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Gender determination according to the anthropometric measurements of the lower jaw

Original article

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SUMMARY

Introduction: *In forensic medicine, the gender estimation is the first step for the identification of complete or incomplete human skulls. For this purpose, a series of morphological indicators of sexual dimorphism is analyzed qualitatively, whose objective is to determine the sex according to the anthropometric measurements of the jaw.*

Methods. *In the present study, mandibular growth and its accuracy in the diagnosis of gender were analyzed. The method used was the examination of 400 lateral cephalometric radiographs of male and female subjects between 8 and 30 years old with an Angle Class I or Neutral-occlusion bite, who had not undergone orthodontic treatment before, using as observational parameters, the cephalometric measurements representing the mandibular growth: Co-Go, Co-Gn, Go-Gn, Fg-Pg.*

Results: *There was a significant correlation between cephalometric measurements of mandibular growth (r = 0.6551). All the measurements were higher in men than in women at the end of the analysis; however, a longer length was reported in women at the beginning of the evaluation.*

Discussion: *The presence of differences in the dimensions of mandibular growth justifies the revision of this indicator for the diagnosis of gender taking into account that it varies in each specific population.*

Keywords: *sexual dimorphism, mandibular growth, lateral cephalometrics, forensic identification.*

INTRODUCTION

Forensic dentistry was born from a formal and scientific point of view in 1898 when Oscar Amoedo, stressed the importance of this specialty, publishing his book 'Tart dentaire in médecine légale', being the first treaty of legal dentistry He is known as the father of legal dentistry.1 From the 19th century, Legal and Forensic Dentistry, like Medicine, has evolved completely in comparison with the rest of the health professions.

Due to the high number of deaths in various types of disasters and the state in which bodies are usually found (mutilated, charred, skeletonized, putrefied, etc.), difficulties for their identification have arisen. The forensic dentists and anthropologists have established scientific methods of identification of corpses reduced to the skeletal state, based on the fundamental pillars of the identification, such as: the determination of the species, race, sex and age estimation. 2

Dentistry within the field of forensic sciences works interdisciplinary in the handling and adequate examination of evidence collected from the stomatognathic system; those disciplines provide all the technical and scientific knowledge useful to the administration of justice in order to establish the identity of a deceased person. 3 Identification is important in the criminal and civil sphere and can range from the establishment of crime responsibility to the compensation of family members. 4-5 Aparicio DC et al established oral autopsy procedures; we also use odontogram, rugoscopy, cheiloscopy, maxillary lift, maxillo-mandibular resection, sampling and biometry of the arches. We can also perform radiographic comparison of the maxillary sinuses and the bone pattern, as well as comparison of prosthetic devices that provide social and biometric information. 6

The diagnosis of sex is very important in forensic anthropology. When bones are incomplete, anthropological estimation cannot be performed. Cranial anthropometric measurements provide important background for Forensic Medicine. Cranial anthropometrics analyzes living subjects or bones, directly or through studies in lateral or frontal radiographs. Therefore, it is essential to have parameters that allow the detection of sexual dimorphism.

The difficulty in determining sex of skeletal remains is a known problem that limits anthropological research and forensic practice. 11 There have been developed numerous methods to carry out the determination of sex; they can be divided into morphological and molecular methods; the evaluation of gender from qualitative indicators must be contextualized to the population. 16 In forensic medicine, the diagnosis of sex is the first step in the identification of complete or incomplete human skulls. A first approximation is made through the qualitative analysis of a series of morphological indicators of sexual dimorphism. 13 Krogman & Iscan describe 14 indicators of sex diagnosis. 14 One of these indicators is the shape of the palate; total edentulism does not significantly affect the accuracy of gender diagnosis, but the presence of dental pieces favors the underestimation of women when observing this parameter.13 Bone remains in good condition allow the observation of morphological sexual dimorphism with a 95% accuracy. 17

The best indicators were found in the osseus traits related to the insertion and action of the large muscle groups: mastoid process, zygomatic bone, jaw and roughness of the occipital bone. Atrophy of bone tissue can diminish the accuracy of these methods.18 In 2009, the shape of the piriform aperture was studied as one of the classic indicators of sexual dimorphism 19; Hwang and Kang speculate that the shape of the piriform aperture is adapted to the environment in its geographical variation. 20 The transverse facial relationships present variations in different ethnic groups, including transpalatal width, maxillary width, facial width and mandibular width 21. Moyers considered arc increases occur mainly during the active eruption of teeth, from the analysis of a Caucasian group; differences in both sexes were obtained.

Jaw is the hardest and most durable bone of the skull, with a high degree of sexual dimorphism, especially the branch of the jaw, which is subject to greater pressure due to the process of chewing 22. In 2011, using samples from the population of the North India, 5 metric parameters were observed: coronoid height, projective height, condylar height, maximum amplitude and minimum width of the branch. All parameters presented sexual dimorphism, the best of them was the coronoid height. 22 Loth & Henneber observed the flexure in the posterior border of the mandibular branch, at the level of the occlusal plane; in men there is a flexion that is absent in women, or at a different level with respect to the occlusal plane. 23 There is a better percentage of success in women (63.25% vs 48.5% in men) 24. Depending on age, the change of craniofacial dimensions will have different rhythms; there will be no constant rates. Some parts grow more slowly. There are factors that influence the growth and development of craniofacial dimensions, such as; ecological, racial, age and sex, and genetic factors. 25 At birth men have specific forms of their jaw; however differences between sexes decrease rapidly, leading to an almost total reduction in sexual dimorphism between the ages 4-14 years. From puberty to adulthood, males are characterized by changes in allometric shape, while the shape of the female jaw continues even after changing size and ceasing to increase. 26

Dental maturation dimorphism becomes visible only at puberty; it is concentrated in the branch but it is not related to the development of the teeth. 27 The determination of sex is more accurate in adults than in puberty, as a result of the effect of sex hormones, estrogen and progesterone in the development of morphological differences. Hormones control the development and growth of bones; women complete their development earlier than men, which modify their appearance drastically during puberty. 27 The chin and the width of the dental arch allow to classify correctly 70-90% of the subjects between 0 and 5 years of age.15 The dimensions of the mesiodistal and bucco-lingual crown of the teeth have also been studied for the determination of sex in individuals subadults. Cardoso indicates that, in adults and sub-adults, canines are the pieces that have the most sexual dimorphism. 12 The jaw also appears to be useful for classifying sex in immature skeletons. Loth and Hennenberg described a simple, qualitative method for the differentiation of sex in subadult jaws 8. These results were discussed by Coqueugniot, who conducted a similar study to obtain lower precision levels.9 Subsequently, Suazo et al developed a study with a sample of Brazilian mandibles and the levels of precision were reported between 57.5 and 60.5% for the determination of sex, with greater sensitivity for the determination of male gender.

Numerous studies have shown that skeletal characteristics vary in different populations. Several authors indicate that it is possible to determine sex based on infant jaws. Mandibular measurements include; bicondylar width, bigonial width, minimum width and height of the mandibular ramus, gonion- gnation length, height of the mandibular symphysis and the transverse and anteroposterior dimensions of the condyle. 11 In lateral radiography cephalometrics, we found measurements of mandibular growth, Co-Go (Condilo-gonion), Co-Gn (condyle-gnathion), Go-Gn (gonion-gnathion), Fg-Pg (most posterior region of the condyle, mandibular- pogonion). Skeletal growth and development processes are influenced by a wide range of mechanisms, especially genetic, endocrine, functional and environmental. 28 CT measurements of maxillary sinuses are useful in determining gender; however it has a relatively low rate of less than 70%. 29 The length, width and height of the maxillary sinuses, along with other bones can be used when the entire skeleton is not available. During adulthood, their shapes and sizes change, especially because of teeth loss as well as genetic diseases, post-infections and environmental factors. 29 Although several statistical models have been developed to carry out a quantitative analysis of the morphological indicators of dimorphism, which determine sex by visual inspection, the problem is that skeletal characteristics vary in different populations.

In our country there are few morphometric studies performed on jaws of Mexicans. Due to this, the purpose of this study was to analyze different dimensions in jaws and determine those of utility in the forensic diagnosis of sex in the Mexican population. The lack of cephalometric parameters in our region to know the development of the lower jaw, gives importance to the present study, since it is necessary to have measurements that approximate the different patterns that this population presents.

METHODS

Our sample consisted of 400 lateral cephalometries in subjects with Neutro-occlusion or Class I Angle all with outstanding facial balance. None had undergone previous orthodontic treatment and their ages ranged from 8 years and 0 months to 30 years and 11 months. The age distribution had a sample of 20 female subjects at the age of 8 years, 20 of 9 years-old, 20 of 10 years-old, 20 of 11 years-old, 20 of 12 years-old, 20 of 13 years-old, 20 of 14 years-old and 20 of 15-30 years-old. The male group had a sample of 20 of 8, 20 of 9, 20 of 10, 20 of 11, 20 of 12, 20 of 13, 20 of 14, 20 of 15, 20 of 16, 20 of 17, 20 of18 and 20 of 19-30 years-old.

To perform lateral cephalometric radiographs, the head is placed in a cephalostat with the plane parallel to the ground Frankfurt. We used a Tomé Ceph X x-ray model manufactured by Orion Corporation Soredex calibrated at 70 kVp, with the exposure time ranging from 0.32 to 0.64 seconds. The image was captured in a computer from which later with a measurement program (SIDEXIS XG) the searched data was extracted and recorded until obtaining the expected total. All cephalometric radiographs were obtained in the same place by a single operator. X-rays were offered with enough clarity and contrast to allow good visualization and identification of bony structures.

In accordance with the precepts of McNamara Jr. and Wylie, the following linear distances were measured: Co-Gn: effective jaw length (obtained by Co bond to Gn); Co-Go: height of the mandibular ramus (obtained by Co to Go union); Go-Gn: the length of the mandibular body (obtained by joining Go to Gn); and Fg-Pg: total mandibular length (obtained through the orthogonal projection of both the posterior posterior pogonion and the point of the mandibular condyle in the mandibular Go-Me plane). It refers to the chin, Go to the gonion, Pg to the pogonion, Gn to the gnathion, Co to the condyle and Fg to the point located in the most posterior region of the mandibular condyle.

RESULTS

Table 1 shows the results obtained in the radiological review of female individuals; the average of a total of 20 data is reported for each age. An increase with age is shown in all the mandibular variables evaluated in this study.

Edad	Co-Gn	Co-Go	Go-Gn	Pg-Fg
8 años	100.76mm	45.68mm	67.50mm	94.43mm
9 años	105.04mm	47.26mm	70.25mm	99.29mm
10 años	108.46mm	48.58mm	73.24mm	102.55mm
11 años	111.72mm	51.35mm	73.31mm	105.68mm
12 años	114.25mm	52.09mm	76.61mm	107.84mm
13 años	115.31mm	54.65mm	77.83mm	107.88mm
14 años	118.03mm	55.79mm	79.43mm	110.29mm
15-30 años	120.24mm	56.34mm	82.93mm	112.08mm

Table 1. Average of mandibular measurements in women in relation to age.

Table 2 shows the mandibular measurements in men. The average of a total of 20 data is reported for each age. It was found that there is a trend of progressive growth in all variables.

Edad	Co-Gn	Co-Go	Go-Gn	Pg-Fg
8 años	98.92mm	43.38mm	65.43mm	92.21mm
9 años	102.57mm	45.86mm	68.83mm	96.57mm
10 años	105.28mm	46.99mm	71.24mm	99.35mm
11 años	107.72mm	49.63mm	72.01mm	103.13mm
12 años	110.26mm	50.52mm	75.30mm	105.44mm
13 años	113.38mm	52.65mm	76.43mm	105.73mm
14 años	116.03mm	53.43mm	78.22mm	108.35mm
15 años	118.24mm	54.34mm	79.93mm	109.64mm
16 años	119.65mm	55.28mm	80.32mm	111.28mm
17 años	120.09mm	56.02mm	81.24mm	113.89mm
18 años	122.64mm	56.65mm	83.58mm	114.12mm
19-30 años	124.63mm	58.31mm	83.67mm	114.79mm

Table 2. Average of mandibular measurements in men in relation to age

As we can see in figure 1, the variable Co-Gn (Condilo-Gnathion) in the female sex shows a growth of 100.76mm until reaching a maximum of 120.24mm., On the other hand in the male part of 98.92mm until reaching 124.63mm The variable Co-Go (Condilo-Gonion) in the female sex we can see that part of 45.68mm to reach 56.34mm, on the other hand the male part 43.38mm to reach 58.31mm. The variable Go-Gn (Gonion-Gnathion) in the female part of the 67.50mm to reach 82.93mm, on the other hand the male part of 65.43mm to reach 83.67 mm. Finally, the variable Pg-Fg (Pogonion- most posterior region of the mandibular condyle) in the female part of 94.43mm to reach 112.08 mm, in the male the variable part of 92.21 to reach 114.94mm.

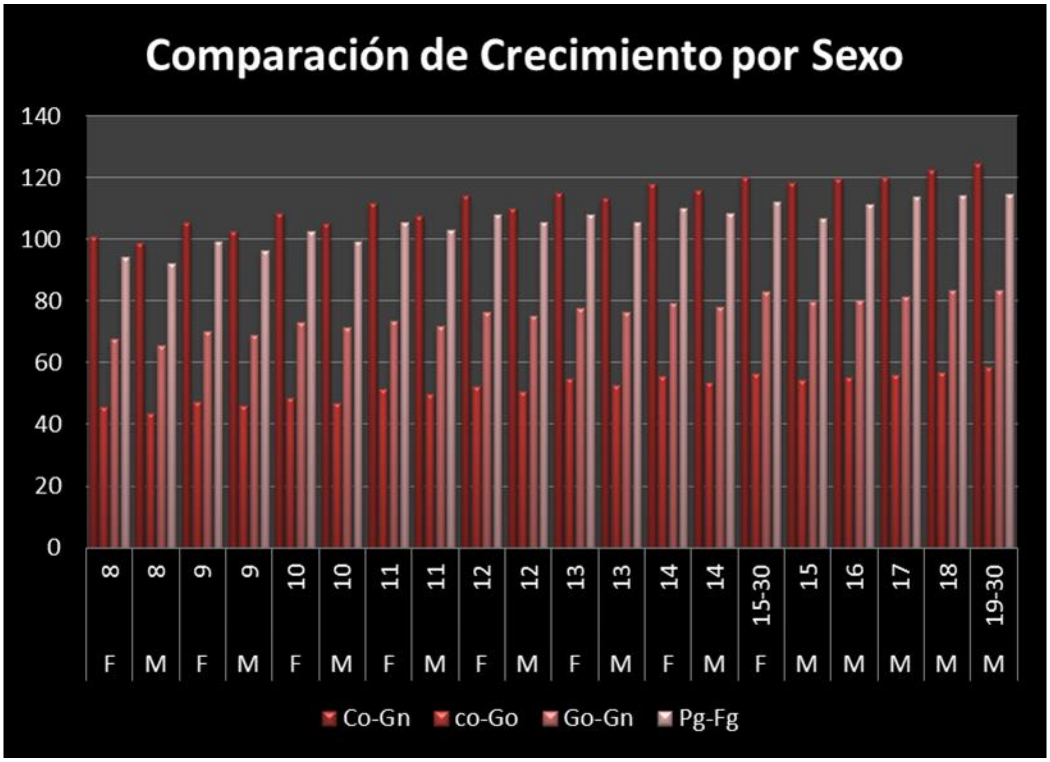


Figure 1. Comparative analysis of growth by age and sex

As shown in figure 2, with dispersion characteristics, the four variables had a greater length of onset in the female sex, however, at the close of development this length was greater in the male sex.

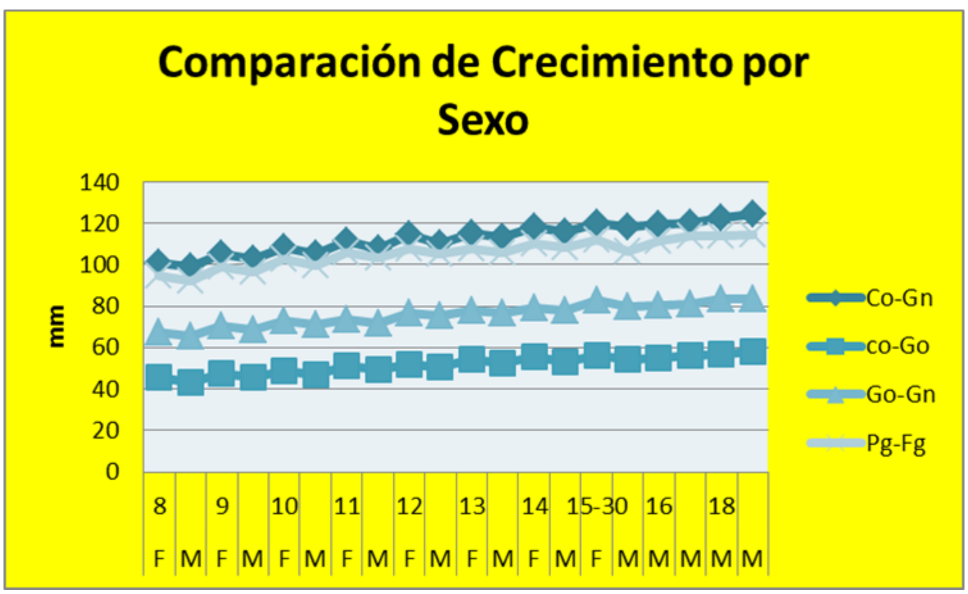
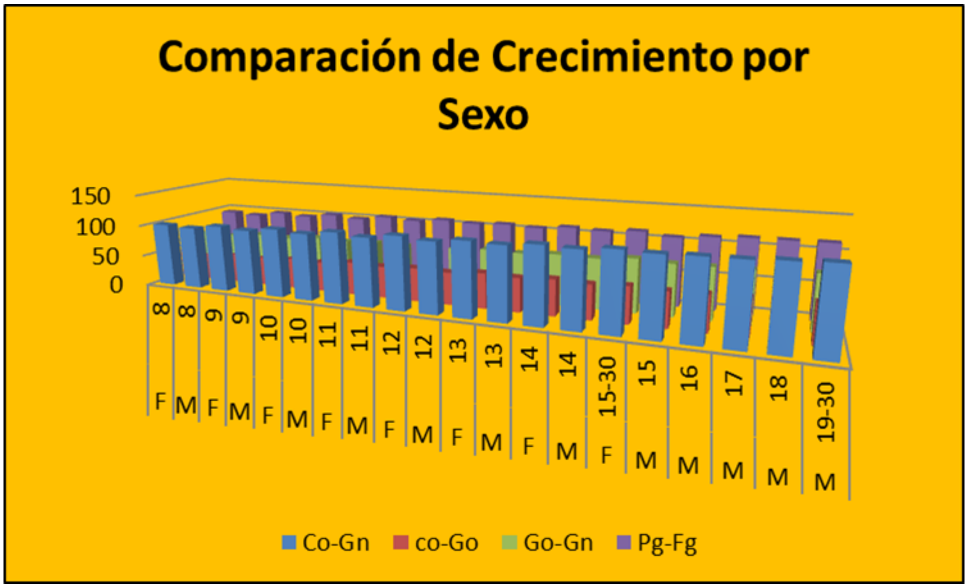


Figure 2. Analysis of dispersion in relation to age, sex and anthropometric parameters

As shown in figure 3, the variable with the longest start length at the end of the development was Co-Gn. While the Co-Go variable is the one with the shortest start length at the end of development.



Gráfica 4. Comparación de crecimiento por sexo

In figure 5 we observe the behavior of the means of each variable; the variables Co-Gn and the variable Pg-Fg have very high means, being above the means of the variables Co-Go and the variable Go-Gn.

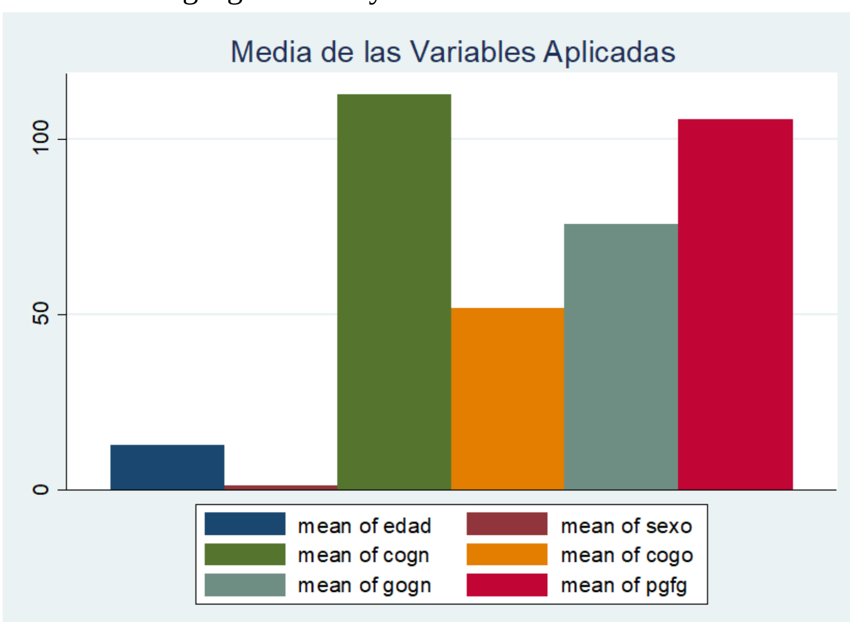


Figure 5. Average of the anthropometric variables analyzed in the study

DISCUSSION

To determine the sex of the skeletal remains, the jaw seems to be one of the most useful elements.The dimorphic features in jaws allow the correct identification of a large number of cases, but it is known that they present a behavior according to the specific population, which may explain the inferior precision of previous studies.

On the other hand, the general literature assumes that the objective evaluation of bone remains through metric comparisons allows us to obtain a better standardized statistic for the determination of age and sex diagnosis in forensic sciences.

The present study analyzes a series of linear measurements in the jaws of women and men concluding that there is a difference in the size of the jaw in the sample analyzed. The figures show an increase with age in all the mandibular variables evaluated in this study, that is, Co-Go, Co-Gn, Go-Gn and Pg Fg. It was found that there is a trend of progressive growth in all variables. This study corroborates previous research in terms of mandibular growth.

The present study may be useful as a tool for sex identification; however, it should not be taken as definitive, as it should be remembered that the sample of subjects analyzed has an Angle class I occlusion type, that is, subjects with anomalies in their type of dentition were excluded from the investigation.

It is recommended for further studies the analysis in subjects with class II (division 1 and 2) and class III occlusion angle, comparing them with those measurements obtained in the present study.

REFERENCES

1. Moyapueyo, V., Roldan, B., Sánchez, J. Odontología legal y forense. Fuentes y reseña histórica. 1994. España: Masson, S.A.
2. Navarro, A., Roldán. N., Kiru. Método de Mann para estimar la edad esquelética en cráneos del laboratorio de criminalística de la policía nacional del Perú. 2007. 4(1) 2-7.
3. Marín, L., Moreno, F. Odontología forense: Identificación odontológica de cadáveres quemados. Reporte de dos casos. 2004. Grupo de Investigación Cirugía Oral y Maxilofacial de la Universidad del Valle. 12 (2)
4. Aparicio, D., Hurtado, A., Pedraza, A., Casas, J. Identificación positiva por medio del uso de la rugoscopia en un municipio de Cundinamarca (Colombia): reporte de caso. 2007. 45(3):446-449.
5. Vaz, M., Silveira, B. The experience of the Forensic Anthropology Service of the Medical Examiner's Office in Porto Alegre, Brazil. Forensic Sci. 2008, 179: 45-49
6. Grimaldo- Carjevschi, M. Rugoscopia, queiloscopia, oclusografía y oclusoradiografía como métodos de identificación en odontología forense. Una revisión de la literatura. 2010. 48 (2).
7. De la Cruz, B., Daruge, E., Francesquini, L. Aplicaciones clínicas de la odontología forense.

Historia-Importancia. Reporte de caso. 2003. Vol. 9.

8. Loth, S. R. & Henneberg, M. Sexually dimorphic mandibular morphology in the first few years of life. J. Phys. Anthropol. 2001, 115:179-86.
9. Coqueugniot, H.; Giacobini, G. & Malerba, G. L. Utilisation de caracteres morphologiques dans la diagnose sexuelle des mandibules d'enfants: application a la collection osteologique de Turin (Italie). Bull. mém. Soc. Anthropol. Paris. 2002, 14(1-2):131-9.
10. Suazo, G. I. C.; Zavando, M. D. A. & Smith, R. L. Blind test of mandibular morphology with sex indicator in subadult mandibles. Int. J. Morphol, 2008, 26(4):845-8.
11. Suazo G.I.C., Zavando M.D.A., Smith R.L. Determinación del sexo en mandíbulas en el primer año de vida mediante una mayor aproximación cuantitativa. Int. J.Morfhol., 27(1):113-116,2009.
12. Cardoso, H. F. Sample-specific (universal) metric approaches for determining the sex of immature human skeletal remains using permanent tooth dimensions. J. Archaeol. Sci. 2008, 35:158-68.
13. Suazo G.I., Zavando M.D., Luiz S.R. Exactitud de la forma del paladar como indicador de sexo en cráneos humanos con pérdida de dientes maxilares. Int. J. Morphol., 2008, 26(4): 989-993.
14. Krogman, W. M. & Iscan, M. Y. The Human Skeleton. In Forensic Medicine. Springfield, lllinois, Charles C. Thomas Pub., 1986.
15. Schutkowski, H. Sex determination of infant and juvenile skeletons: Morphognostic features. Am. J. Phys. Anthropol., 1993, 90:199-205.
16. Rösing F.W., Graw M., Marré B., Ritz- Timme., Rothschild M.A.,Rötzcher K.R., Scmeling A., Schröder I., Geserick G. Recommendations for the forensic diagnosis of sexand age from skeletons. Journal of comparative human biology 58: 75-89, 2007.
17. Kimmerle E.H., Ross A., Slice D. Sexual dimorphism in America: geometric morphometric analysis of the craniofacial region. J. Forensic Sci. 53:54-7, 2008.
18. Suazo G.I., Zavando M.D., Smith R.l. Evaluating accuracy and precision in morphologic traits for sexual dimorphism in malnutrition human skull: a comparative study. Int. J. Morphol. 2008, 26(4):877-881.
19. Cantín L.M., Suazo G.I., Zavando M.D., Luiz S.R. Sexual Domorphism Determination by Piriform Aperture Morphometric Analysis in Brazilian Human Skulls. Int. J. Morphol. 2009, 27(2): 327-331.
20. Hwang, T. S. & Kang, H. S. Morphometry of nasal bases and nostrils in Koreans. Ann. Anat. 2003, 185:189-93.
21. Ramos N.A.,Suazo I.C., Martinez M.M.L, Reyes L. Relaciones transversales faciales en niños chilenos de la región del Maule. Int. J. Morphol, 25(4): 703-707, 2007.
22. Saini V., Srivastava R., Raiz R., Shamal S., Satya N., Singh T., Tripathi S., Mandibular ramus: An indicator for sex in fragmentary Mandible. Journal of Forensic Sciences. 2011, 56: 513-516.
23. Loth, S. R. & Henneberg, M. Mandibular ramus flexure: a new

morphologic indicator of sexual dimorphism in the human skeleton. Am. J. Phys. Anthrop. 1996, 99(3):473-85.

24. Suazo G.I.C., San Pedro V.J., Schilling Q.N.A., Celis C.C.E., Hidalgo R.J.A., Cantín L.M. Test ciego con Ortopantomografía de la flexura de la rama mandibular como un indicador de sexo en adultos jóvenes chilenos. Int. J. Morphol. 2008, 26(1): 89-92.
25. Manhdi E., Abolfazl F., Fariba. Evaluación de algunos parámetros antropómetricos en niños de 4-11 años en Kurmanj origen étnico (Norte Khorasan, Irán)
26. Coquerelle M., Bookstein F.L., Braga J., Halazonetis D.J., Weber G.W., Mitteroecker P.El dimorfismo sexual de la mandíbula humana y su asociación con el desarrollo dental. Physical Anthropology. 2011,145(2): 192-202.
27. Suazo G.I., Zavando D. Efecto de la edad en el crecimiento de los rasgos morfológicos para la determinación del sexo en cráneos y mandíbulas Humanas. Int. J. Morphol. 2012, 30(1): 296-301.
28. Moreira S.I., Naback L.V., Vieira S.V. Relación entre el crecimiento mandibular y maduración esquelética en melanoderma de mujer joven brasileña. Dental Press J. Orthod. 2010, 15(2): 58-70.
29. Yasar T.H., Duran A., Canturk Determinación del género mediante la medición del tamaño de los senos maxilares en las tomografías computarizadas. Surgical & Radiologic Anatomy. 2007, 29:9-13.
30. Testut, L.; Latarjet, A. y Latarjet, M. Tratado de Anatomía humana, Salvat Editores S.A., Barcelona, 1988. Pág. 84.
31. Sperber GH. Craniofacial Embriology. Dental Handbook. 4th Edition. Wright. Great Britain, 1989.
32. Meikle MC. Craniofacial Development, Growth and Evolution. 1st edition. Bateson Publishing, Bressingham, Norfolk, England. 2002
33. Kjaer I, Keeling JW & Fischer B. The Prenatal Human Cranium-normal and pathologic development. Munksgaard, 1999.
34. Kjaer I. Hitochemical investigation on the symphysis menti in the human fetus related to fetal skeletal maturation in the hand and foot. Anat 1975; 93:606-633.
35. Petrovic, AG. An experimental and cybernetic approach to the mechanism of action of functional appliances on the mandibular growth. Maloclusión and the periodontum, Cranifacial Growth Series, Center for Human Growth and Development, University of Michigan. 1984
36. Silberman, M., Reddi, AH., Hand, AR., Leapman, R., Von der Mark, K., Franzen, A. Chondroid bone arises from mesenchymal stem cells in organ culture of mandibular condyles. Journal of Craniofacial Genetics and Development Biology 1987; 7:59-80.
37. Williams PL. Gray’s Anatomy. 38th edition. Ed. Churchill Livingstone, 1995.
38. Enlow DH. Facial Growth. 3rd edition. W.B. Sander, Philadelphia, 1990.

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