*Original Article*

# Location of the Sphenopalatine Foramen in Thai Cadavers

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***Background:*** The sphenopalatine artery which supplies most of the blood to the nasal mucosa is encased in the sphenopalastine foramen [SPF]. Knowing the location of the SPF is mendatory in sinonasal surgery in order to control posterior epistaxis and to avoid iatrogenic injury of the vessel.

***Objective:*** To determine the location and morphometric evaluation of the SPF in its relation to surrounding anatomical landmarks.

***Materials and Methods:*** The lateral nasal wall of 66 embalmed half-headed Thai cadavers 20 years of age at death were dissected to expose the SPF and nearby structures. The mean diameters and distances between the SPF and fixed anatomical landmarks on the lateral nasal wall were determined-i.e. the horizontal ground lamella of the middle turbinate [HGLMT], the natural ostium and roof of the maxillary sinus, and the opening of the Eustachian tube.

***Results:*** The respective mean vertical and horizontal diameter of the SPF was 6.1 and 4.9 mm. The SPF is situated antero-superiorly to the posterior end of the middle turbinate. The 71.2% of the foramina were located above the attachment of the HGLMT (i.e., opened into the superior meatus) while the other 28.8% overrode the level of the HGLMT attachment (i.e., opened into the superior and middle meati). The respective mean distances from the SPF to the HGLMT, the natural ostium of the maxillary sinus, the opening of the Eustachian tube, and the roof of the maxillary sinus was 5.6, 18.1, 18.9 and 11.8 mm

***Conclusion:*** The location of the SPF is mostly above the attachment of the horizontal ground lamella of the middle turbinate and anterosuperiorly to the posterior end of the middle turbinate. Surgeons who treat posterior epistaxis should observe above the HGLMT to find the artery leading into the SPF. Surgical procedures around the natural ostium of the maxillary sinus may lead to bleeding from the sphenopalatine artery; particularly, when extending close to the posterior wall of the maxillary sinus at the level of upper 1/3 and lower 2/3 junction of the height of the sinus.

***Keywords:*** Sphenopalatine foramen, Sphenopalatine artery, Epistaxis, Ground lamella of middle turbinate

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Epistaxis is a condition that may need urgency/emergency management. For those with intractable epistaxis especially bleeding from the sphenopalatine artery, massive epistaxis will occur and need emergency management either by nasal packing, arterial ligation/cauterization or arterial embolization. However, nowadays SPA ligation/cauterization is preferred than nasal packing and arterial embolization because of shorter hospital stay, less morbidity and more cost effectiveness [1,2]. SPA ligation for intractable bleedings has been proved to be very efficacious with a success rate between 85 and 93% [3-9].

The sphenopalatine artery-the terminal branch of the internal maxillary artery-is the major vascular supply of the nasal cavity. It enters the nasal cavity through the sphenopalatine foramen [SPF]. The SPF is formed by the under surface of the body of the sphenoid bone and the sphenopalatine notch of the palatine bone. In the articulated skull, the SPF leads from the pterygopalatine fossa into the posterior part of the superior nasal meatus and transmits the

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sphenopalatine vessels together with the nasopalatine branch of the maxillary nerve.

The textbook description of the SPF places its opening just above the attachment of the posterior end of the middle turbinate[10]. Previous studies, however, confirm that it is not true for all skulls[11-14]. Wareing et al[11] described the arrangement of the SPF as three classes. In the Class I arrangement, the entire opening of the SPF lies within the superior meatus. In the Class II arrangement, the opening of the SPF opened into both the superior and middle meatus. In the Class III arrangement, there were separate openings into the superior meatus and the middle meatus. Scanavine et al[12] reported three groups of the SPF: viz., Group 1, the opening of the SPF lies within the superior meatus; Group 2, the opening of the SPF lies between the superior and middle meatus; and, Group 3, the opening of the SPF lies within the middle meatus. An Asian study by Lee et al[13] reported that most of the SPF lies within the superior meatus while a few foramina extended superiorly beyond the posterior portion of the lamella of the superior turbinate, and there was no SPF extending inferiorly beyond the middle turbinate. In another Asian study by Alherabi et al[14], the SPF was situated within the superior meatus and some extended downwards to the middle meatus. These dissimilarities indicate that there are variable routes of the major blood supply to the nasal cavity. The study of the SPF location, including its relationship with nearby landmarks, can be helpful for sinonasal surgery. The current study thus aimed to determine the location of the SPF and morphometric evaluation of its relation to fixed anatomical landmarks.

## Materials and Methods

This descriptive study was conducted at the Faculty of Medicine, Khon Kaen University, Thailand. Eligibility criteria were: Thai ethnic embalmed male or female cadavers over 20 years of age at death. Unidentifiable cadavers and those with damaged, indistinct and indiscernible bony landmarks were excluded (i.e., SPF, natural ostium of maxillary sinus, opening of Eustachian tube, and horizontal ground lamella of the middle turbinate [HGLMT]). The lateral nasal walls were meticulously dissected and the anatomical distances were measured using a Mitutoyo digital Vernier in the following order:

1) Identify the SPF and determine its relationship to the attachment of the HGLMT.

2) Cut the superior and middle turbinates with the remaining part of the HGLMT attached to lateral nasal wall.

3) Identify the natural ostium of maxillary sinus and measure the distance from the posterior edge of the ostium to the center of the SPF.

4) Measure the distance between the center of the SPF and the center of the Eustachian tube;

5) Measure the bony vertical and horizontal diameters of the SPF.

6) Draw a straight line from the posterior aspect of the maxillary sinus ostium to the center of the Eustachian tube then measure the vertical distance from this line to the center of the SPF.

7) Remove the medial wall of the maxillary sinus with and its mucosa then determine the relationship between the SPF and the posterior wall of the maxillary sinus in coronal plane.

8) Remove the mucoperiosteum of the lateral nasal wall and look for the accessory SPF.

9) Measure the vertical distance between the roof and the base of the maxillary sinus, and the distance between the roof of the maxillary sinus and the center of SPF.

The current pilot study was conducted on 9 cadavers. The SPF in 7 specimens opened into the superior meatus. The study of 66 embalmed specimens were then dissected and investigated; based on the pilot study with a 95% confidence interval and a precision of prevalence of the SPF opening in the superior meatus of 10%. The results were statistically analysed. The nominal data were presented with a point estimate and the 95% confidence interval. Continuous data were tested for normality of distribution. If the data had a normal distribution, the mean with the 95% confidence interval were presented, but if not the median with the 25$^{th}$ and 75$^{th}$ percentile were presented.

The present study was approved by the Khon Kaen University Ethics Committee on Human Research.

## Results

The study comprised 47 males and 19 females (between 27 and 95 years of age at time of death) (mean, 65 years). The respective number of right and left specimens was 30 (45.5%) and 36 (54.5%). Sixteen specimens were half skulls from different cadavers.

The SPF of all specimens were located antero-superiorly to the posterior end of the middle turbinate and 47 of them (71.2%; 95% CI: 59.4 to 80.7) opened into the superior meatus. The SPF of 19 specimens (28.8%; 95% CI: 19.3 to 40.6) were found to open into both the superior and middle meati (Table 1). There was no specimen with the orifice of the SPF opening

into the middle meatus only. The accessory openings were also absent.

The upper rim of the SPF was situated above the HGLMT (distance range, 1.7 to 8.3 mm; mean 5.6; 95% CI 5.3 to 6.0). In specimens for which the SPF had an overriding attachment of the HGLMT, the lower rim of the SPF was situated below the HGLMT (distance range, 1.0 to 4.0 mm; mean 1.8; 95% CI 1.4 to 2.3) (Table 2 and 3).

The vertical diameter of the SPF ranged between 3.9 and 12.1 mm (mean, 6.1; 95% CI 5.8 to 6.5). The horizontal diameter of the SPF ranged between 3.3 and 7.6 mm (mean, 4.9; 95% CI 4.7 to 5.2) (Table 4).

The distance between the natural ostium of the maxillary sinus and the SPF ranged between 11.2 and 25.1 mm (mean, 18.1; 95% CI 17.2 to 18.9). The distance between the SPF and the opening of the Eustachian tube ranged between 9.1 and 38.4 mm (mean, 18.9; 95% CI 18.1 to 19.7). The distance between the ostium and the opening of the Eustachian tube ranged between 20.6 and 41.5 mm (mean, 33.4; 95% CI 32.3 to 34.6). The SPF situated above the line joining the ostium to the opening of the eustachian tube with vertical distance ranged from 5.0 to 11.4 mm (mean 8.0, 95% CI 7.7 to 8.3) (Table 5, Figure 1).

The distance of the SPF below the level of the roof of the maxillary sinus ranged between 6.5 to 19.1 mm (mean, 11.8; 95% CI 11.1 to 12.5). The SPF was situated (a) behind the posterior wall of the maxillary sinus in 39 specimens (59.1%); (b) on the same plane of the sinus in 26 (39.4%); and, (c) in front of the sinus in one specimen (1.5%) (Table 6, Figure 2).

There was no statistically significant difference in any of the variables with respect to sex.

## Discussion

Endoscopic ligation of the sphenopalatine artery is an increasingly popular management of intractable posterior epistaxis. The sphenopalatine

**Table 1.** Location of SPF in relation to insertion of horizontal ground lamella of middle turbinate [HGLMT]

| | SPF above HGLMT | | | SPF bestride HGLMT | | |
|---|---|---|---|---|---|---|
| | n | % | 95% CI | n | % | 95% CI |
| Males (n = 47) | 31 | 66.0 | 51.7 to 77.8 | 16 | 34.0 | 22.2 to 48.3 |
| Females (n = 19) | 16 | 84.2 | 62.4 to 94.5 | 3 | 15.8 | 5.5 to 37.6 |
| Total (66) | 47 | 71.2 | 59.4 to 80.7 | 19 | 28.8 | 19.3 to 40.6 |

**Table 2.** Distance between upper rim of SPF and HGLMT

| | Range (mm) | Mean (mm) | 95% CI |
|---|---|---|---|
| Males (47) | 1.7 to 8.3 | 5.7 | 5.2 to 6.1 |
| Females (19) | 2.7 to 7.8 | 5.5 | 5.0 to 6.0 |
| Total (66) | 1.7 to 8.3 | 5.6 | 5.3 to 6.0 |

**Table 3.** Distance between lower rim of SPF and HGLMT in case of overriding arrangement

| | Range (mm) | Mean (mm) | 95% CI |
|---|---|---|---|
| Males (16) | 1.0 to 4.0 | 1.9 | 1.4 to 2.4 |
| Females (3) | 1.6 to 2.0 | 1.8 | 1.3 to 2.3 |
| Total (19) | 1.0 to 4.0 | 1.8 | 1.4 to 2.3 |

**Table 4.** Diameters of SPF

| | Vertical diameter | | | Horizontal diameter | | |
|---|---|---|---|---|---|---|
| | Range (mm) | Mean (mm) | 95% CI | Range (mm) | Mean (mm) | 95% CI |
| Males (47) | 3.9 to 12.1 | 6.3 | 5.9 to 6.7 | 3.3 to 7.6 | 4.9 | 4.6 to 5.2 |
| Females (19) | 4.2 to 8.0 | 5.8 | 5.3 to 6.2 | 3.7 to 7.1 | 5.2 | 4.6 to 5.7 |
| Total (66) | 3.9 to 12.1 | 6.1 | 5.8 to 6.5 | 3.3 to 7.6 | 4.9 | 4.7 to 5.2 |

**Table 5.** Distance between SPF, natural ostium of maxillary sinus [OS], and opening of Eustachian tube [ET]

| Distance (mm) | Male (47) | Female (19) | Total (66) |
|---|---|---|---|
| OS-SPF | | | |
| Range | 11.2 to 25.1 | 11.5 to 22.7 | 11.2 to 25.1 |
| Mean | 18.3 | 17.5 | 18.1 |
| 95% CI | 17.3 to 19.4 | 15.9 to 19.1 | 17.2 to 18.9 |
| SPF-ET | | | |
| Range | 9.1 to 38.4 | 15.2 to 20.7 | 9.1 to 38.4 |
| Mean | 19.3 | 18.1 | 18.9 |
| 95% CI | 18.2 to 20.4 | 17.3 to 18.8 | 18.1 to 19.7 |
| OS-ET | | | |
| Range | 20.6 to 41.5 | 21.8 to 38.0 | 20.6 to 41.5 |
| Mean | 34.1 | 31.8 | 33.4 |
| 95% CI | 32.7 to 35.5 | 29.7 to 33.8 | 32.3 to 34.6 |
| SPF-"OS-ET line" | | | |
| Range | 5.0 to 11.4 | 6.1 to 10.1 | 5.0 to 11.4 |
| Mean | 8.1 | 7.8 | 8.0 |
| 95% CI | 7.6 to 8.5 | 7.3 to 8.3 | 7.7 to 8.3 |
| "Intersection point from SPF to OS-ET line"-ET | | | |
| Range | 10.6 to 23.9 | 12.3 to 20.3 | 10.6 to 23.9 |
| Mean | 17.5 | 17.4 | 17.5 |
| 95% CI | 16.6 to 18.3 | 16.5 to 18.4 | 16.8 to 18.1 |

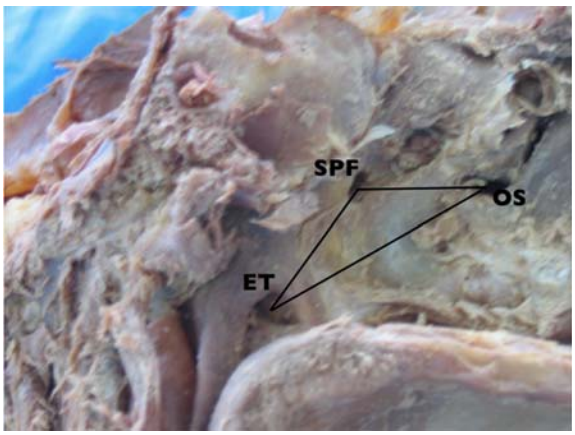


**Figure 1.** Photograph and diagram of lateral nasal wall with removal of mucosa and turbinates showing relationship of the sphenopalatine foramen [SPF], natural ostium of maxillary sinus [OS], horizontal ground lamella of middle turbinate [HGLMT], and opening of eustachian tube [ET].

artery enters the nasal cavity through the sphenopalatine foramen, which is located on the lateral nasal wall, and has many variations vis-a-vis location and number. Its boundaries include the sphenoidal process of the palatine anteriorly, the palatine orbital process posteriorly, the perpendicular plate of the palatine superiorly, and the pterygopalatine fossa laterally. Thus, knowledge of the location of SPF is essential for the endoscopic sinus surgeon.

The current study demonstrated that most (71.2%) of the SPFs open into the superior meatus. This high prevalence was in contrast to the results reported by Alherabi et al[14] (25%) and Wareing et al[11] (35%), but in conformity with Scanavine et al[12] (81.5%), Scanavini et al[15] (87%), and Lee et al[13] (90%). In the current study, we did not find multiple SPFs in any specimen. Wareing et al[11] and Scanavini et al[15] reported this uncommon occurrence in 9% and 13%, respectively.

The current study determined the relationship between the SPF and the other fixed anatomical landmarks, which might a surgeon to better locate the SPF (i.e., that the SPF is situated at the junction of the upper one-third and lower two-thirds of the vertical height of the maxillary sinus in the coronal plane of the posterior wall of the sinus or behind the sinus). The distance, moreover from the natural osmium of the maxillary sinus to the SPF is approximately half of the distance from the osmium to the Eustachian tube.

**Table 6.** Height of maxillary sinus and distance from roof of maxillary sinus to SPF

| | Height of maxillary sinus (mm) | | | Distance between roof of maxillary sinus and SPF (mm) | | |
|---|---|---|---|---|---|---|
| | Range | Mean | 95% CI | Range | Mean | 95% CI |
| Males (47) | 24.0 to 48.6 | 37.8 | 36.1 to 39.4 | 6.5 to 19.1 | 12.3 | 11.5 to 13.1 |
| Females (19) | 21.9 to 39.1 | 32.7 | 29.8 to 35.5 | 6.5 to 14.4 | 10.6 | 9.4 to 11.8 |
| Total (66) | 21.9 to 48.6 | 36.3 | 34.8 to 37.8 | 6.5 to 19.1 | 11.8 | 11.1 to 12.5 |

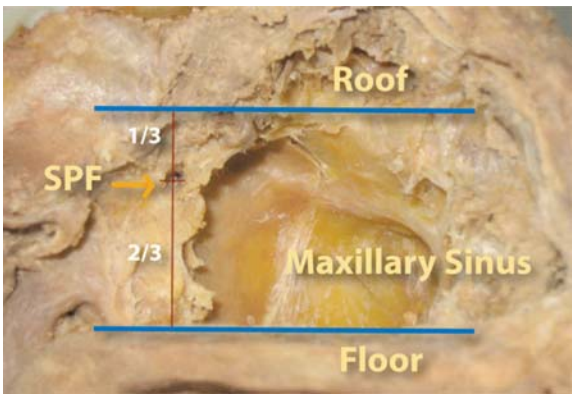


**Figure 2.** Photograph and diagram of lateral nasal wall with removal of mucosa, turbinates and medial wall of maxillary sinus [MS] showing relationship between the sphenopalatine foramen [SPF] and height of posterior wall of maxillary sinus.

## Conclusion

The current study advised the location of the SPF in relation to the fixed anatomical landmarks that may assist in rapid observation of the sphenopalatine artery. As a rule, surgeons who treat posterior epistaxis should observe above the HGLMT to find the artery in the SPF. Surgical procedures, moreover, around the natural ostium of the maxillary sinus and the Eustachian-tube orifice may inadvertently lead to bleeding from the sphenopalatine artery-particularly when the surgery is extending close to the posterior wall of the maxillary sinus at the level of the upper one-third and lower two-thirds junction of the height of the sinus.

## What is already known on this topic?

There has been no study on the location of the SPF with respect to nearby landmarks for sinonasal surgery in Thais in Thailand.

## What this study adds?

The present study shows that most SPFs open into the superior meatus. The SPF is situated at the junction of the upper one-third and lower two-thirds of the vertical height of the maxillary sinus in the coronal plane of the posterior wall of maxillary sinus or behind the sinus. The distance from the natural ostium of the maxillary sinus to the SPF nearly equals half of the distance from the ostium to the Eustachian-tube orifice.

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## Potential conflicts of interest

The authors declare no conflicts of interest.

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