UNIVERSIDADE ESTADUAL DE CAMPINAS
FACULDADE DE ODONTOLOGIA DE PIRACICABA

MARIA CLAUDIA HARADA FERREIRA

ESTUDO MORFOLÓGICO DO CANAL PTERIGOIDE EM IMAGENS DE TOMOGRAFIA COMPUTADORIZADA DE UMA POPULAÇÃO DO SUDESTE DO BRASIL

MORPHOLOGICAL STUDY OF THE PTERYGOID CANAL IN COMPUTED TOMOGRAPHY IMAGES OF A POPULATION FROM SOUTHEAST BRAZIL

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Tese apresentada à Faculdade de Odontologia de Piracicaba da Universidade Estadual de Campinas como parte dos requisitos exigidos para obtenção do título de Doutora em Biologia Buco-Dental, na Área de Anatomia.

Thesis presented to the Piracicaba Dental School of the University of Campinas in partial fulfillment of the requirements for the degree of Doctor in Oral Biology, in the Area of Anatomy.

Orientadora: Profa. Dra. Ana Cláudia Rossi

ESTE EXEMPLAR CORRESPONDE À VERSÃO FINAL DA TESE DEFENDIDA PELA ALUNA MARIA CLAUDIA HARADA FERREIRA E ORIENTADA PELA PROFESSORA DOUTORA ANA CLÁUDIA ROSSI.

PIRACICABA

2024

Ficha catalográfica
Universidade Estadual de Campinas (UNICAMP)
Biblioteca da Faculdade de Odontologia de Piracicaba
Heloisa Maria Ceccotti - CRB 8/6403

F413e

Ferreira, Maria Claudia Harada, 1994-
Estudo morfológico do canal pterigoide em imagens de tomografia computadorizada de uma população do sudeste do Brasil / Maria Claudia Harada Ferreira. – Piracicaba, SP : [s.n.], 2024.

Orientador: Ana Cláudia Rossi.
Tese (doutorado) – Universidade Estadual de Campinas (UNICAMP), Faculdade de Odontologia de Piracicaba.

1. Osso esfenoidal. 2. Seio esfenoidal. 3. Tomografia computadorizada por raios X. I. Rossi, Ana Cláudia, 1988-. II. Universidade Estadual de Campinas (UNICAMP). Faculdade de Odontologia de Piracicaba. III. Título.

Informações Complementares

Título em outro idioma: Morphological study of the pterygoid canal computed tomography images of a population from southeast Brazil
Palavras-chave em inglês:
Sphenoid bone
Sphenoid sinus
Tomography, X-ray computed
Área de concentração: Anatomia
Titulação: Doutora em Biologia Buco-Dental
Banca examinadora:
Ana Cláudia Rossi [Orientador]
Juliana Haddad
Roberta Okamoto
Cristhiane Martins Schmidt
Eduardo Daruge Junior
Data de defesa: 05-07-2024
Programa de Pós-Graduação: Biologia Buco-Dental

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A Comissão Julgadora dos trabalhos de Defesa de Tese de Doutorado, em sessão pública realizada em 05 de julho de 2024, considerou a candidata MARIA CLAUDIA HARADA FERREIRA aprovada.

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A Ata da defesa, assinada pelos membros da Comissão Examinadora, consta no SIGA/Sistema de Fluxo de Dissertação/Tese e na Secretaria do Programa da Unidade.

Dedico esse trabalho à minha família, principalmente, aos meus pais e aos meus irmãos, que foram essenciais para a minha formação pessoal e acadêmica.

AGRADECIMENTOS

Agradeço à Faculdade de Odontologia de Piracicaba a qual possibilitou conhecer pessoas incríveis, obter e aplicar o conhecimento e desfrutar de oportunidades ímpares.

Agradeço à minha querida orientadora e amiga, professora Dra. Ana Cláudia Rossi, por todos os seus ensinamentos transmitidos de forma tão inspiradora e dedicada. Agradeço também aos incentivos e orientações baseados em valores do bem e por ser muitas vezes luz nos caminhos dos seus alunos.

Agradeço ao querido pesquisador e amigo, professor Dr. Alexandre Rodrigues Freire pela contribuição intermediada pelo seu bom humor. Agradeço pelo suporte e paciência nos estudos realizados.

Agradeço ao meu namorado, Paulo Victor Bernardo Ferreira Alves, por ser um dos meus maiores incentivadores. Obrigada por toda a força e ombro amigo durante esta e as próximas fases da vida.

Agradeço também aos meus amigos e amigas, principalmente, à Débora Costa Ruiz, por ter sido minha companheira, meu farol e meu porto seguro; e à Lara de Anchieta Caponi, por ter sido lar, aconchego e carinho.

Agradeço ao Departamento de Biociências, Área de Anatomia, por compartilharem conhecimento e tornarem o ambiente de pesquisa prazeroso, à base de muito café e conversa.

Agradeço ao apoio no presente trabalho da Coordenação de Aperfeiçoamento de Pessoal de Nível Superior – Brasil (CAPES) – Código de Financiamento 001.

Por fim, agradeço por estarmos com vida e saudáveis perante a pandemia do COVID-19, que nos surpreendeu e tornou os anos que passaram atípicos e incertos. Minha compaixão às vítimas.

RESUMO

O canal pterigoide é uma estrutura de grande importância anatômica e funcional, pois transmite a artéria, a veia e o nervo pterigoides, desempenhando um papel essencial na disseminação de patologias tumorais. Foram utilizadas tomografias computadorizadas para avaliar a morfologia do canal pterigoide em uma amostra dividida em dois grupos, sendo um com 58 tomografias computadorizadas de crânios do sexo masculino e outro grupo com 42 tomografias computadorizadas de crânios do sexo feminino. Foi utilizado o software Mimics 18.0 (Materialise, NV, Bélgica) para a realização da segmentação das imagens de cada tomografia computadorizada. A segmentação foi definida avaliando-se um limiar para obter voxels, cujos valores foram estipulados numa faixa de acordo com os componentes anatômicos avaliados região correspondente ao osso esfenoide e fossa pterigopalatina. Para o conjunto de tomografias computadorizadas que foi avaliado, foi definida a classificação do canal pterigoide. Os resultados mostraram que o tipo mais comum de canal pterigoide foi o tipo 2, onde o canal é parcialmente protruso no soalho do seio esfenoide. Além disso, constatou-se que o volume do canal pterigoide foi maior no sexo masculino em comparação com o feminino, especialmente nos tipos 2 e 3. Esses achados sugerem que o sexo pode desempenhar um papel na morfologia do canal pterigoide, com o sexo masculino tendo maior probabilidade de apresentar canais de maior volume e projeções mais pronunciadas no seio esfenoidal. Isso pode ter implicações importantes para cirurgiões endoscópicos da base do crânio, fornecendo informações críticas para a localização segura dessa região durante procedimentos cirúrgicos. No entanto, é importante ressaltar que este estudo teve algumas limitações, como o tamanho da amostra e a representatividade regional da população estudada. Portanto, são necessárias mais pesquisas com amostras maiores e mais abrangentes para confirmar esses resultados e entender melhor as variações na morfologia do canal pterigoide em diferentes populações. Assim, os resultados do presente estudo foram de acordo com a hipótese de que a morfologia do canal pterigoide pode apresentar variação entre os indivíduos de sexos diferentes, principalmente, nos indivíduos que apresentaram os canais pterigoides dos tipos 2 e 3. O canal pterigoide mais incidente foi o canal do tipo 2.

Palavras-chave: Osso esfenoidal. Seio esfenoidal. Tomografia computadorizada por raios X.

ABSTRACT

The pterygoid canal is a structure of great anatomical and functional importance, as it transmits the artery, vein, and pterygoid nerve, playing an essential role in the spread of tumoral pathologies. Computed tomography scans were used to evaluate the morphology of the pterygoid canal in a sample divided into two groups, one with 58 computed tomography scans of male skulls and another group with 42 computed tomography scans of female skulls. The Mimics 18.0 software (Materialise, NV, Belgium) was used to perform the segmentation of the images of each computed tomography scan. Segmentation was defined by evaluating a threshold to obtain voxels, whose values were set in a range according to the anatomical components evaluated in the region corresponding to the sphenoid bone and pterygopalatine fossa. For the set of computed tomography scans evaluated, the classification of the pterygoid canal was defined. The results showed that the most common type of pterygoid canal was type 2, where the canal is partially protruding into the floor of the sphenoid sinus. Additionally, it was found that the volume of the pterygoid canal was larger in males compared to females, especially in types 2 and 3. These findings suggest that sex may play a role in the morphology of the pterygoid canal, with males being more likely to present larger volume canals and more pronounced projections into the sphenoid sinus. This may have important implications for endoscopic skull base surgeons, providing critical information for the safe localization of this region during surgical procedures. However, it is important to note that this study had some limitations, such as the sample size and the regional representativeness of the studied population. Therefore, further research with larger and more comprehensive samples is needed to confirm these results and better understand variations in the morphology of the pterygoid canal in different populations. Thus, the results of the present study were in accordance with the hypothesis that the morphology of the pterygoid canal may vary among individuals of different sexes, mainly in individuals who presented pterygoid canals of types 2 and 3. The most incident pterygoid canal was type 2.

Keywords: Sphenoid bone. Sphenoid sinus. Tomography, X-ray computed

SUMÁRIO

1 INTRODUÇÃO

O osso esfenoide é um osso ímpar que compõe parte da base do crânio e contribui para a formação do assoalho da fossa craniana média. Está intimamente associado aos nervos cranianos e parte do encéfalo e permite a passagem de estruturas neurovasculares para dentro e fora do crânio, através dos seus forames e canais. Ele possui um formato semelhante ao um morcego, podendo ser dividido em corpo, asa menor, asa maior e os processos pterigoides.

Os processos pterigoides originam-se bilateralmente da conexão entre o corpo e a asa maior e se projetam para baixo. Eles são compostos pelas lâminas pterigoideas medial e lateral, as quais são separadas pela incisura pterigoidea. Na base do processo pterigóide encontramos o canal pterigóide (Jaworek-Troć, *et al*., 2019).

O canal de Vidian (canal pterigóide) foi descrito pelo médico, cirurgião e anatomista italiano Guido Guidi (do latim *Vidus Vidius*). O canal pterigoide transmite a artéria, a veia e o nervo pterigoides e pode ser observado na base do crânio, na borda anterior do forame lacerado, através do assoalho do seio esfenoidal, para terminar na fossa pterigopalatina (Bahşi, *et al*. 2019).

Ao realizar um estudo do canal pterigoide, Santana, *et al*. (2020), observaram que a fossa pterigopalatina é um espaço interósseo de grande importância anátomo-funcional, patológica e cirúrgica. Isso se deve à sua localização, às relações anatômicas e ao conteúdo vasculonervoso que favorecem a disseminação de patologias tumorais. Nesse espaço interósseo estão a artéria maxilar e o nervo maxilar (forame redondo), além do gânglio parassimpático pterigopalatino, de onde se distribuem ramos para as cavidades nasal e bucal, seios paranasais e partes das regiões orbitária e craniana, estendendo-se até a face. Além disso, também observaram que a parede posterior da fossa é uma importante referência para a microcirurgia e cirurgia endoscópica, através de diferentes vias de acesso, como transbucal, transmaxilar e transnasal.

O nervo pterigoide é formado por fibras pré-ganglionares parassimpáticas do nervo petroso maior advindas do gânglio geniculado do nervo facial, e por fibras simpáticas do nervo petroso profundo, sendo estas originárias do gânglio cervical superior, via plexo simpático carótico. Depois de deixar o canal de pterigoide na fossa pterigopalatina, o nervo pterigoide entra na face posterior do gânglio de Meckel. A

constrição vascular na cavidade nasal é realizada pelas fibras simpáticas, enquanto as fibras parassimpáticas controlam as secreções das glândulas mucosas nasais, palatinas, faríngeas, do seio maxilar e glândulas bucais e labiais superiores. Omami *et al*. (2011) acreditam que o desequilíbrio relativo da estimulação parassimpática para simpática dos vasos sanguíneos e glândulas da mucosa nasal possa ser a causa para a rinite vasomotora, sendo um dos tratamentos introduzidos na prática otorrinolaringológica a neurectomia de Vidian, que envolve a secção cirúrgica do nervo pterigoide.

Fortes *et al*. (2008) afirmaram que para identificação e controle da artéria carótida interna e da fossa craniana média é essencial o conhecimento das relações anatômicas do nervo pterigoide e do nervo maxilar. Kassam *et al*. (2005) relatam que se deve ter cuidado durante a remoção óssea, pois o espaço entre o nervo maxilar e o canal pterigoide diminui em forma de cone até um espaço relativamente estreito separando os dois na profundidade da fossa craniana. Mato *et al*. (2015) observaram que a distância entre o canal de pterigoide e o forame redondo é relevante para abordagens endonasais ao espaço quadrangular, que é limitado pela porção horizontal da parte petrosa da artéria carótida interna inferiormente, o nervo maxilar lateralmente, a carótida paraclival medialmente e o nervo abducente superiormente. Portanto, é importante conhecer as distâncias entre o canal pterigoide e o forame redondo.

A avaliação da morfologia do canal pterigoide e sua relação com as demais estruturas do complexo craniofacial, como o osso esfenoide e o forame redondo, por exemplo, pode contribuir para o sucesso de procedimentos cirúrgicos executados nessa região.

2 ARTIGO: Morphological study of the pterygoid canal in CT scans of a population from southeast Brazil*

*Artigo submetido ao periódico European Journal of Anatomy (Anexo 2)

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ABSTRACT

Objective: To evaluate the morphology of the pterygoid canal in computed tomography (CT) scans of a southeastern Brazilian population. Materials and Methods: One hundred CT scans were evaluated, with 58 from male skulls and 42 from female skulls. The Mimics 18.0 software (Materialise, NV, Belgium) was used for segmentation of the images from each CT scan in the region corresponding to the sphenoid bone and the pterygopalatine fossa. After segmentation, volume (mm^3) and length (mm) were obtained using a specific tool. The types of pterygoid canals were analyzed following criteria: type 1 (pterygoid canal completely within the sphenoid sinus), type 2 (pterygoid canal on the floor of the sphenoid sinus or partially protruding into the sphenoid sinus), and type 3 (pterygoid canal completely embedded in the sphenoid corpus). Descriptive data for continuous variables were presented as mean and standard deviation or median and interquartile range. Two-way ANOVA tests with Tukey's post hoc test were used for analyzing continuous variables comparing different types within each sex and between sexes (unpaired analyses). A confidence interval of 95% and a significance level of 5% were established for all tests. Statistical analysis was performed using GraphPAD Prism v.8 software (San Diego, CA, USA). Results: The most common configuration of the pterygoid canal was type 2 for both the right and left sides. For both sides of the evaluated skulls, it was observed that type 3 pterygoid canal had a larger volume in both males and females compared to other types. Although not always significant, for all types, the volume and length in males was higher than in females, especially when comparing types 2 and 3. Conclusion: The morphology of the pterygoid canal may vary among individuals of different sexes, particularly in individuals with type 2 and 3 pterygoid canals. The most incident pterygoid canal was type 2.

Keywords: pterygoid canal; computed tomography; volume.

INTRODUCTION

The sphenoid bone is a singular bone that comprises part of the base of the skull and contributes to the formation of the floor of the middle cranial fossa. It is closely associated with cranial nerves and parts of the brain and allows the passage of neurovascular structures into and out of the skull through its foramina and canals. It has a bat-like shape and can be divided into a body, lesser wing, greater wing, and pterygoid processes.

The pterygoid processes originate bilaterally from the connection between the body and the greater wing and project downward. They are composed of the medial and lateral pterygoid plates, which are separated by the pterygoid notch. At the base of the pterygoid process, we find the pterygoid canal (Jaworek-Troć, *et al*., 2019).

The Vidian canal (pterygoid canal) was described by the Italian physician, surgeon, and anatomist Guido Guidi (latin: *Vidus Vidius*). The pterygoid canal transmits

the artery, vein, and nerve of the pterygoid and can be observed at the base of the skull, at the anterior border of the foramen lacerum, through the floor of the sphenoidal sinus, to end in the pterygopalatine fossa (Bahşi, *et al*., 2019).

In studying the pterygoid canal, Santana, *et al*. (2020), observed that the pterygopalatine fossa is an interosseous space of great anatomofunctional, pathological, and surgical importance. This is due to its location, anatomical relations, and vasculonervous content that favor the spread of tumorous pathologies. In this interosseous space are the maxillary artery and maxillary nerve (foramen rotundum), as well as the pterygopalatine parasympathetic ganglion, from which branches distribute to the nasal and oral cavities, paranasal sinuses, and parts of the orbital and cranial regions, extending to the face. Additionally, they also observed that the posterior wall of the fossa is an important reference for microsurgery and endoscopic surgery, through different access routes, such as transbuccal, transmaxillary, and transnasal.

The pterygoid nerve is formed by preganglionic parasympathetic fibers of the greater petrosal nerve originating from the geniculate ganglion of the facial nerve, and by sympathetic fibers of the deep petrosal nerve, which originate from the superior cervical ganglion, via the carotid sympathetic plexus. After leaving the pterygoid canal in the pterygopalatine fossa, the pterygoid nerve enters the posterior face of the Meckel ganglion. Vascular constriction in the nasal cavity is performed by sympathetic fibers, while parasympathetic fibers control secretions from nasal, palatine, pharyngeal, maxillary sinus, and upper oral and labial glands. Omami *et al*. (2011) believe that the relative imbalance of parasympathetic to sympathetic stimulation of nasal mucosa blood vessels and glands may be the cause of vasomotor rhinitis, with one of the treatments introduced in otolaryngological practice being Vidian neurectomy, which involves surgical sectioning of the pterygoid nerve.

Fortes *et al*. (2008) stated that for the identification and control of the internal carotid artery and the middle cranial fossa, knowledge of the anatomical relations of the pterygoid nerve and the maxillary nerve is essential. Kassam *et al*. (2005) report that care should be taken during bone removal, as the space between the maxillary nerve and the pterygoid canal narrows into a cone shape to a relatively narrow space separating the two at the depth of the cranial fossa. Mato *et al*. (2015) observed that the distance between the pterygoid canal and the foramen rotundum is relevant for endonasal approaches to the quadrangular space, which is limited by the horizontal

portion of the petrous part of the internal carotid artery inferiorly, the maxillary nerve laterally, the paraclival carotid medially, and the abducens nerve superiorly. Therefore, it is important to know the distances between the pterygoid canal and the foramen rotundum.

The evaluation of the morphology of the pterygoid canal and its relationship with other structures of the craniofacial complex, such as the sphenoid bone and the foramen rotundum, for example, can contribute to the success of surgical procedures performed in this region. Thus, the aim of this study was evaluated the morphology of the pterygoid canal in computed tomography (CT) scans of a southeastern Brazilian population.

MATERIALS AND METHODS

The present research was analyzed and approved by the Ethics Committee from FOP/UNICAMP (CAAE protocol: 46463421.9.0000.5418).

Sample

The research used 100 computed tomography of cataloged individuals, with the date of death between 2008 and 2010, who were exhumed during the period 2013 and 2014. The computed tomography were from human skulls belonging to the "Professor Dr. Eduardo Daruge" Osteological and Tomographic Biobank at the Piracicaba Dental School of the University of Campinas (UNICAMP).

The tomographic images were obtained using an Aisteion Multislice 4 CT System (Toshiba Medical Systems Corporation - Japan), for the skull protocol: 100 MA, 120KV, with 1mm slices.

The sample was divided into two groups, one for male samples, with 58 computed tomography of male skulls and 42 computed tomography of female skulls. The age of the sample ranged from 18 to 100 years in both groups.

Inclusion and exclusion criteria

The inclusion criteria were used computed tomography of intact skulls without macroscopic deformities, fractures, or any other pathological or surgical alteration were used. Bone remnants were not excluded due to ancestry or age.

The exclusion criteria were used computed tomography of skulls from syndromic individuals or with any anatomical abnormalities in the region of interest, as

well as individuals with implants, plates, screws, or any other metallic artifact near the region, were excluded.

Pterygoid Canal Volume and Length evaluation

The Mimics 18.0 software (Materialise, NV, Belgium) was used to perform the segmentation of the images from each computed tomography. Segmentation involved marking each bone structure of interest in each tomographic slice. Segmentation was defined by assessing a threshold to obtain voxels, whose values were established within a range according to the anatomical components evaluated in the corresponding region of the sphenoid bone and pterygopalatine fossa. 3D reconstruction was performed to enable visualization of these components (Figure 1).

After segmentation, the volume (mm^3) and the length (mm) were obtained using a specific tool in the Mimics 18.0 software (Materialise, NV, Belgium). The software calculates the volume from the previously performed segmentation.

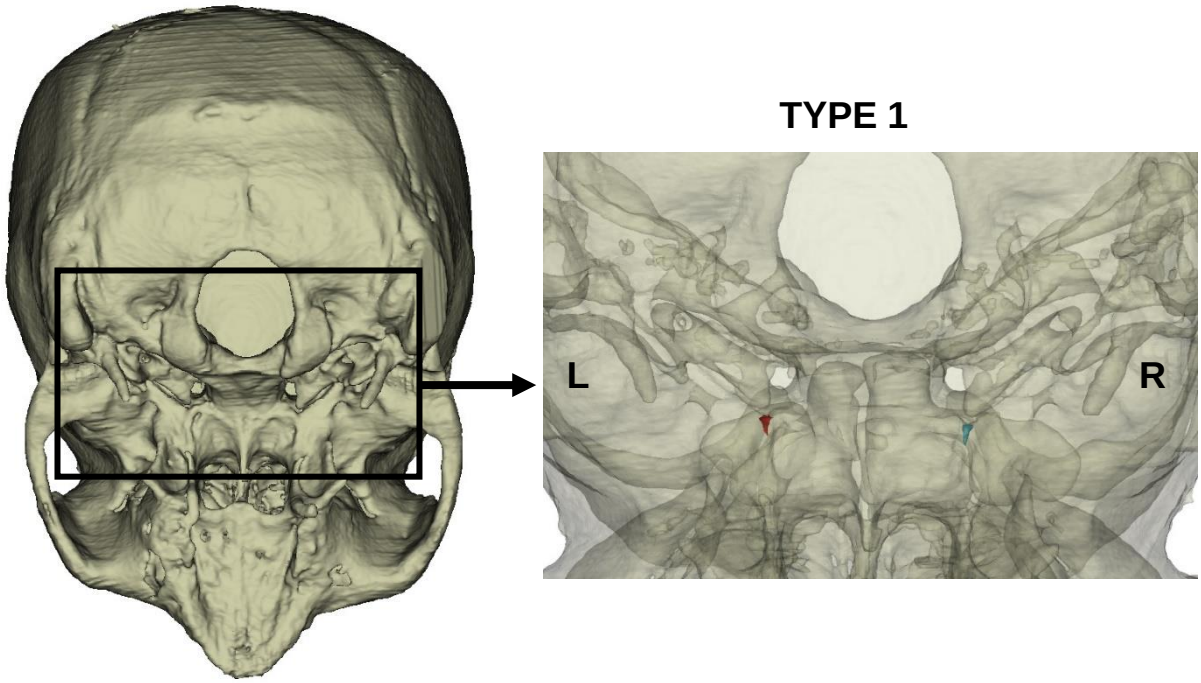

Figure 1. Three-dimensional reconstruction of the inferior view of the human skull highlighting the volume obtained from type 1 pterygoid canal on each side as an example of measurement. **R**: Right; **L**: Left (Mimics 18.0 software - Materialise, NV, Belgium).

Classification of the pterygoid canal

All evaluations were performed using the three-dimensional reconstruction of the computed tomography. The types of pterygoid canal were defined according to Lee *et al*. (2011):

- Type 1: Pterygoid canal located entirely protruding on the floor of the sphenoid sinus, and one process is present.

- Type 2: Pterygoid canal located partially protruding on the floor of the sphenoid sinus.

- Type 3: Pterygoid canal located entirely within the body of the sphenoid bone (Figure 2).

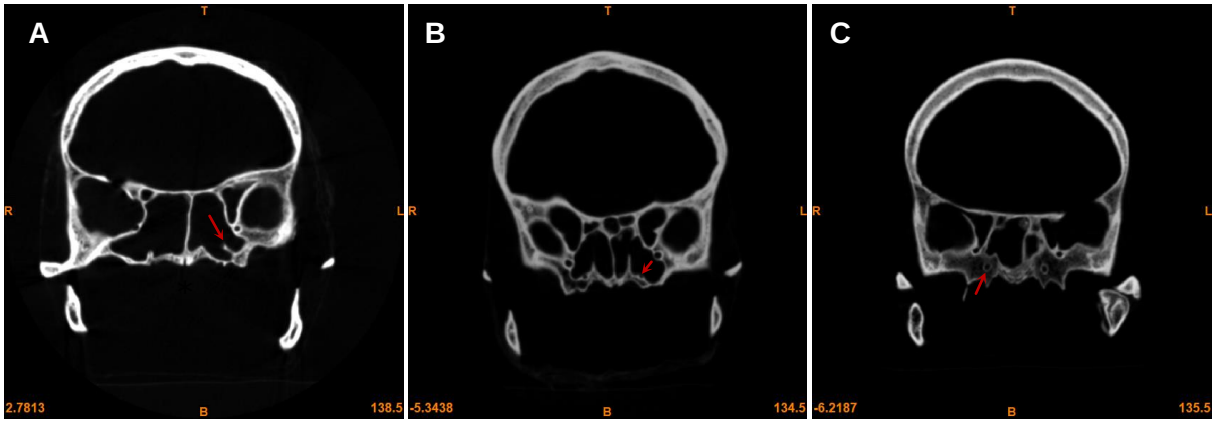

Figure 2. Classification of the pterygoid canal according to Lee *et al*. (2011) observed through the coronal plane in Mimics 18.0 software (Materialise, NV, Belgium): **A** – Type 1: Pterygoid canal located entirely protruding on the floor of the sphenoid sinus, and one process is present. **B** – Type 2: Pterygoid canal located partially protruding on the floor of the sphenoid sinus. **C** – Type 3: Pterygoid canal located entirely within the body of the sphenoid bone. **Red arrow** – pterygoid canal.

Statistical analysis

The data were tabulated using the Microsoft Office Excel® package. The analysis of the incidence of morphological types of pterygoid canals was performed using percentages (%). Descriptive data of continuous variables were presented as mean and standard deviation or median and interquartile range. Normality tests were used to assess the distribution of continuous variables. Since the data distribution was normal, the Two-way ANOVA test with Tukey's post-test (unpaired analyses) was used. A confidence interval of 95% and a significance level of 5% were established for all tests. For multiple comparisons, the initial significance level of 5% was corrected by dividing the initial threshold by the number of comparisons. Statistical analysis was performed using GraphPAD Prism v.10 software (San Diego, CA, USA).

RESULTS

For the evaluated sample, the mean age found was 62.26 (Standard Deviation: 20.80) years for females and 53.86 (Standard Deviation: 17.64) years for males.

Incidence of pterygoid canal types by sex

Out of 100 computed tomographies evaluated, on the right side of the skull, 10% of individuals had type 1 pterygoid canal, 48% had type 2, and 42% had type 3. On the left side, 6% had type 1 pterygoid canal, 54% had type 2, and 40% had type 3. When both sides were summed, overall, it was found that 41% of computed tomographies presented type 1 canal, 51% presented type 2, and 8% presented type 3 canal.

When both sides were summed and considering the variable of sex, it was found that for males, 8.7% were type 1, 55.1% were type 2, and 36.2% were type 3. For females, 7.14% were type 1, 45.24% were type 2, and 47.62% were type 3.

Volume (mm^3) of pterygoid canal types by sex on each side

Descriptive analysis of Mean, Standard Deviation, Median, and Interquartile Range of volume (mm^3) for comparisons between sexes (male vs. female) in each morphological type found on the right side were presented in Table 1.

Assuming normal distribution for both evaluated sides, with alpha=0.05, calculated by the D'Agostino & Pearson test (right side) and Kolmogorov-Smirnov test (left side), the Two-way ANOVA test was performed to assess differences in volume between sexes in each type of pterygoid canal found and between sides in each type of pterygoid canal found.

The Two-way ANOVA test, for the right side, when comparing volumes of morphological types 1, 2, and 3 between sexes, showed statistically significant differences among types ($P < 0.0001$). On the right side, it was possible to verify that type 3 pterygoid canal had a larger volume for both males and females compared to other types. Although not always significant, for all types, the volume in males was larger than females ($P = 0.4643$) (Table 1).

Table 1. Mean, Standard Deviation, Median, and Interquartile Range of volume (mm^3) for comparisons between sexes (male vs. female) in each morphological type found on the right side.

VOLUME (MM^3)	TYPE 1	TYPE 2	TYPE 3
MALE			
Mean	13.38	15.11	23.16
Standard deviation	6.325	9.115	7.630
Median	11.14	12.22	22.91
Interquartile range	16.70	36.36	30.27
FEMALE			
Mean	11.72	12.32	23.00
Standard deviation	5.393	6.863	8.897
Median	11.12	12.53	21.12
Interquartile range	13.00	21.89	28.06

Multiple comparisons by Tukey's test conducted between the means of each morphological type in each sex showed significant differences on the right side when comparing type 2 and type 3 in males (P=0.0075), type 2 and type 3 in females (P=0.0014), type 2 in males with type 3 in females (P=0.0167), and type 3 in males with type 2 in females (P=0.0005) (Figure 3). No statistical differences were found for other comparisons.

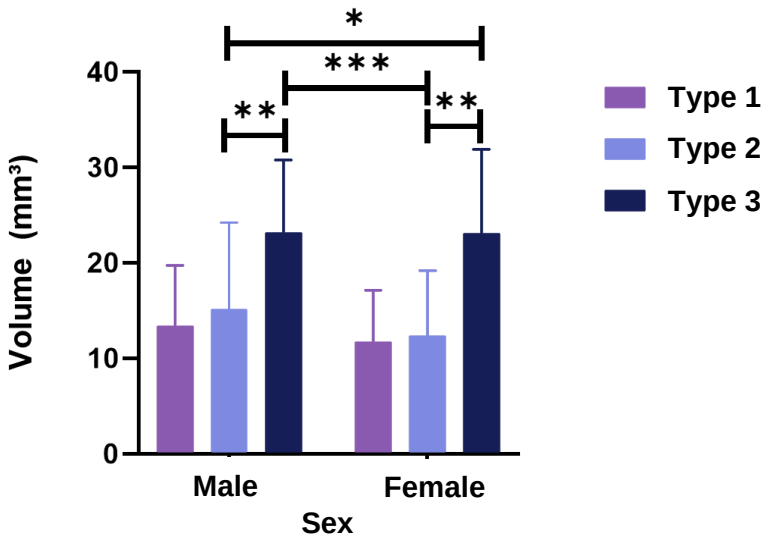

Figure 3. Mean volume on the right side (mm^3) by sex in each morphological type of pterygoid canal. *Statistical difference.

The descriptive analysis of Mean, Standard Deviation, Median, and Interquartile Range of volume (mm^3) for comparisons between sexes (male vs. female) in each morphological type found on the left side is presented in Table 2.

Table 2. Mean, Standard Deviation, Median, and Interquartile Range of volume (mm^3) for comparisons between sexes (male vs. female) in each morphological type found on the left side.

VOLUME (MM^3)	TYPE 1	TYPE 2	TYPE 3
MALE			
Mean	8.945	14.27	24.37
Standard deviation	2.646	13.44	10.92
Median	8.942	11.19	22.88
Interquartile range	5.453	72.48	39.24
FEMALE			
Mean	8.780	9.796	19.67
Standard deviation	3.120	5.256	8.281
Median	8.780	8.764	16.05
Interquartile range	4.413	17.170	24.73

The Two-way ANOVA test, for the left side, when comparing volumes of morphological types 1, 2, and 3 between sexes, detected statistically significant differences among the types (P <0.0001). On the left side, it was possible to verify that type 3 pterygoid canal had a larger volume for both males and females compared to other types. Although not always significant, for all types, the volume in males was greater than females (P= 0.3610) (Table 2).

Multiple comparisons by Tukey's test conducted between the means of each morphological type in each sex showed significant differences on the left side when comparing type 2 and type 3 in females (P=0.0390) and type 3 in males with type 2 in females (P=0.0034) (Figure 4). No statistical differences were found for other comparisons.

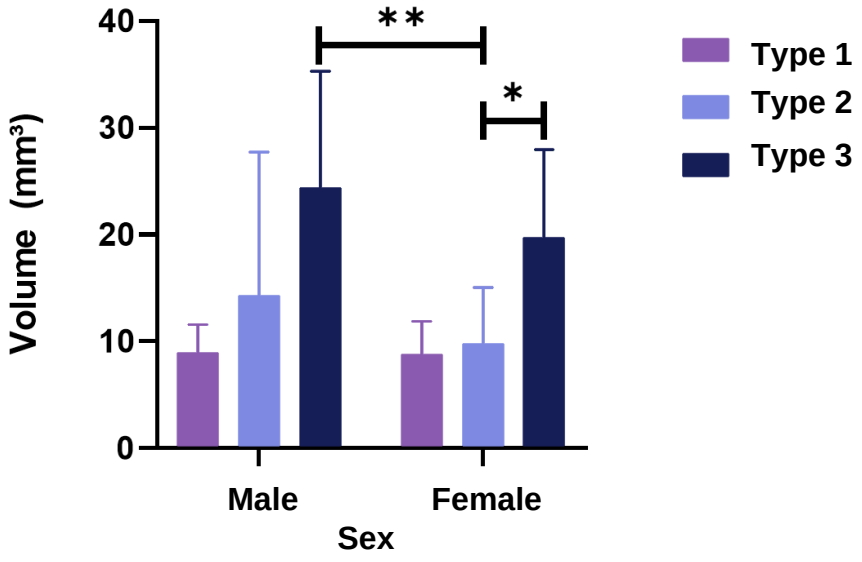

Figure 4. Means of volume on the left side (mm^3) by sex in each morphological type of pterygoid canal. *Statistical difference.

Length (mm) of pterygoid canal types by sex on each side

Descriptive analysis of Mean, Standard Deviation, Median, and Interquartile Range of length (mm) for comparisons between sexes (male vs. female) in each morphological type found on the right side were presented in Table 3.

Assuming normal distribution for both evaluated sides, with alpha=0.05, calculated by the D'Agostino & Pearson test (right side) and Kolmogorov-Smirnov test (left side), the Two-way ANOVA test was performed to assess differences in length between sexes in each type of pterygoid canal found and between sides in each type of pterygoid canal found.

The Two-way ANOVA test, for the right side, when comparing length of morphological types 1, 2, and 3 between sexes, showed statistically significant differences among types (P=0.0021).

Table 3. Mean, Standard Deviation, Median, and Interquartile Range of length (mm) for comparisons between sexes (male vs. female) in each morphological type found on the right side.

LENGTH (MM)	TYPE 1	TYPE 2	TYPE 3
MALE			
Mean	11.41	8.887	10.38
Standard deviation	0.8911	3.239	2.006
Median	11.65	9.540	10.36
Interquartile range	2.600	13.33	7.850
FEMALE			
Mean	9.478	7.746	10.16
Standard deviation	1.322	3.457	2.069
Median	9.940	8.140	10.12
Interquartile range	2.950	11.65	7.390

Multiple comparisons by Tukey's test conducted between the means of each morphological type in each sex showed significant differences on the right side when comparing type 3 in males with type 2 in females (P=0.0258) (Figure 5). No statistical differences were found for other comparisons.

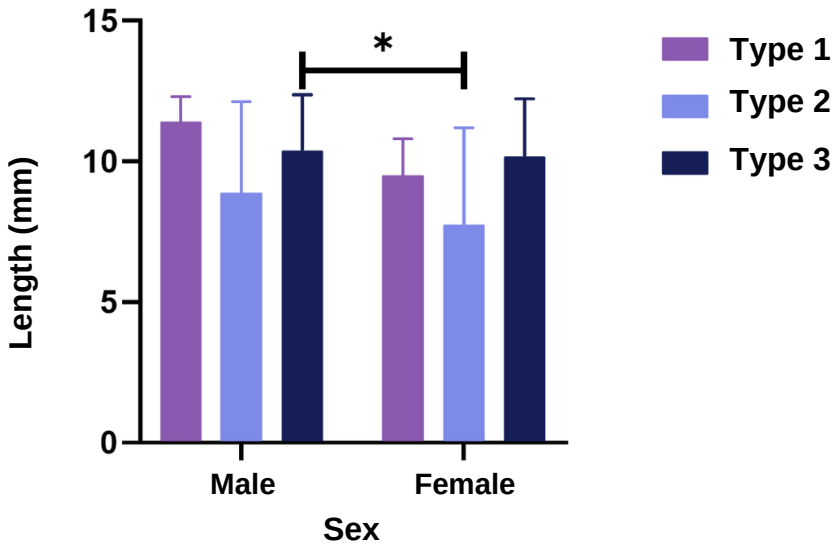

Figure 5. Means of length on the right side (mm) by sex in each morphological type of pterygoid canal. *Statistical difference.

Descriptive analysis of Mean, Standard Deviation, Median, and Interquartile Range of length (mm) for comparisons between sexes (male vs. female) in each morphological type found on the left side were presented in Table 4.

Assuming normal distribution for both evaluated sides, with alpha=0.05, calculated by the D'Agostino & Pearson test (right side) and Kolmogorov-Smirnov test (left side), the Two-way ANOVA test was performed to assess differences in length between sexes in each type of pterygoid canal found and between sides in each type of pterygoid canal found.

The Two-way ANOVA test, for the left side, when comparing length of morphological types 1, 2, and 3 between sexes, showed statistically significant differences among types (P=0.0016) and among sexes (P=0.0067).

Table 4. Mean, Standard Deviation, Median, and Interquartile Range of length (mm) for comparisons between sexes (male vs. female) in each morphological type found on the left side.

LENGTH (MM)	TYPE 1	TYPE 2	TYPE 3
MALE			
Mean	11.76	8.563	10.23
Standard deviation	2.614	3.594	1.619
Median	11.22	9.230	10.16
Interquartile range	6.110	11.74	6.570
FEMALE			
Mean	6.370	7.043	9.739
Standard deviation	3.818	2.755	1.752
Median	6.370	6.410	9.820
Interquartile range	5.400	9.450	6.910

Multiple comparisons by Tukey's test conducted between the means of each morphological type in each sex showed significant differences on the left side when comparing type 1 in males with type 2 in females (P=0.0298), type 3 in males with type 2 in females (P=0.0077) and type 2 in female with type 3 in female (P=0.0317) (Figure 6). No statistical differences were found for other comparisons.

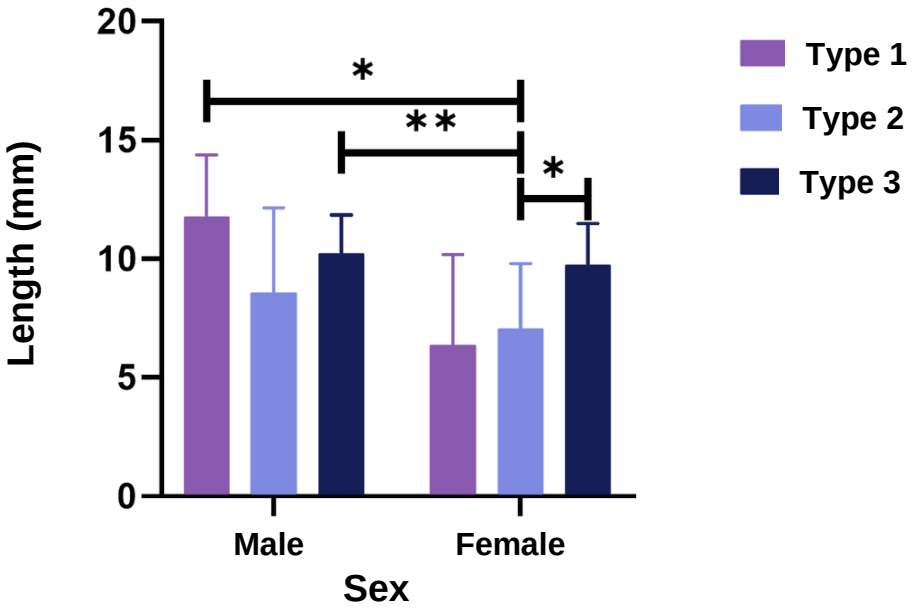

Figure 6. Means of length on the left side (mm) by sex in each morphological type of pterygoid canal. *Statistical difference.

DISCUSSION

The pterygoid canal allows the passage of both the nerve and artery of the same name; it lies at the fusion line of the pterygoid process and the greater wing with the body of the sphenoid bone. The pterygoid nerve is formed by the greater petrosal nerve, the deep petrosal nerve, and sympathetic fibers along the internal carotid artery. The pterygoid artery and corresponding nerves pass through the pterygoid canal and are branches of the maxillary artery (Daniels *et al*., 1998). The pterygoid artery connects parasympathetic fibers to the sphenopalatine ganglion in the pterygopalatine fossa (upper part) (Rypens *et al*., 1991).

The pterygoid canal may project into the sphenoid sinus and can be affected by sinus diseases and at-risk during surgery (Chong *et al*., 2000). Imaging plays a central role in planning and treating diseases at the skull base because clinical evaluation of this region is often difficult or incomplete. Computed tomography is ideal for delineating bone anatomy and is frequently used (Yazar *et al*., 2007).

The pterygoid canal is closely related to the sphenoid sinus. Pandolfo *et al*. (1988) reported that the bone wall between the pterygoid canal and the sphenoid sinus was relatively thin, not exceeding 5 mm, and was incomplete at some points. Therefore, special attention has been given to the morphology and location of the pterygoid canal in relation to the sphenoid sinus during surgery to avoid damage to nerves and blood vessels in the pterygoid canal.

In the present study, the most common configuration of the pterygoid canal was type 2 (partially protruded pterygoid canal on the floor of the sphenoid sinus) for both the right side (48% type 2 canal) and the left side (54% type 2 canal). This is in accordance with Lee *et al*. (2011), who reported an incidence of 47%. Similarly, Yazar *et al*. (2007) and Mohebbi *et al*. (2017) identified type 2 as the most common configuration, with an incidence of 54%. Additionally, they reported cases with bony septum within the pterygoid canal, which likely divides the canal into two parts, nerves, and vessels. Contrary to these reports, Liu *et al*. (2002) reported more type 3 canal configurations (pterygoid canal entirely located in the body of the sphenoid bone).

To the best of our knowledge, the present study is the first to use volume as a parameter to evaluate the morphology of the pterygoid canal. This serves as critical information for the endoscopic skull base surgeon to use when attempting to safely locate the region.

For both the right and left sides of the evaluated skulls, the Two-way ANOVA test, when comparing the volumes of morphological types 1, 2, and 3 between sexes, showed that the type 3 pterygoid canal had a larger volume for both males and females compared to the other types. Although not always significant, for all types, the volume in males was greater than females, especially when comparing types 2 and 3. Thus, it was observed that sex influenced the volume of the pterygoid canal, and in the pneumatization process, if the sphenoid bone is extensively involved, there is a greater probability of the pterygoid canal projecting into the sinus with a stalk (type 1) or being present on the floor of the sphenoid sinus (type 2) in the sex with larger volume.

The mean length of the pterygoid canal in this present study varies from 6.37 to 11.76mm. For types 2 and 3, it was possible verify a significant difference between males and females. In this study, the average length of the pterygoid canal was higher in males than in females similar to Gong *et al*. (2023) and Vuksanovic-Bozaric *et al*. (2019). This may suggest that the VC of females is shorter, thicker, and flatter than that of males.

A limitation of the present research is that it was conducted on a specific and regional sample of the population from southeastern Brazil. Therefore, it is important to expand the evaluation to larger samples covering the entire national territory. Nevertheless, this study helps predict the type of pterygoid canal in the Brazilian population studied.

CONCLUSION

Thus, the results of the present study were in accordance with the hypothesis that the morphology of the pterygoid canal may vary among individuals of different sexes, especially in those who presented pterygoid canals of types 2 and 3. The most prevalent pterygoid canal was type 2.

Funding: This study was financed in part by the Coordenação de Aperfeiçoamento de Pessoal de Nível Superior – Brasil (CAPES) – Finance Code 001.

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3 CONCLUSÃO

Assim, os resultados do presente estudo foram de acordo com a hipótese de que a morfologia do canal pterigoide pode apresentar variação entre os indivíduos de sexos diferentes, principalmente, nos indivíduos que apresentaram os canais pterigoides dos tipos 2 e 3. O canal pterigoide mais incidente foi o canal do tipo 2.

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* De acordo com as normas da UNICAMP/FOP, baseadas na padronização do International Committee of Medical Journal Editors - Vancouver Group. Abreviatura dos periódicos em conformidade com o PubMed.

ANEXOS

Anexo 1 – Comitê de Ética em Pesquisa

UNICAMP - FACULDADE DE ODONTOLOGIA DE PIRACICABA DA UNIVERSIDADE DE CAMPINAS - FOP/UNICAMP

PARECER CONSUBSTANCIADO DO CEP

DADOS DO PROJETO DE PESQUISA

Título da Pesquisa: Estudo morfológico do canal pterigoide em tomografias computadorizadas de uma amostra brasileira

Pesquisador: MARIA CLAUDIA HARADA FERREIRA

Área Temática:

Versão: 1

CAAE: 46463421.9.0000.5418

Instituição Proponente: Faculdade de Odontologia de Piracicaba - Unicamp

Patrocinador Principal: Financiamento Próprio

DADOS DO PARECER

Número do Parecer: 4.752.116

Apresentação do Projeto:

O parecer inicial é elaborado com base na transcrição editada do conteúdo do registro do protocolo na Plataforma Brasil e dos arquivos anexados à Plataforma Brasil. Os pareceres de retorno, emendas e notificações são elaborados a partir dos dados e arquivos da última versão apresentada.

A EQUIPE DE PESQUISA citada na capa do projeto de pesquisa inclui MARIA CLAUDIA HARADA FERREIRA (Cirurgiã-Dentista, Doutoranda no PPG em Biologia Buco-Dental na área de Anatomia da FOP/UNICAMP, Pesquisadora responsável), DÉBORA COSTA RUIZ (Cirurgiã-Dentista, Mestranda no PPG em Radiologia Odontológica da FOP/UNICAMP), FELIPPE BEVILACQUA PRADO (Cirurgião-Dentista, Docente da área de Anatomia da FOP/UNICAMP), ALEXANDRE RODRIGUES FREIRE (Cirurgião-Dentista, Pesquisador de Pós-Doutorado da Área de Anatomia da FOP/UNICAMP), ANA CLÁUDIA ROSSI (Cirurgiã-Dentista, Docente da Área de Anatomia da FOP/UNICAMP), o que é confirmado na declaração dos pesquisadores e na PB.

DELINEAMENTO DA PESQUISA: Trata-se de estudo observacional, descritivo, transversal, com base em arquivos, que envolverá 80 exames tomografias computadorizadas de feixe cônico realizadas em crânios de uma coleção de esqueletos (Biobanco "Osteológico e tomográfico Prof. Dr. Eduardo Daruge" da FOP-UNICAMP) divididos em dois grupos (homens, n=58, e mulheres, n=22), todos

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Este parecer foi elaborado baseado nos documentos abaixo relacionados:

Tipo Documento	Arquivo	Postagem	Autor	Situação
Informações Básicas do Projeto	PB_INFORMAÇÕES_BÁSICAS_DO_PROJETO_1744529.pdf	05/05/2021 15:17:14		Aceito
Projeto Detalhado / Brochura Investigador	Projeto.pdf	05/05/2021 15:16:09	MARIA CLAUDIA HARADA FERREIRA	Aceito
TCLE / Termos de Assentimento / Justificativa de Ausência	Justificativa.pdf	05/05/2021 15:06:01	MARIA CLAUDIA HARADA FERREIRA	Aceito
Outros	Autarquivo.pdf	05/05/2021 15:03:24	MARIA CLAUDIA HARADA FERREIRA	Aceito
Declaração de Instituição e Infraestrutura	DeclaraInstituicao.pdf	05/05/2021 15:00:28	MARIA CLAUDIA HARADA FERREIRA	Aceito
Declaração de Pesquisadores	DeclaraPesquisadores.pdf	05/05/2021 14:54:25	MARIA CLAUDIA HARADA FERREIRA	Aceito
Folha de Rosto	Folhaderosto.pdf	05/05/2021 14:51:21	MARIA CLAUDIA HARADA FERREIRA	Aceito

Situação do Parecer:
Aprovado

Necessita Apreciação da CONEP:
Não

PIRACICABA, 02 de Junho de 2021

Assinado por:
jacks jorge junior
(Coordenador(a))

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Anexo 2 – Comprovante de submissão em revista

Anexo 3 – Verificação de originalidade e prevenção de plágio

ESTUDO MORFOLÓGICO DO CANAL PTERIGOIDE EM IMAGENS DE TOMOGRAFIA COMPUTADORIZADA DE UMA POPULAÇÃO DO SUDESTE DO BRASIL

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