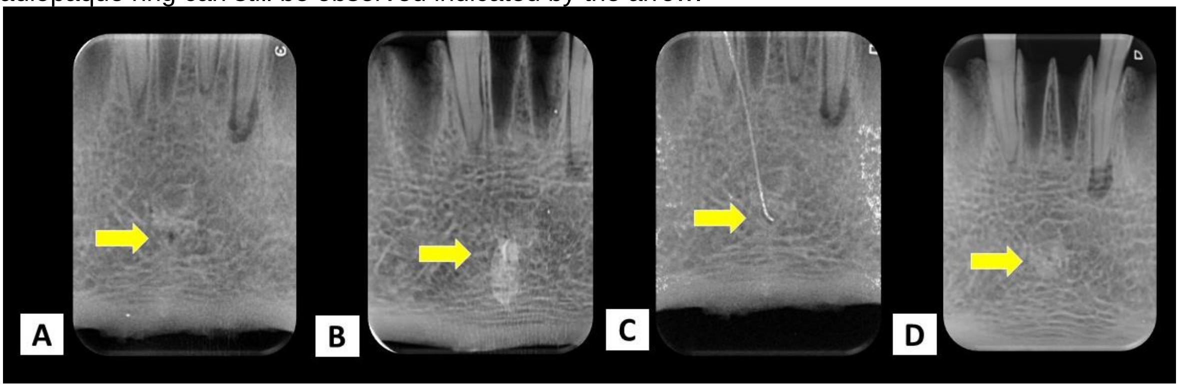
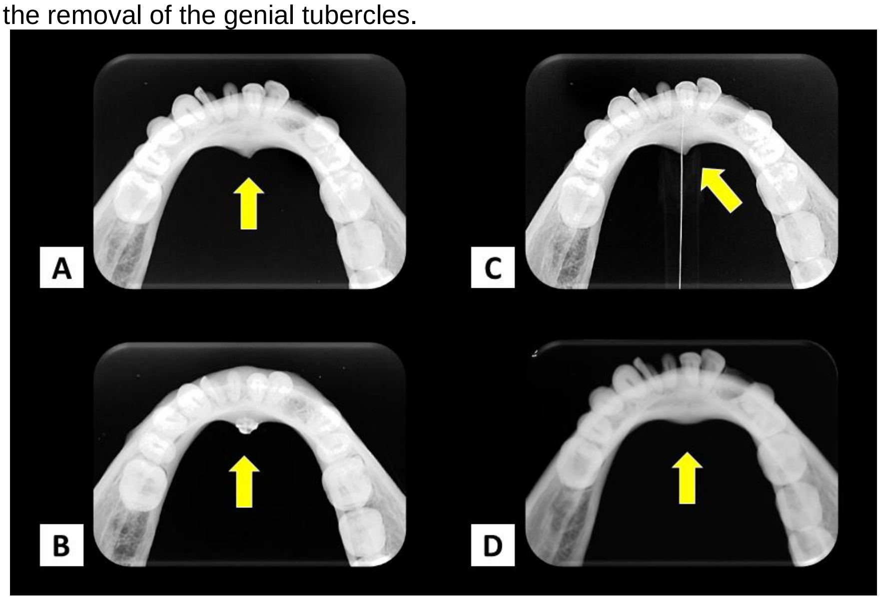
mandible (highlighted by the needle). Besides, with the highlighting of the barium sulphate, it could be noticed that the genial tubercle increases the radiopacity of the symphysis region. This way it could be noticed that when observing the radiopaque ring it refers to the cortical bones and the increase of radiopacity in the region is due to the mental protuberance, which is found by vestibular (Picture 2).

Picture 2 A: initial periapical radiography, arrow indicates the radiopaque ring area; B: periapical radiography with the genial tubercles highlighted by barium sulphate; C: periapical radiography with gingival needle inserted in the lingual canal; D: final periapical radiography after the removal of the genial tubercles, notice that radiopaque ring can still be observed indicated by the arrow.



In the total occlusal radiographic images changes were observed in each one of the stages, once through the position of the mandible when performing the exam the genial tubercles projections were well evident, making them great bidimensional examination to illustrate the presence of these anatomic structures in Picture 3.

Picture 3 A: Initial occlusal radiography; B: occlusal radiography with the genial tubercles highlighted by the barium sulphate; C: occlusal radiography with gingival needle inserted in the lingual canal; D: final occlusal radiography after the removal of the genial tubercles.



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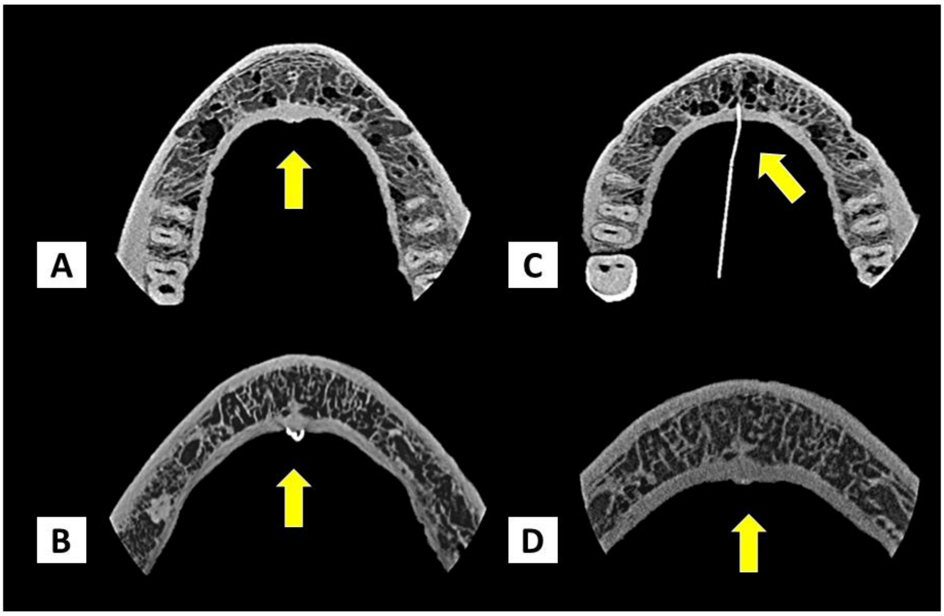
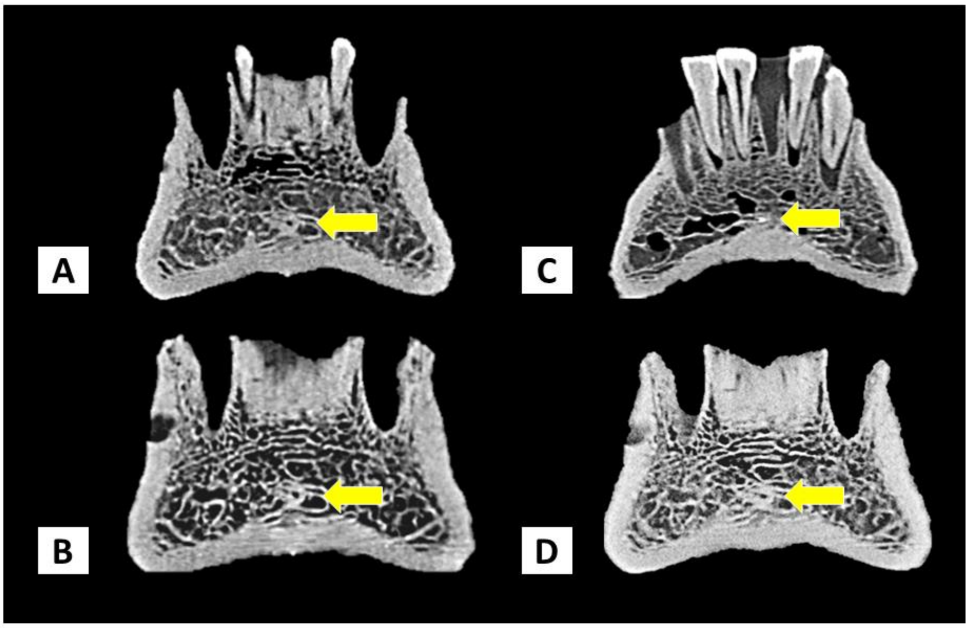
The CBCT presents the property of providing tridimensional images with rich details, thus it is possible to assess the area, volume and shape of the genial tubercles according to what is shown in Pictures 4 to 7.

Picture 4: CBCT – Axial cuts: initial (A – notice the arrow indicating the region of the genial tubercles), CBCT with genial tubercles highlighted by the barium sulphate (B – indicated by the arrow), CBCT with gingival needle inserted in the lingual canal (C – indicated by the arrow) and final CBCT after the removal of the genial tubercles (D– region indicated by the arrow).



Picture 5: CBCT – Coronal cuts: initial (A – notice the arrow indicating the region of the genial tubercles), CBCT with genial tubercles highlighted by the barium sulphate (B – indicated by the arrow), CBCT with gingival needle inserted in the lingual canal (C – indicated by the arrow) and final CBCT after the removal of the genial tubercles (D– region indicated by the arrow).



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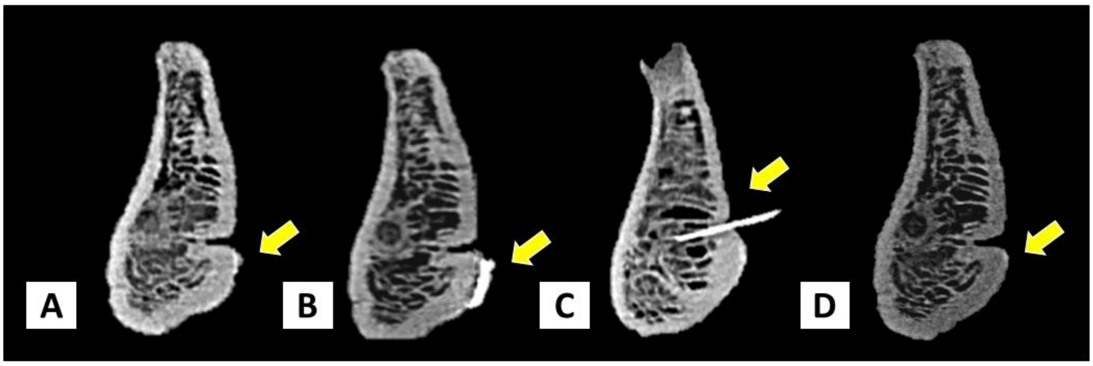
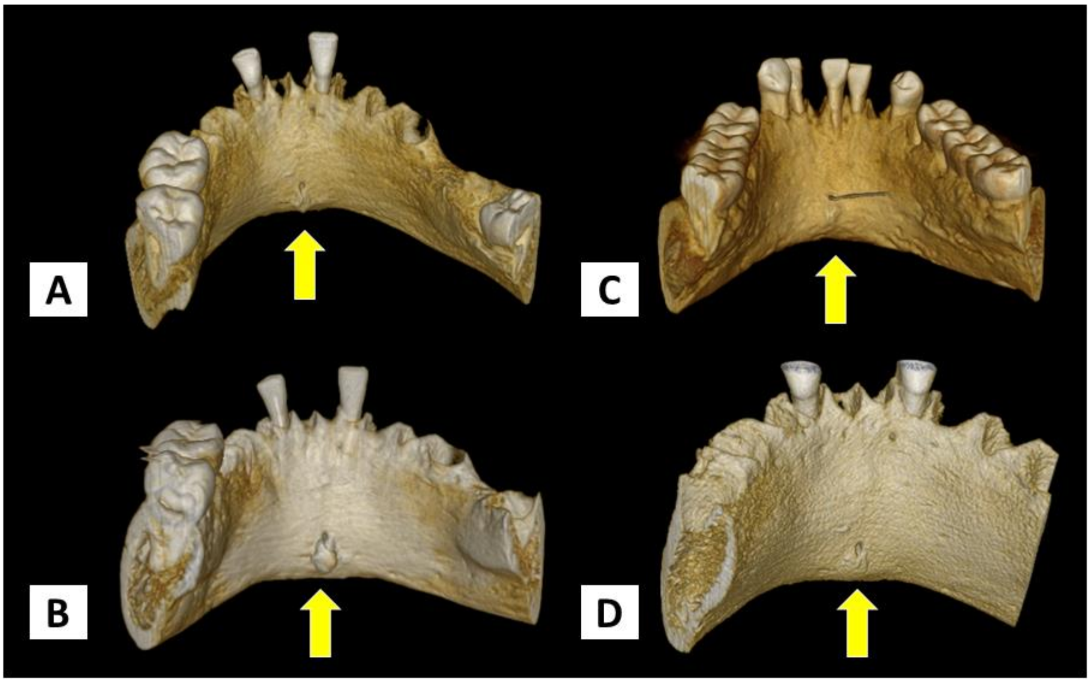
Picture 6: CBCT – Sagittal cuts: initial (A – notice the arrow indicating the region of the genial tubercles), CBCT with genial tubercles highlighted by the barium sulphate (B – indicated by the arrow), CBCT with gingival needle inserted in the lingual canal (C – indicated by the arrow) and final CBCT after the removal of the genial tubercles (D– region indicated by the arrow).



Picture 7: CBCT – Tridimensional reconstructions: initial (A – notice the arrow indicating the region of the genial tubercles), CBCT with genial tubercles highlighted by the barium sulphate (B – indicated by the arrow), CBCT with gingival needle inserted in the lingual canal (C – indicated by the arrow) and final CBCT after the removal of the genial tubercles (D– region indicated by the arrow).



DISCUSSION

After studying the bidimensional images of the 15 mandibles, a better visualization of the genial tubercles could be noticed in the total occlusal radiography of the mandible, once the periapical radiographic images of the lower incisors did not change after the removal of the tubercles and, when the radiopaque ring is observed it is the internal cortical bone of the lingual canal; but the cone beam computed tomography – CBCT – allows a clear

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distinguishing of the genial tubercles and the lingual canal, as highlighted by the work of Nejaim *et al*. (2017).

Performed in all the stages of the study, CBCT is the ideal examination for the complete assessment of the genial tubercles, once it presents the property of providing images without overlapping them and tridimensional reconstructions. Claim proved in the research by Elizabeth *et al*. (2007) who studied the effectiveness of CBCT in determining the location of the genial tubercles in 17 adult corpses in an anatomy lab, assessing the mandibular height, width/height of genial tubercles, distance to the lower edge of the mandible and mandibular thickness through clinical measurements which did not present statistically significant differences in the tomographic images, highlighting the accuracy of the examination in the anatomic location of the genial tubercles. Corroborating these findings, recent morphometric analyses highlight the importance of precise differentiation between genial tubercles and the midline mandibular lingual canal using CBCT, reinforcing its relevance for accurate clinical diagnoses and minimizing potential surgical complications (Martinez *et al*., 2022).

Lee *et al*. (2017) and Elizabeth *et al.* (2007) also studied the reliability of the identification of the genial tubercles through CBCT in patients with mandibular asymmetry and the use of this anatomic repair as reference for the diagnosis of the alteration. The genial tubercles are also used as reference in other situations, as state Yik e Pravinkumar (2018), who assessed the safe inter-foramina mandibular distance for the performance of osteotomy for implant in a population in Malaysia using CBCT and having the genial tubercles as a reference.

Some modifications in the projection of the genial tubercles in each one of the stages were observed in the radiographic images, mainly in the total occlusal radiographies which showed the tubercles more evident as a detriment to the position of the mandible to the performance of the examination.

Păuna, Babiuc & Farcaşiu (2015) assessed a case of prosthetic rehabilitation in a patient with severe atrophy of the mandible associated to the prominence of the genial tubercles, which in order to make the totally removable prosthesis had to be carried out a panoramic radiography and CBCT. In the study of Magat *et al.* (2018) it was possible to observe an increase of the genial tubercles when assessing the tomographic images, but not in the panoramic radiography. Additionally, recent case reports have emphasized unique anatomical variations in the size, shape, and positioning of genial tubercles, reinforcing the

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critical need for precise radiographic and tomographic assessments prior to surgical interventions in the anterior mandibular region (Singh *et al*., 2024).

Chin *et al*. (2012) assessed the position and dimensions of the genial tubercles in a Taiwanese sampling, through CBCT, and in all groups the height of the genial tubercles was close to their width, just like in the results of this research (Table 1), whose samples presented an average dimension of 4,0 mm^3; regarding the distance of the genial tubercles to the lower edge of the mandible, still in the above mentioned study, it was higher in male patients whose skeleton standard was class II than in male patients with standard class I.

In another bidimensional analysis, Kim *et al.* (2019), using a clinical measurement, identified the average height of genial tubercles of. However, in the study of Jindal *et al.* (2015) the CBCT revealed genial tubercles of 11 mm in width and 21 mm in length, going as long as 15 mm besides the residual mandibular crest.

Barbick and Dolwick (2009) used anatomic information of the genial tubercles for the surgical planning in the treatment of the Obstructive Sleep Apnea Syndrome, through the surgery of mandibular advance together with the genial tubercles. As a modification, Barbick & Dolwick (2009) also proposed, from the morphometric assessment of the genial tubercles, the performance of minor osteotomies advancing a small portion of the genioglossus muscle, minimizing the surgical area and decreasing the neuro-sensorial deficit post-surgery. The information about morphometry, location, projection and anatomic variations of the genial tubercles are of vital importance for the surgical planning for the treatment of Obstructive Sleep Apnea Syndrome, since it is a complex physical-pathologic illness making CBCT an essential image examination for the accurate assessment of these anatomical structures (Schendel *et al*., 2011; Lee *et al*., 2017; Park *et al*., 2017; Song *et al*., 2017). Recent studies further confirm the crucial role of three-dimensional tomographic imaging in genioglossus advancement surgeries, highlighting the detailed anatomical considerations of genial tubercles necessary for successful outcomes and reduced complications in patients with obstructive sleep apnea syndrome (Johnson *et al*., 2022).

For the performance of all surgical interventions it is necessary to make thorough planning with a deep anatomic knowledge of the region / structure involved in the procedure (Elizabeth *et al*., 2007; Júnior *et al*., 2007; Schendel, 2011). Rodrigues *et al*. (2012) presented a case with indication for surgical removal of the genial tubercles to adapt a totally removable prosthesis in a female patient at the age of 69; from a clinical assessment and morphometry analysis, location and projection of the tubercles by CBCT.

When comparing the bidimensional images among themselves, the total occlusal radiography of the mandible and the periapical radiography of the lower incisors, a superiority was observed in the viewing of the anatomic structures in the occlusal radiography once the image observed is compatible with the genial tubercles; as well as in the tomographic images which present a clear dominance in the assessment of these structures. Recent population-specific studies conducted with Egyptian patients further illustrate significant variations in mandibular lingual canals and foramina, underscoring the necessity for individualized radiographic and tomographic evaluations to ensure clinical precision across different populations (Hassan *et al*., 2021).

CONCLUSIONS

In the bidimensional radiographic examinations, the genial tubercles are clearly seen only in the total occlusal radiography of the mandible. The periapical radiographic images of the lower incisors did not change with the removal of the genial tubercles, proving that the image highlighted in the periapical radiography is the cortical bone of the lingual canal, when observing the radiopaque ring, or the mental protuberance, when observing the radiopaque shadow in the median region of the symphysis.

The CBCT is the ideal examination for a complete assessment of the genial tubercles, once it presents the property of providing images without overlapping them and tridimensional reconstructions. Thus, it is possible to assess the area, volume and shape of the genial tubercles and also to distinguish these structures from the lingual canal and the mental protuberance.

DISCLAIMER (ARTIFICIAL INTELLIGENCE)

Authors hereby declare that generative AI technologies such as Large Language Models, etc. have been used during the writing or editing of manuscripts. This explanation will include the name, version, model, and source of the generative AI technology and as well as all input prompts provided to the generative AI technology.

DETAILS OF THE AI USAGE ARE GIVEN BELOW

During the preparation of this work, the authors used ChatGPT 3.5 to assist in the translation of the article. After using this tool/service, the authors reviewed and edited the content as necessary and take full responsibility for the content of the publication.

ETHICAL APPROVAL

All authors hereby declare that all experiments have been examined and approved by the appropriate ethics committee and have therefore been performed in accordance with the ethical standards.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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REFERENCES

1. AL-AMERY, S. M.; NAZAR, N.; IQBAL, A.; AL-MALIKI, R. Genial tubercles: Morphological study of the controversial anatomical landmark using cone beam computed tomography. **World Journal of Radiology**, v. 11, n. 7, p. 94-101, 2019.

2. BARBICK, M.B.; DOLWICK, M. F. Genial tubercle advancement for obstructive sleep apnea syndrome: a modification of design. **Journal of Oral and Maxillofacial Surgery**, v.67, n.1, p. 1767-1770, Jan 2009.

3. CHIN, W.Y. Genial tubercle position and dimensions by cone-beam computerized tomography in a Taiwanese sample. **Oral Surgery, Oral Medicine, Oral Pathology, Oral Radiology**, v.113, n.6, p. 46-50, June 2012.

4. CICCHETTI, D.V. Guidelines, criteria, and rules of thumb for evaluating normed and tandardized assessment instruments in psychology. **Psychol Assess**, v.6, n.4, p. 284–290, 1994.

5. ELIZABETH, M. *et al*. Accuracy of cone beam computed tomography in determining the location of the genial tubercle. **Otolaryngology–Head and Neck Surgery**, v.137, n.1, p. 115-118, July 2007.

6. HASSAN, A. M.; HUSSEIN, S. S.; ALY, N. M.; MOHAMED, E. S. Cone beam computed tomography for evaluation of mandibular lingual canals and foramina in Egyptian population. **Egyptian Journal of Radiology and Nuclear Medicine**, v. 52, n. 1, p. 47, 2021.

7. JINDAL, G. *et al*. Rare Enlargement of Genial Tubercles and its Management: A Case Report. **Journal of Clinical and Diagnostic Research**, v.9, n.11, p. 23-24, Nov 2015.

8. JOHNSON, A. R.; PATEL, S. K.; MEYERS, J. S.; WONG, C. R. 3D Genial Tubercle Anatomic Considerations in Genioglossus Advancement Surgery. **The Laryngoscope**, v. 132, n. 4, p. 1254-1260, 2022.

9. JÚNIOR, J. F. S. *et al*. Genioplasty for genioglossus muscle advancement in patients with obstructive sleep apnea-hypopnea syndrome and mandibular retrognathia. **Rev Bras Otorrinolaringol**, v.73, n.4, p. 480-6, 2007.

10. KIM, C.H. *et al*. Mandibular Muscle Attachments in Genial Advancement Surgery for Obstructive Sleep Apnea. **The Laryngoscope**, v.0, n.0, p. 1-6, 2019.

11. KOLSUZ, M.E. *et al*. Evaluation of genial tubercle anatomy using cone beam computed tomography. **Journal of Oral Science**, v.57, n.2, p. 151-156, May 2015.

12. LEE, J.W. *et al*. Accurate genial tubercle capturing method usingcomputer-assisted virtual surgery for genioglossusadvancement. **British Journal of Oral and Maxillofacial Surgery**, v.55, n.1, p. 92-93, May 2016.

Revista ARACÊ
ISSN: 2358-2472

13. LEE, S.Y. *et al*. The genial tubercle: A prospective novel landmark for the diagnosis of mandibular asymmetry. **The Korean Journal of Original Article Orthodontics**, v.47, n.1, p. 50-59, 2017.

14. MAGAT, G. *et al*. Unusual enlargement of genial tubercle on cone beam computed tomography (CBCT): case report. **Anatomy**, v.12, n.2, p. 97-100, Aug 2018

15. MARTINEZ, J. R.; FERNANDEZ, L. C.; RAMIREZ, D. H.; GARCIA, L. A. Morphometric Analysis of the Midline Mandibular Lingual Canal and Mandibular Lingual Foramina: A Cone Beam Computed Tomography (CBCT) Evaluation. **International Journal of Environmental Research and Public Health**, v. 19, n. 24, p. 16910, 2022.

16. NEJAIM, Y *et al*. Evaluation of the morphology of the genial tubercle using cone-beam computed tomography. **British Journal of Oral and Maxillofacial Surgery**, v.11, n.2, p. 1-2, 2017.

17. PARK, J.S. *et al*. Where to position osteotomies in genioglossal advancement surgery based on locations of the mental foramen, canine, lateral incisor, central incisor, and genial tubercle. **Journal of Oral and Maxillofacial Surgery**, v.11, n.1, p. 1-6, May 2017.

18. PĂUNA, M.R.; BABIUC, J.; FARCAŞIU, A.T. Prosthodontic management of an extreme atrophy of the mandible correlated with a prominent genial tubercle – a clinical report. **Romanian Journal of Morphology & Embryology**, v.56, n.2, p. 867–870, July 2015.

19. RODRIGUES, V.H.L.O. *et al*. Surgical removal of genial tubercles. **International Journal of Clinical Dentistry**, v.5, n.3, p. 1-8, 2012.

20. SCHENDEL, S.; POWELL, N.; JACOBSON, R. Maxillary,mandibular, and chin advancement: treatment planning based on airway anatomy in obstructive sleep apnea. **J Oral Maxillofac Surg,** v.69, p. 663–676, 2011.

21. SILVA, M. A.; SOUZA, L. A.; CARVALHO, M. S.; OLIVEIRA, R. S. Morphometric aspects and proposal of a new classification of genial tubercles in cone-beam computed tomography in a Brazilian population. **Oral Radiology**, v. 38, n. 3, p. 450-456, 2022.

22. SINGH, P.; KUMAR, V.; AGARWAL, A.; KHANNA, A. Unique anomalous in the main mental foramen opening, mandibular canal pathway, and size and shape of genial tubercles: A case report. **Journal of Oral and Maxillofacial Surgery, Medicine, and Pathology**, v. 36, n. 2, p. 265-269, 2024.

23. SONG, S.A. *et al*. Genial Tubercle Advancement and Genioplasty for Obstructive Sleep Apnea: A Systematic Review and Meta-Analysis. **The Laryngoscope**, v.127, n.1, p. 984-992, Apr 2017.

24. YIK S.V.; PRAVINKUMAR, G.P. Safe zone in anterior mandible related to the genial tubercle for implant osteotomy in a Chinese-Malaysian population: A CBCT study. **The Journal Of Prosthetic Dentistry**. V.119, n.1, p. 568-73, 2018.