Cephalometric profile analysis between genders. A study protocol

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Abstract:

Background: According to current American Association of Orthodontists guidelines, two-dimensional lateral and posteroanterior cephalometric radiographs are recognized as essential components of diagnostic imaging records in orthodontics. Cephalometry is defined as the discipline that analyzes the craniofacial complex in a segmented way, to study the interrelationships between its structures and understand how the growth or alteration of one of these structures can compromise the whole. Through cephalometry, it is possible to indicate the clinical approach for patients, involving dental therapy with intraoral appliances and physical therapy with continuous positive pressure in the upper airway. **Objectives:** Investigate possible differences in cephalometric anatomical patterns between genders. **Methods:** This study protocol follows the STROBE - Strengthening the Reporting of Observational Studies in Epidemiology guidelines. A convenience sample will be used, consisting of teleradiography (cephalograms) of adult patients of both genders, carried out in a private Dental Clinic, located in the city of São José dos Campos (SP), Brazil, by the established inclusion and exclusion criteria. Six angular and nine linear measurements will be used in the analysis of cephalometric measures according to the study protocol. The exams will be distributed into three groups and paired according to the value of the angle formed between point A nasion and point B nasion (ANB). Groups will be formed by exams with class 1 skeletal relationship (0° < ANB angle ≤ 4º), group 2 with class 2 exams (ANB angle > 4°), and group 3 formed by class 3 exams (ANB angle ≤ 0°). **Considerations:** In some cases, craniofacial changes may predict the risk of sleep-disordered breathing, such as obstructive sleep apnea (OSA). Increased length and thickness of the soft palate and hyoid bone in the mandibular plane and retrognathia are associated with the pathogenesis of OSA. Therefore, the etiology of sleep-disordered breathing may vary in patients according to gender, according to cephalometric analysis.

Keywords: Cephalometry; obstructive sleep apnea; gender; sleep dentistry; physiotherapy in sleep disorders.

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BACKGROUND

According to the most recent practice guidelines from the American Association of Orthodontists, two-dimensional lateral and posteroanterior (PA) cephalometric radiographs are recognized as essential components of diagnostic imaging records in orthodontics[(1)]. Cephalometry is defined as the discipline that analyzes the craniofacial complex in a segmented manner, to study the interrelationships between its structures and understand how the growth or alteration of one of these structures can affect the whole[(2)]. The concept of using angles and linear measurements to evaluate facial compositions dates back to the 15th century, when Leonardo da Vinci used these analyses to study facial shape. Da Vinci designed a line that ran along the suture from the frontal bone to the nasal bones, continuing to the back of the sella turcica, similar to the S-N line widely used today (Figure 1)[3].

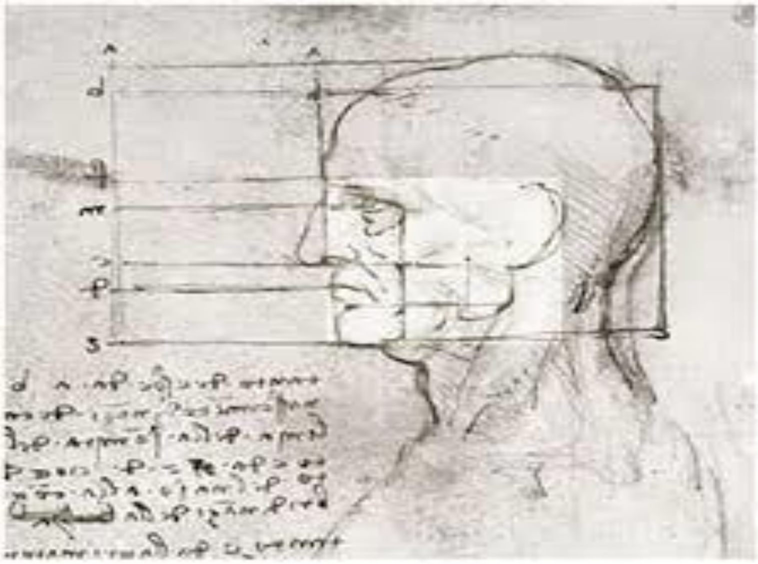

Figure 1. Anatomical points of the skull proposed by Leonardo da Vinci.

However, it was only in the 16th century that Spigel made the first scientific record of cranial anatomical measurements, using the term "lineae cephalometricae"[4]. From the 16th century to the 20th century, several professionals in the field and scientific institutions developed techniques for craniofacial measurement, evaluating dental discrepancies through the analysis of the interrelationship of teeth in plaster models.

The Frankfurt plan (Pl FH) was initially proposed by Von Ihering in 1882. This plan considers that the description of the skull must be made based on the premise that the skull is positioned horizontally, parallel to the ground. The measurement is determined by an imaginary line that passes through the lowest point of the lower edge of the left orbit to the upper edge (highest point) of the left and right external auditory canal[3].

The Frankfurt plane, as shown in Figure 2, can be established both in the individual's head and through a teleradiography, passing through the upper points of the right and left external auditory canals (Po - porion point), as well as through the lowest points in the margin of the left and right orbit (Or – orbital point). Despite being described and cited as a plan, that requires an image in three dimensions (3D), the Frankfurt Plan is a line drawn on teleradiography, producing an image in two dimensions (2D)[5, 6].

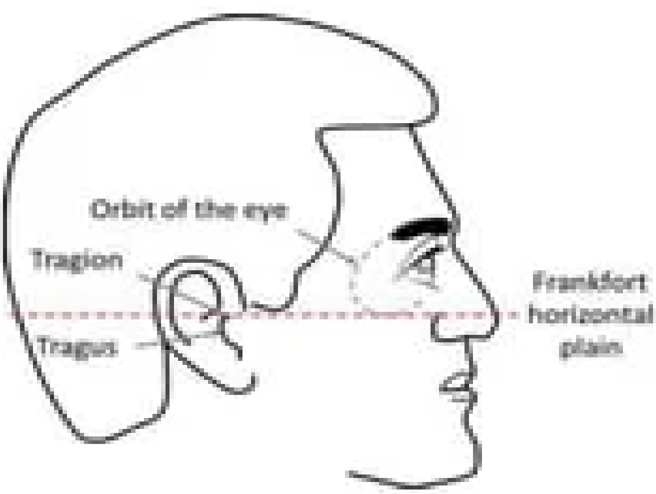

Figure 2. The Frankfurt plane.

The discovery of X-rays by Roentgen in 1895 boosted the development of the cephalogram by Hofrath in Dusseldorf and Broadbent in Cleveland in 1931. From that date on, professionals began to accurately use established cephalometric measurements to analyze skeletal structures and dental techniques, in addition to improving observations related to soft tissues and their relationship with the position of the jaws and dentition[1, 7-10].

The introduction of anthropometric markings to orthodontists occurred at the beginning of the 20th century, originating from the meeting of the 13th General Congress of the German Anthropological Society. This meeting resulted in the development of the current Frankfurt Horizontal Plan[7]. Current cephalometric techniques have evolved with the contributions of several authors such as Steiner, Ricketts, McNamara, Wylie, and Interlandi, among others, each establishing their points, lines, and cephalometric planes. However, this variety of proposals results in a large number of measures, which makes it impossible to mention all of them[10].

Despite the introduction of numerous cephalometric analyses over the years, many of the most relevant anthropometric points used today were initially established in the first cephalometric workshop, held in 1957, at Western Reserve University in Cleveland, Ohio, USA[11]. Radiographic cephalometric analysis is a tool that allows the visualization of two-dimensional structures of bone and soft tissues, providing information about the sizes and shapes of craniofacial components, as well as their location. This analysis is fundamental for orthodontic diagnosis and treatment planning, in addition to being essential for examining changes related to therapeutic results. These analyses compare the skeletal, dental, and facial characteristics observed in each patient, using morphological, numerical, or normality standards[12].

In two-dimensional lateral cephalometric analysis, the general objectives include evaluating the relationship of the maxilla and mandible to the skull, the relationship of the dentition to the maxilla and mandible, the interrelationship of the maxillomandibular complex, as well as the relationship between the entire complex and the soft tissues that surround it. During this process, the points to be used are marked based on the x-ray. Subsequently, the lengths are measured and the associated angles are calculated. In most analyses, a combination of measurements from several protocols is used[13, 14].

In the PA dimension, two-dimensional cephalometry has some limitations, such as errors arising from magnification, overlapping structures, and patient positioning. However, it is useful for evaluating transverse discrepancies, facial asymmetries, the orbital area, the frontal sinuses, and the nasal cavity. This is done by demarcating cephalometric points and drawing linear and angular orientation lines. Furthermore, it is a simple and economical method for measuring facial typology and anatomical structure related to the airway. Currently, the use of this imaging technique is becoming less frequent with the advent of three-dimensional imaging, which provides diagnostic information visualized with greater detail[1, 7, 12].

Cephalometry plays a fundamental role in quantifying craniofacial bone growth, allowing the identification of possible factors related to impaired respiratory patterns. This is crucial to understanding the emergence of numerous breathing disorders during wakefulness and/or sleep, such as sleep bruxism and/or obstructive sleep apnea (OSA). Cephalometry is a low-cost examination, with minimal radiation exposure and easy analysis. Through measurements obtained by cephalometry, it is possible to indicate the clinical approach for patients, which may involve dental therapy with intraoral appliances and physical therapy with continuous positive airway pressure (CPAP). In this context, the objective of this research protocol is to investigate possible differences in cephalometric anatomical patterns between genders.

METHODS

Study design

This is a study protocol that follows the guidelines of STROBE - Strengthening the Reporting of Observational Studies in Epidemiology[15], illustrated in Figure 3. The study was planned as observational, being of a retrospective cross-sectional type, consisting of the analysis of cephalometric exams. The objective is to compare the profile between males and females.

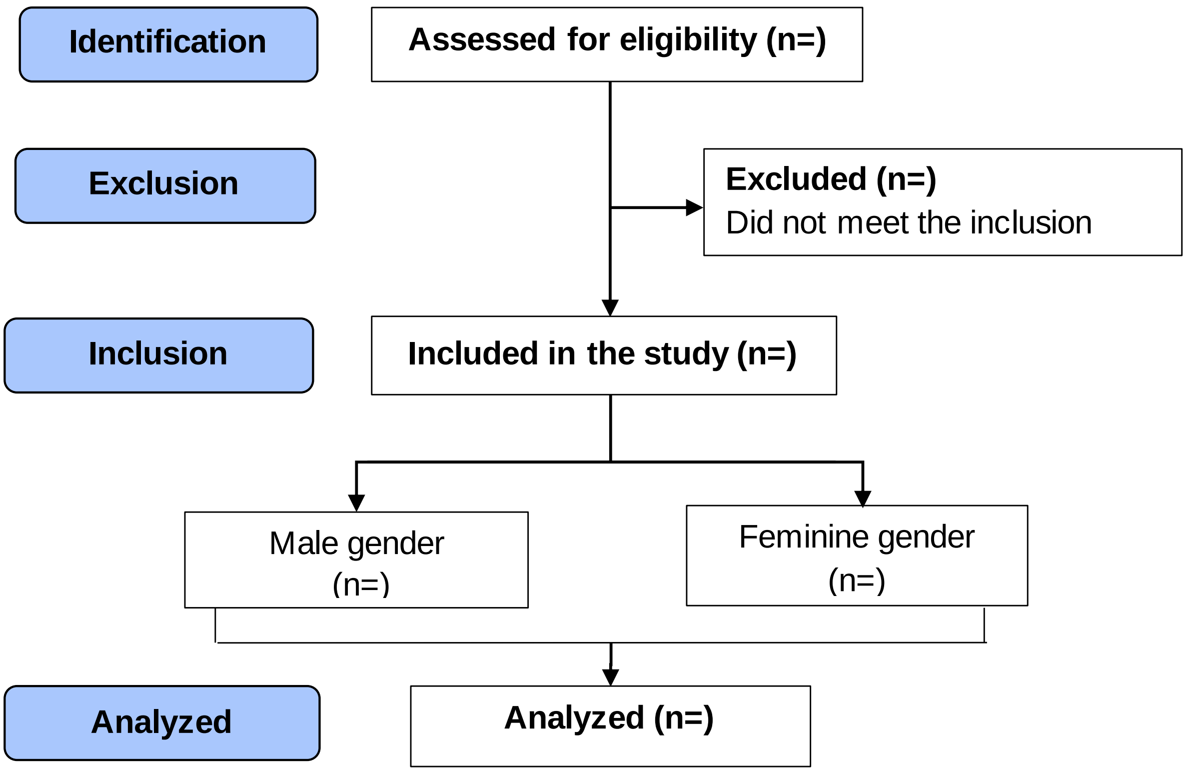

Figure 3. Flowchart STROBE

Ethical aspects

This research protocol received approval from the Ethics and Research Committee of the Universidade Estadual Júlio de Mesquita – UNESP, CAMPUS São José dos Campos, under number 25000.058696/2010-74. The results of this study will be disseminated through presentations at scientific events in the dental field, scientific reports and publication in specialized journals).

Sample selection

For this study, a convenience sample will be used, consisting of teleradiography (cephalograms) of adult patients of both genders. These cephalograms were performed at the Dental Clinic specializing in Sleep Dentistry, located in the city of São José dos Campos (SP), in accordance with the established inclusion and exclusion criteria.
The exams will be distributed into three groups and paired according to the value of the angle formed between plane point - A nasion and plane-B nasion (ANB):

- Group 1: exams with Class 1 skeletal relationship ($0^{o} <$ ANB angle $\leq 4^{o}$).
- Group 2: exams with Class 2 skeletal relationship (ANB angle $> 4°$).
- Group 3: exams with Class 3 skeletal relationship (ANB angle $\leq 0°$).

Cephalometric points

In this study, six angular measurements and nine linear measurements will be used to evaluate lateral cephalometric radiographs obtained under standardized conditions. The reference points, as well as the reference lines and measurements to be used, are shown in Figure 4.

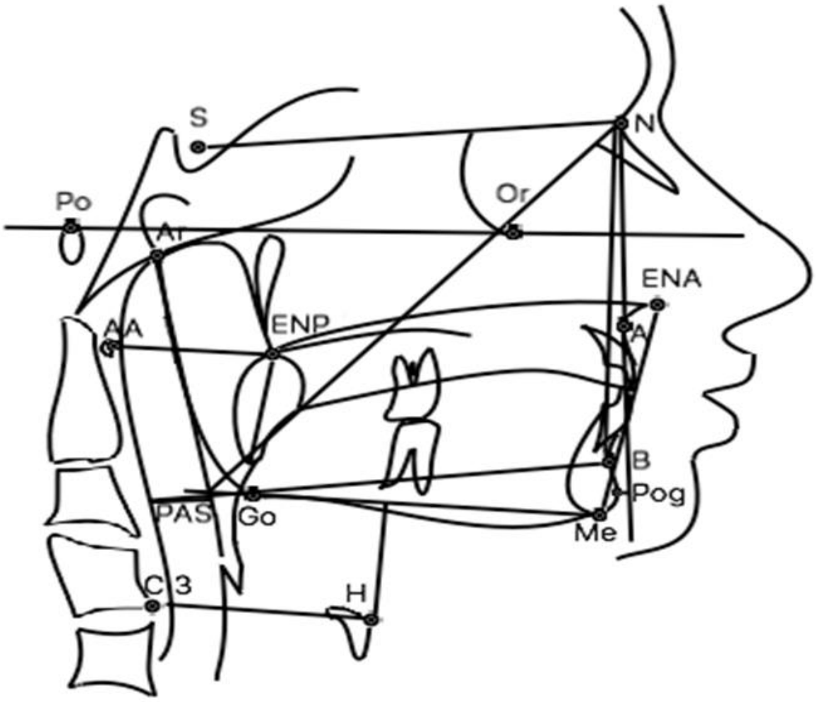

Figure 4 – Cephalometric landmarks, angles and reference planes.

Note: N (Nasio), S (Sella), Po (Porion), Ar (Articular), Or (Orbital), ENA (Anterior nasal spine), ENP (Posterior nasal spine), A (A-point), B (point-B), Me (Mental), Go (Gonion), H (Hyoid), AA (atlas), Pog (Pogonion), C3 (Third Vertebra). Source: Linear measurements will be used: Perpendicular Pogoni on-Nasion (Pog-N), Perpendicular A-Nasion Point (A-N), Anterior-Mental Nasal Spine (ENA-Me), Anterior Skull Base, Soft Palate Length, Atlas-Maxilla Distance, Space Posterior Air (PAS), Hyoid-Third Vertebra Distance (H-C3), Hyoid-Mandibular Plane Distance (H-PM).

The angular measurements to be used will be the angle formed between the vessel sellar plane and the nasion point-A plane (SNA), the angle formed between the nasion sellar plane and the nasion point-B plane (SNB), ANB, Mandibular Plane Gionio-Mentoniano (Go- Me), angle formed between gonial articular plane and gonius plane nasion (Superior Plane Gonic Angle [Ar-Go]. Nasion), angle formed between gonian mental plane and gonius plane nasion (Inferior Plane Gonic Angle [Me -Go] Nasion).

Each cephalometric radiograph will have its parameters traced and measured by two investigators independently. Afterwards, the results will be compared. To estimate inter-examiner variability, a pre-test will be conducted with 75 randomly selected lateral cephalometric radiographs. These will be drawn up by the two researchers and re-evaluated by a third examiner

Inclusion and exclusion criteria

In the present study, exams that present adequate visual and graphic quality for marking anatomical points will be included. On the other hand, examinations of patients who present craniofacial changes that compromise the anatomical configuration will be excluded.

Acquisition of images

Each cephalogram will be transferred from each radiograph to a sheet of "ultraphan" paper, fixed with adhesive tape, where the anatomoradiological structures of interest for preparing the cephalogram will be traced. This tracing will be carried out by a single observer in a darkened room, using a negatoscope to facilitate visualization and highlighting of the structures.

Technique for performing lateral cranial teleradiography

To take the lateral teleradiography of the skull, the patient's positioning will be standardized with the left side closest to the film. In exceptional cases, in which the shot needs to be taken on the right side due to equipment limitations, it will be crucial to indicate a variation(5). Taking lateral cephalograms (Figure 4) must currently follow the following basic and universal rules(5, 16).

X-ray equipment must operate with a range of 30 mA (milliamperes) to 90 kV (kilovolts). The focus must be reduced (pointwise), not exceeding 3 mm. The central beam of the X-rays must be horizontal and fall perpendicular to the radiographic film, crossing the two ear tips and the cephalostat. The patient's midsagittal plane must be at a fixed standard distance of 1.524 m from the X-rays, this being a universal convention. The cephalostat, a device that locates and immobilizes the film and the patient's head, allows the teleradiography to be repeated in the same position and distance(5).

The patient must be positioned with the body upright, with the left side of the face next to the cephalostat, aligned with the Frankfurt plane, and the gaze focused on the horizon(5, 17). The cephalostat ear tips should be inserted into the patient's external ear canals, applying slight upward pressure. The cephalostat glabella facilitates the patient's PA immobilization(16).

During the radiographic examination of dental occlusion, the patient will be positioned in a comfortable position, with the head in a natural position, lips relaxed, and looking at the mirror. If it is necessary to position the mandible in a centric relationship or a resting position (natural head position - PNC), this detail must be recorded in the radiographic report(5).

Statistical analysis

Descriptive statistical analyses of craniofacial measurements will be conducted in samples of female and male patients, categorized into Class I, Class II, and Class III. For all measurements, means and standard deviations will be calculated. The Shapiro-Wilk test will be applied to verify the distribution of the sample data. When comparing the values obtained between male and female patients according to the groups, the Mann-Whitney U Test will be used if the sample presents a non-normal distribution. The method error will be evaluated by the intraclass correlation coefficient (ICC) to verify the reliability and reproducibility of the measurements ($r>0.95$). Values will be considered statistically significant at $p<0.05$.

Confidentiality and privacy

The information obtained in this study will be exclusively accessible to the researchers involved and used solely for scientific research and publication in Dentistry journals. The data collected from the exams carried out by the research participants will be kept strictly, without any type of posting or disclosure of the names of the participants. The names of the participants will not be mentioned in any document, and they will be identified by numbers. All results obtained will be stored separately on a central computer, with access restricted to authorized people only. The information obtained will be retained by the responsible researchers for 5 years, after which it will be properly incinerated.

FINAL CONSIDERATIONS

Facial typology is a crucial factor to be considered in anthropometric analysis, as measurements can vary depending on the type of face. The three most common types are dolichofacial, mesofacial, and brachyfacial. This variation is directly associated with factors such as craniofacial growth, the configuration of orofacial structures, muscles, stomatognathic functions, and occlusion[17-20].

It is also known that the phenotype of the upper airways can vary according to gender[21]. Aesthetic, skeletal, and dental analyzes reveal gender dimorphism, evident through anthropometric measurements that demonstrate higher average values for males compared to females, mainly in the areas of the nose, cheekbones, mouth, and mandibular canines[22-24].

Studies have shown that in men, the volume and thickness of the masseter are significantly greater compared to women, and the mandibular angle is also more acute in men[25, 26]. These differences begin in childhood and persist into adulthood. Therefore, when planning a craniofacial morphological study, it is crucial to consider sex, and the results must be evaluated with caution when there is no sex compatibility between patients and the control group[27].

In some cases, craniofacial changes can predict the risk of sleep-disordered breathing, such as obstructive sleep apnea (OSA). In men, an increase in the length of the soft palate and the mandibular plane of the hyoid bone may contribute to the presence of OSA, while in women, retrognathia and an increase in the thickness of the soft palate have been associated with the pathogenesis of OSA[28]. Therefore, the etiology of sleep-disordered breathing may vary among male patients and may be different from female patients, according to the perspective of cephalometric analysis[29].

Author Contributions:
Author Contributions: Conceptualization, MICC, OAG, LCG, CMRB, BAPFO, HFO and, LVFO; Formal analysis, MICC, OAG and, LVFO; Funding acquisition, LCG and, LVFO; Investigation, methodology, OAG, BSLT, LCG, SKAS, MICC and, LVFO; Data collect, LCG, MICC and LVFO, project administration, LCG, OAG and supervision, MICC and, LCG; Writing—original draft, MICC, MCO, CNSN, MEML, JPRA, BOM and, LVFO; Writing—review and editing, OAG, LCG and, LFVO. All authors have read and agreed to the published version of the manuscript.

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REFERENCES

1. American Association of Orthodontists: Clinical practice guidelines for orthodontics and dentofacial orthopedics 1996; amended 2021. Available at: https://www.orthodont-cz.cz/data_nova/files/Clinical-Practice-Guidelines_Approved-2021-HOD.pdf. Accessed apr 14, 2023.
2. Jarabak JR, Fizzell JA. Technique and treatment with light wire edgewise appliances. 2and. Ed., St. Louis Mosby, 1972;1, p.612.
3. Pereira CB, Mundstock CA, Berthold TB. Introdução à cefalometria radiográfica. 3 ed. Edição Pancaste Editoria, 1999.

4. Finlay L. Craniometry and cephalometry: a history prior to the advent of radiography. Angle Orthod. 1980; 50:312-321
5. Pereira CB, Mundstock CA, Berthold TB. Técnicas radiográficas cefalométricas. Noções da técnica radiográfica. Available at: http://www.acbo.org.br/revista/livro_cefalometria/html/cap03/.
6. Porta G. Anatomia radiológica em norma lateral, 2009. In: Pereira CB, Mundstock CA, Berthold TB. Introdução à cefalometria radiográfica. 5 ed. Capítulo III. Editora Revista Virtual AcBO, 2010.
7. Tanna NK, AlMuzaini AAAY, Mupparapu M. Imaging in orthodontics. Dent Clin North Am. 2021;65(3):623-41.
8. Broadbent BH. A new x-ray technique and its application to ortodontia. Angle Orthod, Appleton. 1931;1:45-66.
9. Holfrath H. Die bedeutung der rontgenfern und abstand saufhame fur die diagnostik der kieferanomallin. Fortschr Orthod,1931;1:238-258.
10. Gandini Jr LG, Santos-Pinto AD, Raveli DB, Sakima MT, Martins LP, Sakima T et al. Análise cefalométrica padrão Unesp Araraquara. R Dental Press Ortodon Ortop Facial, 2005;10(1):139-57.
11. Graber TM. Implementation of the roentgenographic cephalometric technique. Am J Orthod. 1958; 44:906-32.
12. Kotuła J, Kuc AE, Lis J, Kawala B, Sarul M. New sagittal and vertical cephalometric analysis methods: A systematic review. Diagnostics (Basel). 2022;12(7):1723.
13. Ricketts RM. Perspectives in the clinical application of cephalometrics. Angle Orthod.1981; 51:115-50.
14. Jacobson, AR. Jacobson. Radiographic cephalometry from basics to 3-D imaging. (2nd edition), Quintessence, Chicago (2006), pp. 1-320
15. Vandenbroucke JP, von Elm E, Altman DG, Gøtzsche PC, Mulrow CD, Pocock SJ, et al. strengthening the reporting of observational studies in epidemiology (STROBE): explanation and elaboration. PLoS Med. 2007;4(10):e297.
16. Freire-Maia BAV, Pereira MFS de M, Paiva JB de, Rino Neto J. Avaliação cefalométrica radiográfica da posição craniocervical de pacientes orientados em posição natural da cabeça pré e pós-expansão rápida da maxila. Rev Dent Press Ortodon Ortop Facial. 2005;10(2):96–110.
17. Bianchini EMG. A cefalometria nas alterações miofuncionais orais –diagnóstico e tratamento fonoaudiológico. 5a ed Rev e Ampl Carapicuíba: Pró-fono; 2002.
18. Ramires RR, Ferreira LP, Marchesan IQ, Cattoni DM, Andrada e Silva MA. Relação entre cefalometria e análise facial na determinação do tipo de face. Rev CEFAC 2009;11(Supl3):349-54.
19. Vianna-Lara MS, Caria PHF, Tosello DO, Lara F, Amorim MM. Electromyographic activity of masseter and temporal muscles with different facial types. Angle Orthod 2009;79(3):515-20.
20. Ramires RR, Ferreira LP, Marchesan IQ, Cattoni DM, Andrada e Silva MA. Tipologia facial aplicada à Fonoaudiologia: revisão de literatura. Rev Soc Bras Fonoaudiol 2010;15(1):140-5.
21. Taner L, Gürsoy GM, Uzuner FD. Does gender have an effect on craniofacial measurements? Turk J Orthod. 2019;32(2):59-64.
22. Ramires RR, Ferreira LP, Marchesan IQ, Cattoni DM, Silva MAA. Adult facial anthropometric measurements according to facial type and gende. Rev CEFAC. 2011;13(2).
23. Kundi I. Cephalometric soft tissue standard and gender dimorphism in nasal prominence estimated by holdaway's Analysis in patients visiting College of Dentistry, Aljouf University. J Contemp Dent Pract. 2017;18(2):152-155.
24. Lagorsse A, Gebeile-Chauty S. Le genre a-t-il une influence en orthodontie? Une revue de la littérature [Does gender make a difference in orthodontics? A literature review]. Orthod Fr. 2018 Jun;89(2):157-168. French.
25. Kamber-Ćesir A, Dardagan Đonlagić A, Ajanović M, Strujić Porović S, Gavranović A, Kazazić L, et al. The Influence of gender on the cortical width of the lower border of the mandible and the mandibular cortical index. Acta Med Acad. 2018;47(2):149-154.
26. Perez PI, Hendershot K, Teixeira JC, Hohman MH, Adidharma L, Moody M, et al. Analysis of cephalometric points in male and female mandibles: An application to gender-affirming facial surgery. J Craniofac Surg. 2023.
27. Borges, PTM et al. Cephalometric and anthropometric data of obstructive apnea in different age groups. Brazilian Journal of Otorhinolaryngology. 2015;81; 79-84.

28. Cho SH, Jeon JY, Jang KS, Kim SY, Kim KR, Ryu S, et al. Gender-specific cephalometric features related to obesity in sleep apnea patients: trilogy of soft palate-mandible-hyoid bone. Maxillofac Plast Reconstr Surg. 2019;41(1):58.
29. Sakakibara H, Tong M, Matsushita K, Hirata M, Konishi Y, Suetsugu S. Cephalometric abnormalities in non-obese and obese patients with obstructive sleep apnoea. Eur Respir J. 1999;13(2):403-10.