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# Application of Sphenoid Sinus Morphological Characteristics in Sex Estimation Based on Magnetic Resonance Imaging Images

## Aplicación de las Características Morfológicas del Seno Esfenoidal en la Estimación del Sexo Basada en Imágenes de Resonancia Magnética

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**HAI-YAN, L.; ZI-YANG, B.; WANG, J.; XIAO-FANG, Y.; TAE-GEON, K.; KE-MING, Y.; XIU-PING, W. & LI, B.** Application of sphenoid sinus morphological characteristics in sex estimation based on magnetic resonance imaging images. *Int. J. Morphol., 41(4)*:1166-1170, 2023.

**SUMMARY:** Sex determination of unknown persons plays an important role in forensic science. As most bones used for sex determination are recovered in incomplete state, it is often necessary to use bones that are recovered intact e.g., the sphenoid sinus. This study aimed to evaluate the diagnostic value of sphenoid sinuses dimensions for sex determination using Magnetic Resonance Imaging (MRI) images in Chinese adults. MRI images of 79 sphenoid sinuses (from 44 men and 35 women) were retrospectively selected. The height, anterior-posterior diameter, area, and perimeter were measured in the midsagittal view of the sphenoid sinuses. All data were subjected to descriptive and discriminative functional analysis with unpaired t-test and canonical discriminant. Comparison between male and female groups showed significant statistical differences regarding the height, anterior-posterior diameter, area, and perimeter of sphenoid sinuses. The predictive accuracy rate of the sphenoid sinus to identify sex was 63.6 % in males and 62.9 % in females with an overall accuracy of 63.3 %. This study proposed the importance of sexual dimorphism of sphenoid sinus dimensions, especially if other methods are not available. It suggested using MRI in forensics science thus obviating the complete dependence on the usage of conventional computed tomography (CT) and facilitating the study of forensic anatomy at the level of soft tissue .

**KEY WORDS: Forensic science; Sphenoid sinus; MRI; Sex determination.**

## INTRODUCTION

Sex determination of a body is a primary forensic procedure in the identification process. If primary methods of identification are impossible (absence of comparative DNA samples, fingerprints, or teeth records), it can be performed using radiographic techniques, whenever ante mortem images are available (Lorkiewicz-Muszynska *et al*., 2009). In violent traumatic contexts, teeth and frontal sinuses are likely to be missing, or separate into small pieces from the rest of the body, which makes personal identification unable to proceed. Sphenoid sinus, on the other hand, remains to be the most hidden and unreachable of the paranasal sinuses (Mamatha *et al*., 2010; Sevinc *et al*., 2014; Wiebracht *et al*., 2014). It continues to develop during puberty and reaches adult size by the age of 12 (Wiebracht *et al*., 2014). Deeply positioned in the center of the cranial base, it is well protected from degradation resulting from external force (Casselman *et al*., 2013).

It was reported that anatomy of sphenoid sinus could be used in personal identification, but to our knowledge, the significance of both qualitative and quantitative indicators of sphenoid sinus in the field of forensic medicine are rarely assessed. It is comprehensible that traditional cranial radiographies can not visualize them precisely due to the crucial bone structure superimposition (Auffret *et al*., 2016). Although CT can reflect the bony structure well, the sphenoid

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sinus is connected to the sieve like ethmoid sinus, which makes the single three-dimensional reconstruction of sphenoid sinus difficult to measure. Not using three-dimensional reconstruction alone for the measurement of sphenoid sinus, MRI can depict the true anatomy of deep tissue more clearly without bone structure superimposition. It can be used to determine the anatomic structure of the lesion region in detail. More importantly, it can be used to measure the sphenoid sinus at the soft tissue level around it. The aim of this study was therefore to evaluate whether sexual dimorphism from the height, A-P diameter, area and perimeter of sphenoid sinuses could be determined using the MRI imaging modality.

## MATERIAL AND METHOD

**Materials and instruments.** Nuclear magnetic resonance machine GE (Discoverery, MR750w 3.0T, America); Mimics Research software (version 19.0, Materialise Inc,Belgium); Photoshop image processing software; SPSS20.0 statistics software.

**Selection of subjects.** The present study was carried out in the Department of Radiology, affiliated hospital of Shanxi Medical University, after required approval from the Institutional Ethical Committee. A prospective study comprising 79 subjects (44 males and 35 females) ranged from 27 to 87 years age group over a period of 13 months (June 2018 to July 2019) was selected for the purpose of this study. Healthy subjects were randomly selected who attends the outpatient department and informed consent was obtained. Subjects with the medical history of facial trauma, tumors or any pathological process concerning the sphenoid bone and the other surrounding cranial base bones, but also with sinuses mucosa thickening, or any abnormality of the sinuses contents, were excluded from the study.

**Data acquisition.** All subjects were examined on MRI. All the scans were made using a nuclear magnetic resonance machine GE (Discovery, MR750w 3.0T, America). All images were converted to Digital Image Communication in Medicine (DICOM) format. The observer was blind to the details of age and sex of the subjects, using the DICOM compatible Mimics Research software (version 19.0, Materialise Inc, Belgium) to measure the height, A-P diameter, area and perimeter in the midsagittal view of the sphenoid sinus.

The following measurements were performed:

The height was measured as the vertical distance from the lowest point to the highest point in the midsagittal view (Fig. 1).

The anterior-posterior diameter was defined as the perpendicular distance from the most anterior point to the most posterior point in the midsagittal view (Fig. 2).

The area and perimeter were automatically estimated by drawing the outline of sphenoid sinus in the midsagittal view (Fig. 3).


Fig. 1. The height in the midsagittal view of the sphenoid sinuse.

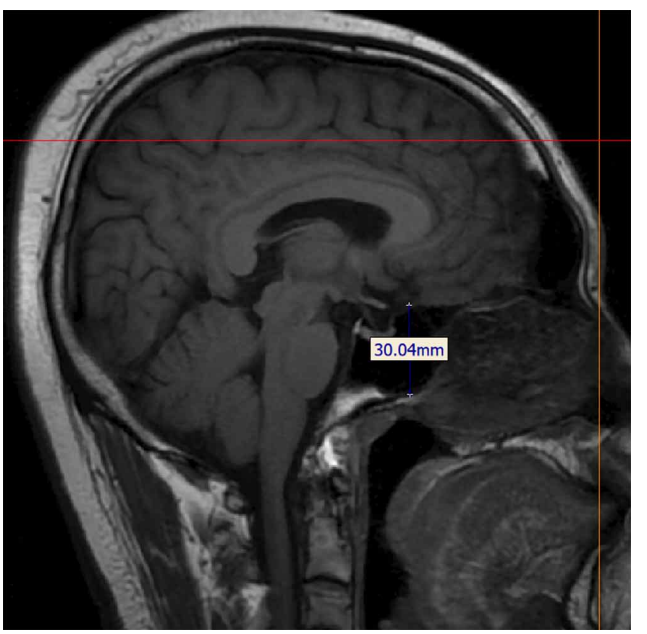


Fig. 2. The A-P diameter in the midsagittal view of the sphenoid sinuse.

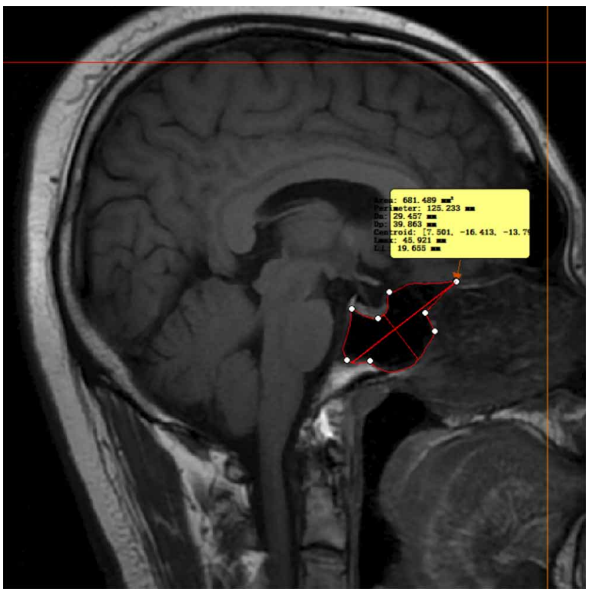

Fig. 3. The area and perimeter in the midsagittal view of the sphenoid sinuse.

**Analysis of data.** All data were subjected to descriptive analysis where comparison between both sexes was done using unpaired t test with a p value less than 0.05 taken as significant level. Canonical discriminant with sex as a grouping variable and sphenoid sinus measurements as independent variables was performed to generate a Canonical discriminant function. Canonical discriminant function provided by the model calculates the discriminate score, which can be used to predict sex by substituting the value of the specific measurements into the equation. The discriminate score is compared with reference values (also provided by the model): functions at group centroids (one for female, the other for male). If the discriminate score is closer to one of the reference values, it indicates we can predict sex accordingly. The predictive accuracy rate of the results and reliability of the procedure was assessed. Data analysis was done using the software, SPSS version 20.0.

## RESULTS

In the current study, all the parameters of sphenoid sinuses of the male were found to be greater than those of female. Table I shows the descriptive analysis of the measurements of sphenoid sinuses according to sex where the mean height, A-P diameter, area and perimeter with their standard deviations (SD) were presented. Significant mean differences were observed among all the four parameters between both sexes (Figs. 4-7).

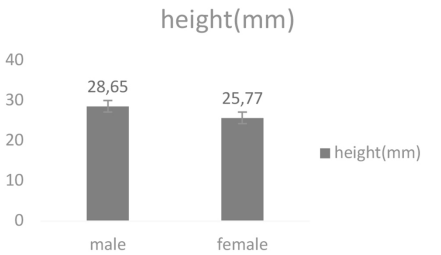


Fig. 4. Comparison of sphenoid sinus height between sexes in histogram.

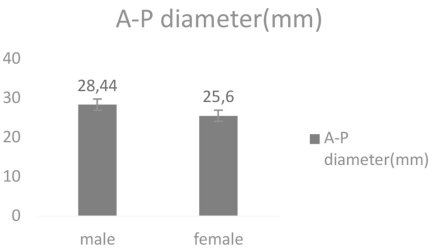


Fig. 5. Comparison of sphenoid sinus A-P diameter between sexes in histogram.

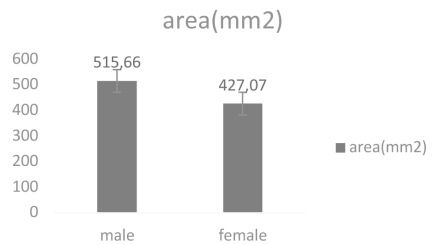


Fig. 6. Comparison of sphenoid sinus area between sexes in histogram.

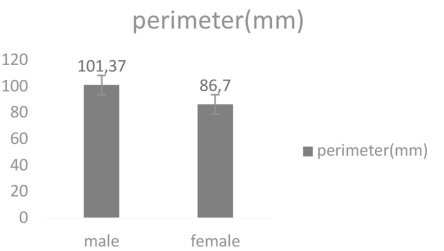


Fig. 7. Comparison of sphenoid sinus perimeter between sexes in histogram.

Table I. Comparison of parameters among male and female groups of sphenoid sinuses.

| Parameters | Male | | Female | | t | p value |
|---|---|---|---|---|---|---|
| | Mean | SD | Mean | SD | | |
| A-P diameter (mm) | 28.43 | 5.61 | 25.63 | 6.33 | -2.08 | <0.05 |
| Height (mm) | 28.66 | 4.70 | 25.77 | 4.43 | -2.78 | <0.05 |
| Area ($mm^2$) | 515.68 | 146.33 | 427.14 | 129.97 | -2.81 | <0.05 |
| Perimeter (mm) | 101.39 | 33.64 | 86.69 | 17.05 | -2.35 | <0.05 |

Canonical discriminant function was obtained as follows: sex=-3,419+0.007·the area in the midsagittal view of the sphenoid sinuses. The obtained determinant equation was applied to the study sample and revealed that the predictive accuracy rate of the sphenoid sinus to identify sex was 63.6 % in males and 62.9 % in females with an overall accuracy of 63.3 % (Table II).

Table II. Classification results of discriminant functional analysis of sphenoid sinus.

| | | Study group | Predicted group membership | | Total |
|---|---|---|---|---|---|
| | | | Males | Females | |
| Original | N | Males | 28 | 16 | 44 |
| | | Females | 13 | 22 | 35 |
| | % | Males | 63.60 | 36.40 | 100.00 |
| | | Females | 37.10 | 62.90 | 100.00 |

## DISCUSSION

In the field of forensic science, sex determination of a body is a crucial initial step in the identification process. Currently there are many techniques for sex identification in forensic science, the most reliable can being DNA analysis. However, this approach does not work in the event of a complete loss of soft tissue due to a major disaster such as fire, tsunami, or plane crash. In such cases, other methods can be used like radiographic techniques, whenever ante mortem images are available. MRI, being a three-dimensional radiographic technique, is radiation-free and without bone superimposition and thus allows a better assessment of the soft tissue and deep cranial tissue such as the sphenoid sinus.

It was reported that the accuracy rate of sex determination is 100 % from a complete skeleton, 98 % from both the pelvis and the cranium, 95 % from the pelvis and the long bones, and 80–90 % from the long bones only (Teke *et al*., 2007). In cases of mass disasters, even the skull and other bones are severely blemished, it has been reported that paranasal sinuses remain intact because of their gas-filled bone structures. Among the four pairs of paranasal sinuses, the sphenoid sinus is the deepest and the least susceptible to injury.

Zecchi *et al*. (1983) studied the three dimensions and the volume of the sphenoid sinus of 300 human cranial radiograms and stated that the measurements and volume of sphenoid sinus between both sexes were significantly different. A study conducted by Oliveira *et al*. (2009) about sex determination from area and volume of the sphenoid sinuses showed that the sphenoid sinus was larger in males than in females and thus can be used to evaluate sexual dimorphism.

It was described that there is a significant variation in the structure of the sphenoid sinus, which contributes to the few papers published defining the sphenoidal configuration and its anatomy (Fujioka & Young, 1978). In 2014, Yamashita *et al*. (2014) divided the sphenoid sinus variations into four types as conchal, presellar, postsellar and sellar. In 2016, Auffret *et al*. (2016) established an anatomical classification system of the sphenoid sinuses anatomical variations and evaluated the value of visual comparison of the CT anatomical aspects of the sphenoid sinuses, and indicated that visual comparison of sphenoid sinuses CT could be an efficient, non-invasive method for personal identification.

The results of present study showed that the height, anterior-posterior diameter, area, and perimeter in the midsagittal view of the sphenoid sinuses was lager in males as compared to females which is similar to the above research.

However, our study has limitations, such as selecting only living volunteers, while postmortem degradations of the skull could be consequent, particularly in traumatic deaths. On the other hand, the sample size is relatively small. Nonetheless, it was shown that sphenoid sinus could be used to some extent for sex identification.

Identification using paranasal sinuses three-dimensional reconstruction from CT seems to be a very popular and non-invasive perspective. However, single three-dimensional reconstructions of the sphenoid sinuses, to our knowledge, have been studied rarely. This may be due to the fact that the sphenoid sinus and ethmoid sinus are connected, so it is difficult to reconstruct the sphenoid sinus alone.

From our study, we can conclude that sphenoid sinus could be used as one of the aids for sex determination, especially if other methods used in the field of forensics are not available. Although only 62.9 % of females and 63.6 % of males were correctly classified, a high level of accuracy rate may be achieved by adding other information of sphenoid sinus. It suggests the use of MRI in forensics thus obviating the complete dependence on the usage of conventional CT and promoting the development of forensic anatomy at the soft tissue level.

**HAI-YAN, L.; ZI-YANG, B.; WANG, J.; XIAO-FANG, Y.; TAE-GEON, K.; KE-MING, Y.;XIU-PING, W. & LI, B.** Aplicación de las características morfológicas del seno esfenoidal en la estimación de sexo basada en imágenes de resonancia magnética. *Int. J. Morphol., 41(4)*:1166-1170, 2023.

**RESUMEN:** La determinación del sexo de personas desconocidas juega un papel importante en la ciencia forense. Como la mayoría de los huesos utilizados para la determinación del sexo se recuperan en un estado incompleto, a menudo es necesario utilizar huesos recuperados intactos, por ejemplo, el seno esfenoidal. Este estudio tuvo como objetivo evaluar el valor diagnóstico de las dimensiones de los senos esfenoidales para la determinación del sexo utilizando imágenes de resonancia magnética en individuos adultos chinos. Se seleccionaron retrospectivamente imágenes de resonancia magnética de 79 senos esfenoidales (de 44 hombres y 35 mujeres). La altura, el diámetro anteroposterior, el área y el perímetro de los senos esfenoidales, se midieron en vista mediana sagital. Todos los datos se sometieron a análisis funcional descriptivo y discriminativo con prueba t no pareada y discriminante canónico. La comparación entre los grupos de hombres y mujeres mostró diferencias estadísticas significativas en cuanto a la altura, el diámetro anteroposterior, el área y el perímetro de los senos esfenoidales. La tasa de precisión predictiva del seno esfenoidal para identificar el sexo fue del 63,6 % en hombres y del 62,9 % en mujeres, con una precisión general del 63,3 %. Este estudio propuso la importancia del dimorfismo sexual de las dimensiones del seno esfenoidal, especialmente si no se dispone de otros métodos. Se sugiere utilizar la resonancia magnética en la ciencia forense, obviando así la dependencia total del uso de la tomografía computarizada convencional y facilitando con esto el estudio de la anatomía forense a nivel de los tejidos blandos.

**PALABRAS CLAVE: Ciencias forenses; Seno esfenoidal; Resonancia magnética; Determinación de sexo.**

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