

# The Relationship of the 2<sup>nd</sup>: 4<sup>th</sup> Digit Ratio to the Maxillary Sinus Volume in Men



Hasan Emre Koçak\*, Harun Acıpayam, Zeki Tolga Bilece, Arzu Karaman Koç, Kamil Hakan Kaya and Fatma Tülin Kayhan

Bakirkoy Dr Sadi Konuk Research and Educational Hospital Otorhinolaryngology Clinic, Turkey

Received: May 24, 2018; Published: June 13, 2018

\*Corresponding author: Hasan Emre Koçak, Bakirkoy Dr. Sadi Konuk Research and Educational Hospital Otorhinolaryngology Clinic, Turkey

## Abstract

**Objective:** Recently, the 2<sup>nd</sup> and 4<sup>th</sup> (2D:4D) digit ratio have been reported to be a non-invasive indicator of intrauterine androgen balance and androgen receptor sensitivity. The maxillary sinus (MS) is the triangular pyramid shaped air filled space found inside the maxilla. Like other paranasal sinuses, MS plays a prominent role in the formation of facial contour. The possible relationship between the MS volume and the 2D:4D ratio in men has been investigated.

**Materials and Method:** 41 male patients aged between 21-39 years (mean 27±5.24), who had a paranasalsinus (PNS) computer tomography (CT) scan. The MS volume was calculated from the PNS CT scans using the Syngo software. The 2D:4D ratios were calculated by measuring in mm the distance between the end point of the 2nd and 4th digits on the palmar side of the right hand and the lowermost crease (the meta carpophalangeal crease) using a digital caliper. The relationship between these two numerical values was statistically analyzed.

**Results:** As a result of the volume analyses, the total volume was found to be 31±8.6. Average 2D length was found as 72.8±10, 4D lengths as 75.1±10.8 and the average 2D:4D ratio as 1. There was a significant negative correlation between the 2D/4D ratio and the right, left and average MS volumes.

**Conclusion:** There is a negative correlation between the 2D:4D ratio and the MS volume. This condition reveals the androgenic hormone effect of the sinus volume in the development process. New studies to be done in the future with more number of patients are needed for a better understanding of this relationship.

**Keywords:** Digit; Maxillary; Ratio; Sinus; Volume

## Introduction

The paranasalsinus (PNSs) are complex viscerocranium bones filled with air and their structure, shape, and sizes show major individual differences [1]. PNSs expand the bone in which they are located during their development. This development does not take place in a uniform manner and continues at different time periods and different speeds during the period of development [2]. Therefore, PNSs are one of the most variable anatomical structures in the body in terms of size, shape and volume [2]. The maxillary sinus (MS) develops from the mesoderm of the 1st branchial arch. The MS begins to form in the 3rd gestational week and its development lasts until young adulthood [1,3]. The MS is the triangular pyramid shaped air filled space found inside the maxilla. It has 3 recesses and the alveolar recess extends up to the alveolar process of the maxilla in the inferior, the zygomatic recess ends with the zygomatic bone in the lateral and the infraorbital recess ends with the infraorbital surface in the superior [4]. Just as the size and shape

of the MS greatly differ from person to person, there are also differences between right and left in the same person [4]. Like other PNSs, MS plays a prominent role in the formation of facial contour and PNS diseases such as sinusitis and cancer occur more [5].

Aside from better understanding these anatomical formations, knowing the size and volume of MSs and the factors affecting their development will be helpful to us in operations such as Endoscopic Sinus Surgery. Thanks to 3D reconstruction, computed tomography (CT) is a perfect radiological method for determining the shape and volume of the MS [6]. Homeobox genes play an important role in the development of the Hoxa and d vertebrae and the urogenital system and these genes also control the development and differentiation of the digits [7]. Recent studies in the literature have suggested digit length analysis as a reliable and non-invasive indicator of prenatal sex hormone exposure [7-14]. There is evidence that the ratio between the length of the 2nd digit (2D) and the length of

the 4th digit (4D) differs based on gender and that this is mostly determined in the prenatal period [8]. Unlike women, 4D is longer in men, meaning that the 2D:4D ratio is lower. This ratio is related to the in utero androgen and estrogen balance and is a non-invasive, reliable indicator of this balance [9]. Post-natal 2D:4D ratios are in a negative correlation with the high-level fetal testosterone levels previously measured from the amniotic fluid [10].

There is evidence that in addition to high fetal androgen levels, a low 2D:4D ratio is also related to the increased receptor sensitivity of androgens [9,11]. The 2D:4D ratios have been found high in male patients with androgen insensitivity syndrome [12]. For these reasons, this ratio has been accepted as a retrospective indicator of in utero androgen levels and a sign of the sensitivity of individuals [13]. Although the digits continue to grow with age, this ratio continues to remain relatively stable until young adulthood [14]. The aim of our study is to demonstrate whether there is a correlation between the 2D:4D ratio and the MS volume.

## Materials and Method

Approval was obtained from the local ethics committee for the study (Ethic Committee Number: b 2016-84). All participants signed informed consent forms. 41 male patients aged between 21-39 years (mean  $27 \pm 4.24$ ) who had PNS CT scans because of chronic

headaches and in whose PNS no pathology was detected were included in the study. Patients who had a history of previous nasal or paranasal surgery or maxillofacial trauma, had a congenital nasal/PNS abnormality or had a pathology that could affect PNS aeration such as chronic sinusitis were not included in the study. The MS volume was calculated using a computer software with the method Prabhat et al. [15] used in their study.

The routine PNS CT imaging procedure is as follows, in the given order: High-resolution CT images were acquired at 120 kV; 180 mA and rotation time 0,6. The serial image of the 0,1 cm slice with 1-second scanning time was obtained. The volume was measured on a computer with Syngo software (Siemens Healthcare GmbH Henkestr, Germany). After we defined air density threshold to (-1024) - (-450) Hounsfield Unit, MS volume (V) was calculated using the "Paint on slices" tool on the workstation. To define a volume, the outline of the sinus was traced manually on each slice of the image stack using the on-screen mouse pointer in the axial plane (Figure 1). Once the tracing was complete, the workstation automatically segmented the entire volume of the sinus from the surrounding structures and the segmented portion could be visualized and manipulated in 3D. At this point, switching to the "Histogram" view on the workstation automatically reflected the volume of the sinus in cubic centimeters (cc).

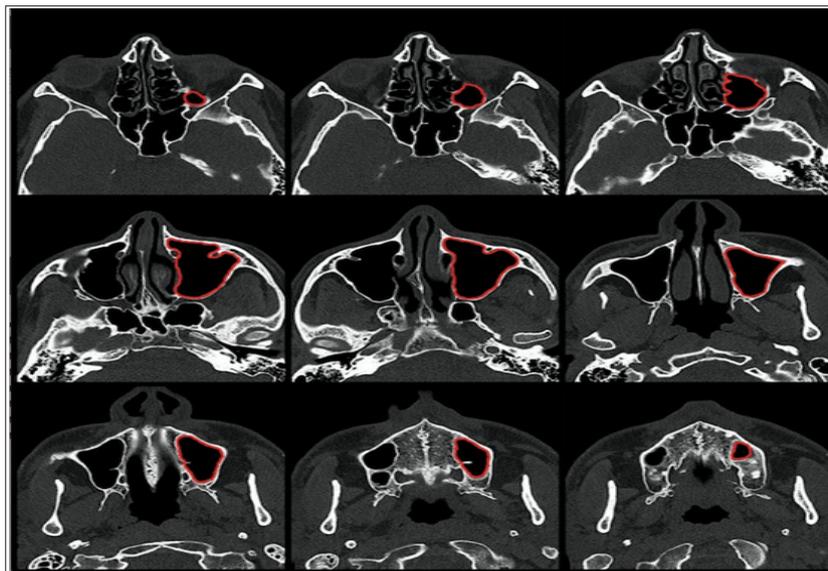


Figure 1: Paint on slice tool.

The entire procedure was repeated for the right and the left MSs separately for every patient. Digit-length was measured via a 150-mm digital verniercalliper with a resolution of 0.01 mm. Digit-length was measured like Bilgic et al. [9] who was measure the digit via a digital verniercalliper with a resolution of 0.01 mm. Measurements of the 4<sup>th</sup> and 2<sup>nd</sup> digits were made directly on the palmar surface of right hand, from the basal crease to the tip of the digit. If more than one fold was detected at the base of the digit, the most proximal fold was used. To obtain the 2D:4D ratio, the length of the 2nd digit was divided by the length of the 4th digit. The relationship between the 2D: 4D ratio and MS volume were statistically analyzed. Mean, standard deviation, median minimum, maximum,

frequency, and ratio values were used in the descriptive statistics of the data. The distribution of the values was measured with the Kolmogorov-Smirnov test. The Spearman correlation analysis was used for the correlation analysis. The SPSS 22.0 (PASW for Windows®, Rel. 18.0.0. 2009, SPSS Inc., Chicago, IL, USA) software was used for the analyses.

## Results

As a result of volume analyses, the right MS volume was found as  $16.1 \pm 4.6$ , the left MS volume was found as  $14.9 \pm 4.6$  and the total volume (right+left) was found as  $31 \pm 8$ . Average 2D length was found as  $72.8 \pm 10$ , 4D length as  $75.1 \pm 10.8$  and the average 2D:4D ratio as 1

(Table 1). There was a significant negative correlation between the 2D/4D ratio and the right, left and average MS volumes. ( $p=0.0002$ ;  $0.0022$ ;  $0.0004$ , respectively); (Table 2) and (Figures 2 & 3).

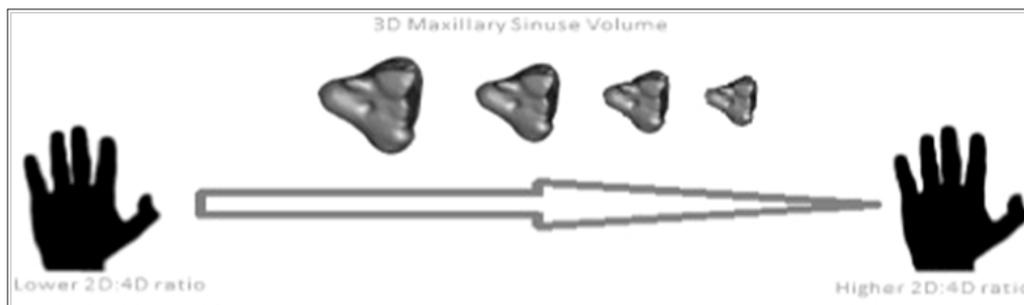
**Table 1:** The distribution and average values of the data.

	Min-Max	Median	Mean± s.d.
2D	30.4-84.9	74.2	72.8±10.0
4D	29.6-86.2	76.0	75.1±10.8
2D/4D	0.9-1.1	1.0	1.0±0.0
Right Maxillary Sinus Volume	8.4-25.9	15.8	16.1±4.6

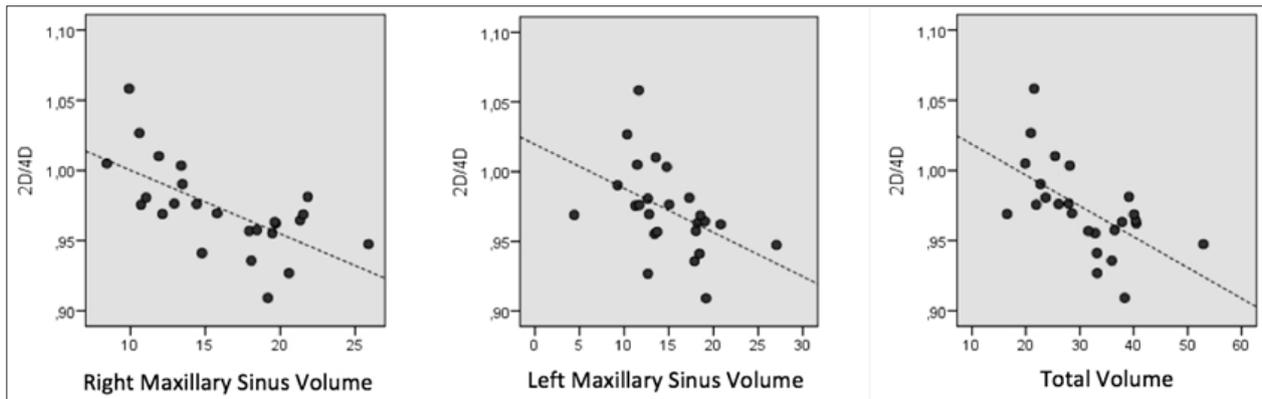
Left Maxillary Sinus Volume	4.4-27.0	13.7	14.9±4.6
Total Volume	16.5-52.9	31.6	31.0±8.6

**Table 2:** The 2D:4D ratio and its correlation with the maxillary sinus volume.

		Right Maxillary Sinus Volume	Left Maxillary Sinus Volume	Total Volume
2D/4D	r	-0.655	-0.582	-0.653
	p	0.000	0.002	0.000
Spearman Correlation				



**Figure 2:** An illustration of the relationship between the 2D:4D ratio and maxillary sinus volume.



**Figure 3:** The relationship between the 2D:4D ratio and maxillary sinus volumes.

### Discussion

Our study, to our best knowledge, is the first study done on this topic in the literature. We found that there is a negative correlation between the 2D:4D ratio and the MS volume. It has been demonstrated in several studies that there is a negative correlation between the 2D:4D ratio and fetal androgen exposure and androgen receptor sensitivity and our study also supports this condition [9-14]. Bilgiç et al. [9] have found a negative correlation between androgenic alopecia (fontal baldness) and the 2D:4D ratio and have reported that according to this, frontal baldness occurs more often and more severely in males whose fourth digit is long. Similarly, there are also studies conducted on adult males with 3D technology, showing that intrauterine androgen exposure and androgen receptor sensitivity affects facial development in men [16]. It has been reported that according to this, men whose 2D:4D ratios are

high have a facial appearance that is longer in the cephalo-caudal direction and shorter in the antero-posterior direction, that is to say more feminine [16].

In the analyses that he made on 17 male children, Meindl [10] found that children with a lower 2D:4D ratio had more unrefined faces, more masculine and stronger body structures and more active personalities. In the study he conducted on birds, Leoni [17] reported that he could easily assign gender with the ratio between the toes of the birds. It has been reported recently that the morphometric analysis of the MS is a useful and reliable technique for gender assignment [18-23]. Mochlhenrich et al. [18] found the MS volume in a maxilla with complete teeth to be 16.6 mm<sup>3</sup> in men and 13.2 mm<sup>3</sup> in women in a study they conducted, and they found this difference significant. Similarly, Kanthem et al. [19] looked at the height (infero-superior), length (antero-posterior) and width

(medio-lateral) as well as the volume of the MS in their study and demonstrated that these parameters were usable in forensic gender assignment.

They reported that of these ratios, the MS volume has the most reliable ratio in forensic gender assignment with an accuracy rate of 78.38%. There are several similar studies in the literature proving that the MS volume changes with gender difference [18-23]. Fernandes [20] found that aside from gender difference, the MS volume also differs with ethnicity by examining the craniums of the people of Europe and South Africa Zulu. Jun [5] has stated that aside from gender, the MS volume also changes based on age and that the gender difference continues in every age group. Unlike the general knowledge in the literature, Uchida et al. [24] have stated that there is no connection between the size of the MS and age and gender but there are not enough publications supporting this. We found a correlation between a low 2D:4D ratio and a wider MS volume in our study. We believe that this leads facial features to gain a more masculine appearance due to high intrauterine androgenic hormone exposure and thus causing the MS volume, the development of which starts in the intrauterine stage, to get wider.

We believe our study to reveal clearly that the MS volume is affected by androgenic hormones. We believe that understanding the anatomical structure and the in utero and post-natal development dynamics of the MS in a better way will be useful in better identifying pathologies of this region and that this will facilitate our work in determining the treatment strategies. One of the drawbacks of our study is that the 2D:4D ratio was only calculated from the right hand digits and the left side was not evaluated. Also, the number of patients included in the study is relatively small. The study was only conducted on males. New studies to be done with more patients are needed for a better understanding of this relationship.

## Conclusion

There is a negative correlation between the 2D:4D ratio and the MS volume. This reveals the androgenic hormone effect of the MS volume in the development process. New studies to be conducted in the future with more number of patients are needed for a better understanding of this relationship.

## References

- Değermenci M, Ertekin T, Ülger H, Acer N, Coşkun A (2016) The Age Related Development of Maxillary Sinus in Children. *J Craniofac Surg* 27(1): 38-44.
- Lorkiewicz Muszyńska D, Kociemba W, Rewekant A, Sroka A, Jończyk Potoczna K, et al. (2015) Development of the maxillary sinus from birth to age 18. Postnatal growth pattern. *Int J Pediatr Otorhinolaryngol* 79: 1393-400.
- Kim J, Song SW, Cho JH, Chang KH, Jun BC (2010) Comparative study of the pneumatization of the mastoid air cells and paranasal sinuses using three-dimensional reconstruction of computed tomography scans. *Surg Radiol Anat* 32(6): 593-599.
- Saccucci M, Cipriani F, Carderi S, Di Carlo G, D'Attilio M, et al. (2015) Gender assessment through three-dimensional analysis of maxillary sinuses by means of Cone Beam Computed Tomography. *Eur Rev Med Pharmacol Sci* 19(2): 185-193.
- Jun BC, Song SW, Park CS, Lee DH, Cho KJ, et al. (2005) The analysis of maxillary sinus aeration according to aging process; volume assessment by 3-dimensional reconstruction by high-resolution CT scanning. *Otolaryngol Head Neck Surg* 132(3): 429-434.
- Reichs KJ (1993) Quantified comparison of frontal sinus patterns by means of computed tomography. *Forensic Sci Int* 61(2-3): 141-168.
- Kondo T, Zákány J, Innis JW, Duboule D (1997) Of fingers, toes and penises. *Nature* 390: 29.
- Manning JT (2002) *Digit ratio: A pointer to fertility, behavior, and health*. Rutgers University Press.
- Bilgic Ö, Altınyazar HC, Eryılmaz D, Tuğrul ZA (2016) Are 2D: 4D finger-length ratios an indicator of androgenetic alopecia in males? *Anaisbrasileiros de dermatologia* 91(2): 156-159.
- Meindl K, Windhager S, Wallner B, Schaefer K (2012) Second-to-fourth digit ratio and facial shape in boys: the lower the digit ratio, the more robust the face. *Proc Biol Sci* 279: 2457-2463.
- Manning JT, Bundred PE, Newton DJ, Flanagan BF (2003) The second to fourth digit ratio and variation in the androgen receptor gene. *Evol Hum Behav* 24(6): 399-405.
- Byne W (2006) Developmental endocrine influences on gender identity: implications for management of disorders of sex development. *Mt Sinai J Med* 73(7): 950-959.
- Breedlove SM (2010) Minireview: organizational hypothesis: instances of the fingerpost. *Endocrinology* 151(9): 4116-4122.
- Trivers R, Manning J, Jacobson A (2006) A longitudinal study of digit ratio (2D: 4D) and other finger ratios in Jamaican children. *Horm Behav* 49(2): 150-156.
- Prabhat M, Rai S, Kaur M, Prabhat K, Bhatnagar P, et al. (2016) Computed tomography based forensic gender determination by measuring the size and volume of the maxillary sinuses. *J Forensic Dent Sci* 8(1): 40-46.
- Weinberg SM, Parsons TE, Raffensperger ZD, Marazita ML (2015) Prenatal sex hormones, digit ratio, and face shape in adult males. *Orthod Craniofac Res* 18(1): 21-26.
- Leoni B, Rubolini D, Romano M, di Giancamillo M, Saino N (2008) Avian hind-limb digit length ratios measured from radiographs are sexually dimorphic. *J Anat* 213 : 425-430.
- Möhlhenrich SC, Heussen N, Peters F, Steiner T, Hölzle F, et al. (2015) Is the Maxillary Sinus Really Suitable in Sex Determination? A Three-Dimensional Analysis of Maxillary Sinus Volume and Surface Depending on Sex and Dentition. *J Craniofac Surg* 26(8): 723-726.
- Kanthen RK, Guttikonda VR, Yeluri S, Kumari G (2015) Sex determination using maxillary sinus. *J Forensic Dent Sci* 7(2): 163-167.
- Fernandes CL (2004) Forensic ethnic identification of crania: The role of the maxillary sinus - A new approach. *Am J Forensic Med Pathol* 25(4): 302-313.
- Sahlstrand Johnson P, Jannert M, Strömbeck A, Abul Kasim K (2011) Computed tomography measurements of different dimensions of maxillary and frontal sinuses. *BMC Med Imaging* 11: 8.
- Vidya CS, Shamasundar NM, Manjunatha B, Raichurkar K (2013) Evaluation of size and volume of maxillary sinus to determine gender by 3D computerized tomography scan method using dry skulls of South Indian origin. *Int J Curr Res Rev* 5(3): 97-100.
- Attia AM, Badrawy AM, Shebel HM (2012) Gender identification from maxillary sinus using multi-detector computed tomography. *Mansoura J Forensic Med Clin Toxicol* 20: 17-26.
- Uchida Y, Goto M, Katsuki T, Akiyoshi T (1998) A cadaveric study of maxillary sinus size as an aid in bone grafting of the maxillary sinus floor. *J Oral Maxillofac Surg* 56(10): 1158-1163.



This work is licensed under Creative Commons Attribution 4.0 License

Submission Link: <https://biomedres.us/submit-manuscript.php>



#### Assets of Publishing with us

- Global archiving of articles
- Immediate, unrestricted online access
- Rigorous Peer Review Process
- Authors Retain Copyrights
- Unique DOI for all articles

<https://biomedres.us/>