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The Determination of Sphenoid Sinus Dimensions in Turkish Healthy Adult Subjects: An MRI Study

Determinación de las Dimensiones del Seno Esfenoidal en Sujetos Adultos Sanos Turcos: Un Estudio de Resonancia Magnética

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SUMMARY: The aim of this study was to identify sphenoid sinus dimensions; and distance between columella nasal and sphenoid sinus; and columella nasal and hypophysis in healthy adult subjects using magnetic resonance imaging (MRI) and to evaluate differences between genders and age groups. The MRI results of 300 healthy subjects (192 females; 108 males) aged 18-68 years were studied. The midsagittal and axial images were used for shape of the sphenoid sinus, and the distance measurements of its related adjacent structures on MRI. The mean values of the distance between columella nasal; and columella nasal and hypophysis; and sinus sphenoidalis width were 65.73±5.22 mm, 87.05±4.79 mm and 37.67±8.40 mm in females respectively, whereas the same values were 71.79±5.06 mm, 94.52±6.07 mm and 41.95±9.32 mm in males, respectively. The means of all measurements were lower in healthy female subjects than in healthy males.Additionally, the classification of sphenoid sinus types were determined to be postsellar type (131), sellar type (46), presellar type (14) and conchal type (1) in females, respectively. The same measurement were determined as postsellar type (82), sellar type (23) and presellar type (3) in males, respectively. Differences between sexes and age related changes were observed in the variations of the size, location and shape of sphenoid sinus were observed The observations presented in this report have defined anatomic parameters that need to be taken into consideration for reference data to determine gender discrepancies, age related changes and helpful for radiologists and clinicians to plan safe surgical approach and avoid surgical risks.

KEY WORDS: Sphenoid bone; Sphenoid sinus; Magnetic resonance imaging.

INTRODUCTION

Sphenoid bone is more important structure of skull base surgery. Sphenoid sinus is the most remained hidden and unreachable of the paranasal sinuses (Mamatha *et al*., 2014; Sevinc *et al*., 2014; Wiebracth & Zimmer, 2014). This allows to safely approach the sella turcica, optic nerve, tuberculum sella and planum sphenoidale for surgeons, in some lesions including skull base lesions and cerebrospinal fluid leaks (Wiebracth & Zimmer). Sphenoid sinus continues to develop during puberty and reaches adult size by 12 age (Wiebracth & Zimmer). It is bordered at the many serious structures like cavernous sinus laterally, the eithmoidal air cells, anterior cranial fossa and optic nerve anteriorly, the clivus posteriorly, the hypophysis fossa and planum sphenoidale superiorly, choana inferiorly, internal carotid artery medially (Mamatha *et al*.; Seddinghi *et al*., 2014; Sevinc *et al*.; Farımaz *et al*., 2018). Sphenoid sinus shows difference in size, shape and degree of pneumatization (Yamashita *et al*., 2014). Variations in septation, shape, and dimensions have a serious effect on surgical planning of the skull base (Wiebracth & Zimmer). The sphenoid sinus variations were classified into four types as conchal, presellar, postsellar and sellar (Yamashita *et al*.). A detailed knowledge of the anatomy of sphenoid sinus and its related adjacent structures preoperatively is vital to the prevention of unintentional damage to these significant structures during surgery implementation (Fasunla *et al*., 2012). Because, any injury to the lateral, posterior or superior of the sphenoid sinus can induce cerebrospinal fluid leaks and this endangers to surrounding regions like optic canal, vidian canal, maxillary, oculomotor, trochlear and abducens nerves, the cavernous sinuses (Wiebracth & Zimmer). The hypophysis which is composed of two anatomically and functionally

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distinct lobes (the anterior and the posterior lobe), are located beneath the brain in the center of the skull base. It is responsible for connecting two major homeostatic systems of the body the nervous and endocrine systems. The MRI of hypothalamic-hypophysis region which is used as diagnostic method, may provide more details of the structures that constitutes the central nervous system and the skull base (Yamashita *et al*.). In the removal of hypophysis tumors, some methods are used that the endoscopic and microscopic transsphenoidal approaches have accepted as a more safe procedure according to transcranial approach (Kim *et al*., 2013).

The purpose of this study was to document the shape of sphenoid sinus and the distance measurements between adjacent structures and sphenoid sinus, sphenoid sinus anatomic parameters and to plan safe surgical approach and avoid surgical risks for radiologists and clinicians using MRI in healthy females and males in our population and to identify the sex and age related differences.

MATERIAL AND METHOD

This study was carried out from the 300 healthy adult subjects (192 females; 108 males) aged 18-68 years (35.62±10.65 years) over a period of 4 years between January 2014 and 2018. All the test procedures were approved by ethics committee. Cranial MRI findings were evaluated by radiologists and anatomists. Healthy adult subjects were selected by criteria of optimal health. Moreover, inclusion criteria for healthy adult subjects were no history of oncologic illness, hemiplegia, intracranial lesions, Parkinson disease, having surgical operation related region, psychiatric or medical illness and surgery of the sphenoid sinus, sinonasal tumor or nasal polyposis and chronic rhinosinusitis. MRI was performed using a 1.5 T MRI system (Siemens; Essenza, Erlangen, Germany). Brain MRI protocol including axial T2-weighted turbo spin echo (TR:3600, TE:87 ms; slice thickness 5 mm; gap 1.5 mm) and sagittal T2-weighted spin echo (TR:3600, TE: 87 ms; slice thickness 5 mm; gap 1.5 mm) was used. The measurements were performed from digital MRI images on a hospital using caliper function with x2 magnification. Using the midsagittal T2-weighted spin echo image, the following parameters of sphenoid sinus dimensions were evaluated (Baskin *et al*., 2003; Güldner *et al*., 2012; Kim *et al*.; Hindi *et al*., 2014; Sevinc *et al*.; Lupascu *et al*., 2014; Rahmati *et al*., 2016; Souadih *et al*., 2018) (Fig. 1).

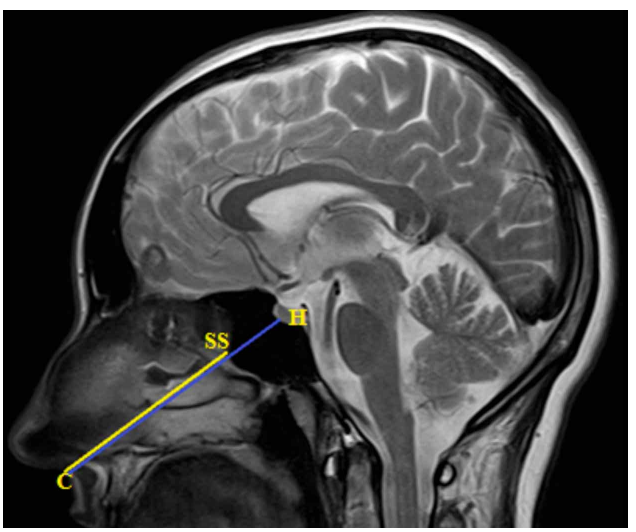

Fig. 1. Midsagittal T2-weighted Spin Echo MRI (TR:3600, TE:87 ms) of measurement areas of female and male healthy subjects. (CSS) The distance between columella nasal and sphenoid sinus. The distance between columella nasal and hypophysis (CH).

(CSS) The distance between the columella nasal and sphenoid sinus.
(CH) The distance between the columella and hypophysis (pituitary gland).
(SSW) The width of sphenoid sinus
(SST) The sphenoid sinus types (It is expressed as conchal type, when the sinus is separated from the sella by thick trabecular bone; it is stated as presellar type, when the sinus is pneumatised without extending posteriorly of the sellar floor and sellar type is when the sinus extends inferiorly and posteriorly of the sella turcica. It words as postsellar type if posterior wall of sphenoid sinus is behind the posterior wall of the sella turcica).

The data were divided into two groups: healthy adult female and male subjects. Estimations were expressed as millimeters. The SPSS 21.0 program was used for statistical analysis of the measurement results. From these measurements, means, standard deviations (SD), minimum and maximum values were calculated; In all statistical analyses; a p value under 0.05 was considered statistically significant.

RESULTS

The means of age of 192 healthy females and 108 healthy males were 35.24±11.07 years and 36.31±9.86 years, respectively. MRI results of the parameters of sphenoid sinus sub-regions (mm) in healthy adult subjects were shown in Table I. From the 300 MRI images, various dimensions of sphenoid sinus were measured (Fig. 1).

The mean scores of the distance between columella nasal and sphenoid sinus (CSS), the distance between

columella nasal and hypophysis (CH) and the width of sphenoid sinus (SSW) were higher in healthy male subjects than in females subjects. The pneumatization degree were determined as postsellar type (131), sellar type (46), presellar type (14) and conchal type (1) were in healthy female subjects, whereas the same parameter were postsellar type (82), sellar type (23) and presellar type (3) in healthy male subjects. Moreover, the means of distance between columella nasal and sphenoid sinus, columella nasal and hypophysis and sinus sphenoidalis width were 65.73±5.22 mm, 87.05±4.79 mm and 37.67±8.40 mm in females respectively, whereas the same values were 71.79±5.06 mm, 94.52±6.07 mm and 41.95±9.32 mm in males, respectively. According to these results, there were statistically significantly differences in all parameters excluding the sphenoid sinus types in between two groups (Tables I and II). Furthermore, when we investigated age related changes of groups there were significant difference in all parameters except sphenoid sinus width and differenceswere between group I and group III.

Table I. MRI measurements related with sphenoid sinus (mm) in healthy adult subjects.

Groups		Healthy group:300	
Measurements		Mean±Standard deviation	
Sex		Females (n=192)	Males (n=108)
Age (years)		35.24±11.07	36.31±9.86
Significance of sexes in the same group (p)		>0.05	
Sinus sphenoidalis width (CCL)		37.67±8.40	41.95±9.32
Significance of sexes in the same group (p)		<0.05	
The distance between columella nasal and hypophisis (CH)		87.05±4.79	94.52±6.07
Significance of sexes in the same group (p)		<0.05	
The distance between columella nasal and sphenoid sinus (CSS)		65.73±5.22	71.79±5.06
Significance of sexes in the same group (p)		<0.05	
Sphenoid sinus types (SST)	Postsellar type	131 (68 %)	82 (76 %)
	Sellar type	46 (24 %)	23 (21 %)
	Presellar type	14 (7 %)	3 (3 %)
	Conchal type	1 (1 %)	-
Significance of sexes in the same group (p)		>0.05	

Table II. Age related changes of sphenoid sinus measurements in healthy adult subjects

Measurements (n=300)	Sphenoid sinus width (CSW)	The distance between columella nasal and hypophisis (CH)	The distance columella nasal sphenoid sinus (CSS)
Group I (n=107) (18-30 years)	39.64±9.16	88.83±5.84	66.34±5.48
Group II (n=114) (31-40 years)	39.46±9.15	89.93±6.53	68.28±6.18
Group III (n=46) (41-50 years)	39.25±8.87	92.53±6.39	70.98±5.15
Group IV (n=25) (51-60 years)	36.84±7.95	88.40±6.88	67.33±6.05
Group V (n=8) (61-68 years)	37.04±7.77	87.34±5.77	67.83±5.15
Significance between groups (p)	p>0.05	p<0.05 (0,009)	p<0.05 (0.000)
Sphenoid sinus types	Conchal type 1 (1 %) Postsellar type 131 (68 %) Presellar type 14 (7 %) Sellar type 46 (24 %)		
Significance of sexes in the same group (p)	p>0.05		

DISCUSSION

In this study, we measured several parameters about sphenoid sinus, the sphenoid sinus types (the degree of pneumatization), the relation with sphenoid sinus and hypophysis of columella nasal in both healthy female and male subjects and compared our findings to both sexes and other populations. In fact, there are several surgery methods

and surgical landmark. So, these type studies including different populations are significant in terms of showing the discrepancies in both female and male subjects at the same age with using MRI.

The crucial subject for the decision of surgery of sellar region was the size and degree of pneumatization of sphenoid sinus or sphenoid sinus types (Seddinghi *et al*., 2014). The degree of pneumatization or sphenoid sinus types and its relation to sella turcica was best evaluated on the sagittal scans of MRI (Hamid *et al*., 2008; Sevinc *et al*.; Seddinghi *et al*., 2014). The detailed preoperative imaging of sphenoid sinus and sellar region by MRI was needed for suitable surgical approach and prevention of risks (Seddinghi *et al*., 2014). Moreover, MRI can give information about significant soft tissue patterns, including the ca-rotid artery, sella turcica, sella floor, and the sphenoid sinus wall. Furthermore, MRI can provide certain evaluations in surgery of hypophysis adenomas as a preoperative evaluation such as CT (Kim *et al*.). In the techniques of neuroimaging, MRI is used as diagnostic method for the field of hypothalamic-hypophysis region. It may examine in detail of the structures that constitute the central nervous system (CNS), sellar and perisellar regions and skull base. Additionally, it has a high sensitivity to specify subtle changes (Yamashita *et al*.).

The most changeable paranasal sinuses is sphenoid sinus in terms of many factors including degree and type of pneumatization and relation with surrounding surgical risks (i.e. optic, occulomotor, trochlear, trigeminal or abducens nerves, internal carotid artery or hypophysis). There are many variations in sphenoid sinus anatomy (Lupascu *et al*.). Having a detailed knowledge of the relations and variable regional anatomy of the sphenoid sinus before operation may guide surgeon in surgical success and decreases surgical complications and fatal risks (Seddinghi *et al*., 2014; Lupascu *et al*.; Rahmati *et al*.). The sphenoid sinus is the most important and variable structure of the paranasal surgery which makes it difficult to approach. Safe access to the sellar region is quite influenced by the pattern of pneumatization in the sphenoid sinus. Anatomic variations are predispose the sphenoid sinus to recurrent or chronic sinusitis (Rahmati *et al*.). The types of the sphenoid sinus can be defined in four groups: I. conchal, II. presellar, III. sellar and IV. postsellar. This classification is done depending on the extent to which the sphenoid bone is pneumatized (Kim *et al*.; Sevinc *et al*.; Lupascu *et al*.). In the conchal type which makes dificulties to surgery, the region below the sella is a solid block of bonewithout an air cavity. In the presellar type which has no bulge of the sellar floor in the sphenoid sinus. This situation provides disadvantageous to transsphenoidal surgery. Moreover, the sphenoid sinus has reasonable air cavity with no sellar recess and its posterior wall is in the front of the anterior wall of the sella turcica. In the sellar type, which is the most common and ideal anatomic shape, when the sella turcica is approached from below, since the floor bulges into direct view of the operative field. In the postsellar type which has roomy sinuses, intercarotid distance and thin anterior wall and floor of sella turcica, provides suitable conditions for transsphenoid hypophysectomy and sphenoid sinus posterior wall is behind the sella turcica posterior wall. However a bony block hinders the range of the vision of the sella turcica (Baskin *et al*.; Kayalioglu *et al*., 2005; Güldner *et al*.; Kim *et al*.; Hindi *et al*.; Sevinc *et al*.; Lupascu *et al*.; Rahmati *et al*.; Souadih *et al*.).

The incidence of the sellar type sphenoid sinus in literature was reported as 53-89 %, whereas the presellar type was declared as 10-38 %. Moreover, conchal type was found between 0 % and 9 % (Hamid *et al*.; Lupascu *et al*.). When we analysed our data including sphenoid sinus types, the postsellar type (68-76 %) pneumatization was the most seen, whereas the least seen type was the conchal type (1-0 %) in females and males, respectively. The most common type of the sphenoid sinus was the postsellar type (49.4 %), followed by sellar type (44.4 %) and presellar type (5.6 %), and the least encountered was the conchal type (0.6 %) were seen in Korean population (Kim *et al*.). The most seen of the sphenoid type was the sellar type (78.9 %), followed by postsellar type (15.3 %), and presellar type (5.8 %) in Brazilians (Yamashita *et al*.). In Iran, the most prevelant type was the postsellar type (83.5 %), followed by sellar type (14.6 %) and the least encountered was the presellar type (1.9 %). Conchal type was not seen in Iranians. Also, the postsellar type was represented mostly in males than females (Rahmati *et al*.). Furthermore, it was reported that the least frequent type in literature was conchal type (Baskin *et al*.; Kayalioglu *et al*.; Sareen *et al*., 2005; Hamid *et al*.; Kim *et al*.; Hindi *et al*.; Mamatha *et al*.; Sevinc *et al*.; Vidya & Raichurkar, 2015; Rahmati *et al*.). Kayalioglu *et al*., reported that conchal type, presellar type, sellar type and postsellar type were seen at rate of 4.2 %, 8.3 %, 60.4 % and 27.1 %, respectively. Also, the same measurements were at rate of 0 %, 13.8 %, 69 % and 17.2 % in cadavers, respectively. In MRI, the same dimensions were 1.7 %, 8.3 %, 48.3% and 41.7 %, respectively. Additionally, conchal type sphenoid sinus was more prevalent in females than males, but presellar type sphenoid sinus was more in males than females (Kayalioglu *et al*.). In Egypt, there were 2 % conchal type, and 21 % presellar type, and 54.7 % sellar type and 22.3 % postsellar type (Hamid *et al*.). It was stated that sellar type sphenoid sinus (55-85 %), and presellar type sphenoid sinus (25-10 %), and postsellar type sphenoid sinus (20-5 %) was found in Indians (Mamatha *et al*.; Vidya & Raichurkar). In ethnic group including Malay, Chinese and Indian

population, postsellar type sphenoid sinus was reported as 83.3 % whereas, presellar type sphenoid sinus was declared as 16.7 %. There was no conchal type sphenoid sinus in same populations. However, there was no statistical relationship between races and sphenoid types (Hindi *et al*.). Due to these data in males we found some differences in the prevelance of the sphenoid sinus types of Brazilians, Egypt, Indian populations and Turkish population with our healthy female and male population (Kayalioglu *et al*.; Hamid *et al*.; Budu *et al*., 2013; Mamatha *et al*.; Yamashita *et al*.; Vidya & Raichurkar). Our result of the least sphenoid sinus type which was conchal type was in concordance with literature (Kayalioglu *et al*.; Sareen *et al*.; Hamid *et al*.; Mamatha *et al*.; Hindi *et al*.; Vidya & Raichurkar).

In Brazilian males the sphenoid sinus was larger than females and it increased with increasing age (Yamashita *et al*.). However, the mean values of the sphenoid sinus width of females were 24.5 mm. In males the same dimension were 27 mm (Yamashita *et al*.). In Japanese male and female population there was no significant difference in the sphenoid sinus width (Yonetsu *et al*., 2000). While our result (37.67±8.40 mm in females; 41.95±9.32 mm in males) was similar to Brazilians, it was different from Japanese population. However, in our population sphenoid sinus width decreased with increasing age until 60 years.

The mean values of distances from the base of the columella nasal to the anterior wall of the sphenoid sinus and the sellar floor were 69.71±4.25 mm and 86.26±4.57 mm, respectively in Korean population (Kim *et al*.). In Brazilian female subjects, the means of the distances from the base of the columella nasal to the anterior wall of the sphenoid sinus and the distance from hypophysis to columella nasal were as 66 mm – 83.5 mm. The corresponding values of Brazilian males were as 77.0 mm-89.0 mm respectively (Yamashita *et al*.). The means of the distances from the base of the columella nasal to the anterior wall of the sphenoid sinus and the distance from hypophysis to columella nasal of Turkish females were 66.2±5.2 mm and 80.2±5.5 mm respectively, whereas the same dimensions were 71.2±5.7 mm and 85.6±5.8 mm in males, respectively (Kayalioglu *et al*.). In our study, the same measurements were 65.73±5.22 mm and 71.79±5.06 mm; 87.05±4.79 mm and 94.52±6.07 mm in females and males, respectively. Due to these data in males we found some differences in the mean values of distance between columella nasal to the sphenoid sinus of Koreans and Brazilians with our healthy males. The Korean and Turkish population having lower, and Brazilians having greater values than ours. Similarly, when we analyzed our data in female population we observed that there are differences Korean and Turkish population and our population data. But, our result is similar to Brazilian female subjects. Moreover, when comparing the means of the distance from columella nasal to hypophysis with this paper of female and male population scores of Korean, Turkish and Brazilian female and male population were lower than our this data. Also, we think that these discrepancies may originate from race, age, genetic, enviromental condition and sex, some diseases. When we investigated age-related changes for CSS and CH, there was significant difference between Group 1 and Group III ($p<0.05$). Moreover, sphenoid sinus width decreased with increasing age (between 18 and 60 years). Conversely, in between 18 and 50 years, the distance between columella nasal and sphenoid sinus and hypophysis increased. But after 51 years the same measurements decreased again.

As a conclusion, the data indicated that sphenoid sinus has significant variations and shows frequently differences from race to race. The observations presented in this study have defined anatomic parameters that need to be taken into consideration to evaluate sphenoid sinus variations and problems and guidelines to determine the reference values in terms of sexes and age. Also, this paper can provide crucial information and may be essential for safe and accurate diagnosis of many anatomical variations.

Having a detailed knowledge of the anatomical structures in sphenoid sinus and sellar region will help to evaluate both normal and pathological changes for surgeon, radiologist or neuroscientist about assessment of pathologic changes in the sphenoid sinus and sellar region region using with MRI.

ÖKSÜZLER, F. Y.; POLAT, S.; ÖKSÜZLER, M.; UYGUR, A. G. & YÜCEL, A. H. Determinación de las dimensiones del seno esfenoidal en sujetos adultos sanos turcos: un estudio de resonancia magnética. *Int. J. Morphol., 37(1)*:22-27, 2019.

RESUMEN: El objetivo de este estudio fue identificar las dimensiones del seno esfenoidal y la distancia entre la columela nasal y el seno esfenoidal y, la glándula nasal y la hipófisis en sujetos adultos sanos con imágenes de resonancia magnética (RM), para evaluar las diferencias entre los sexos y los grupos de edad. Se estudiaron los resultados de RM de 300 sujetos sanos (192 mujeres, 108 hombres) de 18 a 68 años. Se usaron imágenes sagitales y axiales para la forma del seno esfenoidal y las mediciones de distancia de sus estructuras adyacentes relacionadas en la RM. Los valores medios de la distancia entre columela nasal; y columela nasal e hipófisis; y la anchura del seno esfenoidal fue de 65,73 ± 5,22 mm, 87,05 ± 4,79 mm y 37,67 ± 8,40 mm en mujeres, respectivamente, mientras que los mismos valores fueron de 71,79 ± 5,06 mm, 94 , 52 ± 6,07 mm y 41,95 ± 9,32 mm en varones, respectivamente. Las medias de todas las mediciones fueron menores en mujeres sanas que en hombres sanos. Adicionalmente, se determinó que la clasificación del seno esfenoidal era de tipo postsellar (131), tipo selar (46), tipo

presellar (14) y tipo conchal (1), en las mujeres, respectivamente. Las mismas medidas se determinaron como tipo postsellar (82), tipo sellar (23) y tipo presellar (3) en varones, respectivamente. Se observaron diferencias entre sexos y los cambios relacionados con la edad en las variaciones de tamaño, ubicación y forma del seno esfenoidal. Las observaciones presentadas en este informe establecen parámetros anatómicos que se deben considerar como referencia para determinar las diferencias de sexo, y edad. La información de estas diferencias será útil para los radiólogos y los médicos en la planificación de un abordaje quirúrgico seguro y para evitar riesgos quirúrgicos.

PALABRAS CLAVE: Hueso esfenoides; Seno esfenoidal; Resonancia magnética.

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