

Sphenopalatine foramen landmarks: a CT study

By

**Mohammad Waheed El-Anwar¹, Alaa Omar Khazbak², Atef Hussein³, Sameh Saber⁴,
Ahmed Awad Bessar⁴**

¹ Professor, Otorhinolaryngology-Head and Neck Surgery Department,
Faculty of Medicine, Zagazig University, Egypt

² Assistant professor, Otorhinolaryngology-Head and Neck Surgery
Department, Faculty of Medicine, Zagazig University, Egypt

³ Lecturer, Otorhinolaryngology-Head and Neck Surgery Department,
Faculty of Medicine, Zagazig University, Egypt

⁴ Lecturer, Radio diagnosis Department, Faculty of Medicine, Zagazig
University, Egypt

† Corresponding author; Mohammad Waheed El-Anwar

Address: Otorhinolaryngology, Head and Neck Surgery Department,
Faculty of Medicine, Zagazig University, Egypt.

Tel: 00201004695197 **Email:** mwenteg@yahoo.com

Financial support: the authors declare no financial support or interest to this
study.

Conflict of Interest: the authors declare no conflict of interest.

Running title: Sphenopalatine foramen assessment

Sphenopalatine foramen landmarks: a CT study

Abstract

Objective: to assess different radiological bony landmarks for endoscopic localization of the sphenopalatine foramen (SPF).

Patients and methods: Paranasal computed tomography (CT) scans of adults without sinonasal pathology were included. On axial cuts, the anteroposterior distances from the SPF to maxillary line, anterior head of the middle turbinate, basal lamella of the middle turbinate, choanal arch and posterior fontanel of the maxillary sinus ostium were measured. While on coronal cuts, the vertical distances from the SPF to the nasal floor was measured. The registered measurements were then studied and statistically analyzed.

Results: In 70 subjects (140 sides, 840 measurements), the mean distances from the SPF to nasal floor, choanal arch, maxillary line, anterior head of the middle turbinate, basal lamella, and posterior fontanel were 25.6 ± 2.4 mm, 8.5 ± 1.38 mm, 36.4 ± 2.6 mm, 34.6 ± 4.26 mm, 8.1 ± 1.27 mm and 13.7 ± 1.7 mm respectively without significant differences between right and left sides. Females showed significantly shorter mean distances between SPF and the nasal floor ($p= 0.0011$), choanal arch ($p= 0.0459$) and posterior fontanel ($p < 0.0001$) than males. While no significant differences were detected between both sexes as regard distances from SPF to maxillary line ($P= 0.5579$), anterior head of middle turbinate ($p= 0.8581$) and basal lamella ($p= 0.0638$).

Conclusion: Preoperative CT can provide multiple easily detected, reliable and simple bony landmarks that can help SPF endoscopic localization. Thus we recommend adding these measurements to the preoperative CT checklist for patients scheduled for SPA ligation and/or excision of vascular lesions.

Keywords: Sphenopalatine foramen, Sphenopalatine artery, Endoscopic Sinus Surgery, Sinus Surgery, CT, ESS.

Introduction

Epistaxis is one of the commonest otorhinolaryngology emergencies that are seen in about 10% of the population ⁽¹⁻²⁾. Even though, 90% of epistaxis arises from Kiesselbach plexus anteriorly, lateral nasal wall represents the primary site of refractory posterior epistaxis ⁽¹⁻⁴⁾. Because sphenopalatine artery (SPA) with its branches, provide the blood supply to the lateral nasal wall and part of the nasal cavity, thus it is considered the most common source of posterior epistaxis ^(1,3,4).

Severe posterior epistaxis that is refractory to conservative management usually demands surgical cauterization or ligation of the SPA ^(3,5-7).

The direct transnasal endoscopic SPA ligation or cauterization is now considered the procedure of choice due to its effectiveness and low morbidity ^(4,7) with no need for sinus dissection ⁽³⁻⁵⁾. The sphenopalatine foramen (SPF) is identified after mucoperiosteal flap elevation and crista ethmoidalis identification from the posterior aspect of the middle meatus. Sometimes, when landmarks of SPF are not detected easily and rapidly, the maxillary sinus is opened to assist the surgeon to identify the SPF ⁽⁷⁾.

Failure of SPA ligation or cauterization may reach up to 10 % ⁽⁸⁾ that was attributed to the wide anatomical variations of the SPF and SPA in the lateral nasal wall ⁽⁹⁾. In addition, localization of the SPA as it exits SPF may be not easy and challenging due to the active bleeding that could obscure the operative field, due to the friability and edema of the nasal tissues by previous nasal packing ⁽⁷⁾, or by previous surgery or trauma. Therefore, presence of reliable simple fixed surgical landmarks to identify the SPF would be more helpful than the traditional reliance on the crista ethmoidalis. Thus, preoperative proper radiological

localization of SPA during endoscopic sinus surgery (ESS) will make the operation more safe and carries less incidence of morbidity.

Although the anatomical location of the SPF has been reported in previous studies, there are few studies on the computed tomography (CT) bony landmarks ^(7, 10) and the CT landmarks are still not popularized among surgeons or radiologists and not investigated on different races.

Therefore, the aim of this study is to evaluate different radiological landmarks for localization of the SPF.

Patients and methods

This study was conducted in otorhinolaryngology and radio-diagnosis departments, Zagazig University Hospitals, between August 2016 and June 2018. The study was approved by Zagazig University IRB and written informed consent was obtained from included subjects. All participants were selected from subjects referred to CT examination of the head of different etiologies (parotid gland, brain, the mandible and temporomandibular joint). MSCT examination of the nasal cavity was done as a part of the requested examination.

Included subjects were asymptomatic adults (as regard nose and paranasal sinus). Proper history taking, clinical and endoscopic nasal examination, and then MSCT examination were done for all cases and any case with nasal or PNS lesion was excluded. Subjects younger than 20 years, patients who underwent previous sinonasal surgery, or patients with sinonasal pathology or trauma were excluded from the study.

All CT examinations were performed with a 64-slice CT scan (Phillips Ingenuity core 128 TM (v3.5.7.25001, Philips healthcare systems, Netherlands). We used the protocol of 64-

slice MDCT with a detector width of 0.625 mm, a section width of 1.5 mm and an interval reconstruction of 0.5 mm.

We took axial cuts while the subject was in supine position and the beam was parallel to the hard palate. The cuts began from the hard palate to the top of frontal sinus (glabella), using 130 KV and 150 mA/sec with scan time 1.5 sec. Wide window (Window widths about 1300 to 2000 and window levels about -80 to-200). Examinations were done with bone window setting of 2000 HU, centered at 300 HU. High-resolution algorithm was used for enhancement of the fine bony details.

A dedicated post-processing workstation (Extended Brilliance Workspace; Philips medical System- PHILIPS IntellSpace Portal) was used for multiplanar reconstructions and coronal plane we got delicate detail for all subjects. Films were inspected in routine standardized fashion to ensure that small details are not missed.

On axial cuts, the anteroposterior distances from the SPF to maxillary line, anterior head of the middle turbinate, basal lamella of the middle turbinate, choanal arch ⁽⁷⁾ and posterior fontanel of the maxillary sinus ostium ⁽¹⁰⁾ were measured (figure 1) and registered from each side. While on coronal cuts, the vertical distances from the SPF to the nasal floor was measured and recorded ⁽¹¹⁾ (figure 1A). These surgical landmarks were selected for their consistent and reliable identification during nasal endoscopy and CT examination ⁽⁷⁾.

The registered measurements were then studied and statistically analyzed using the SPSS statistical software package (version 18; SPSS, Inc., Chicago, IL, USA). P value of < 0.05 was considered statistically significant.

Results

Seventy adult subjects (140 SPFs, 840 measurements) were included; 49 male (70%) and 21 female (30%), with a mean age of 31.8 ± 7.29 years (range 21- 51).

The mean height of the SPF above the nasal floor was 25.6 ± 2.4 mm (25.6 ± 2.41 for the right side and 25.7 ± 2.41 for the left side). The mean distance from SPF to the choanal arch was 8.5 ± 1.38 mm (8.48 ± 1.33 at right side and 8.68 ± 1.21 at the left side). The mean distance between SPF and maxillary line was 36.4 ± 2.6 mm (36.40 ± 2.61 at right side and 36.37 ± 2.61 at left side). While, the mean distance between the SPF and the anterior head of the middle turbinate was 34.6 ± 4.26 mm (34.4 ± 4.17 on right side and 34.89 ± 4.16 on the left side). On the other hand, the mean distance between SPF and the basal lamella was 8.1 ± 1.27 mm (7.98 ± 1.2 at right side and 8.25 for the left side). The mean distance between SPF and the posterior fontanel of the maxillary sinus osteom was 13.7 ± 1.7 mm (14 ± 1.29 at right side and 13.6 ± 1.3 at left side). For all measured distances, there were no significant differences between right and left sides (table 1).

Females showed significantly shorter mean distances between SPF and the nasal floor ($p=0.0011$), choanal arch ($p=0.0459$) and posterior fontanel ($p<0.0001$) than males. While no significant differences were detected between both sexes as regard distances from SPF to maxillary line ($P=0.5579$), anterior head of middle turbinate ($p=0.8581$) and basal lamella ($p=0.0638$) (table 2).

Discussion

As the standard diagnostic tool, CT provides an essential guide during ESS and external nasal, paranasal, skull base and craniomaxillofacial surgeries^(12- 14). Thus, the radiologist and the endoscopic sinus surgeons should be aware of CT sinonasal details in order to perform a

safe and effective surgery. Sinonasal anatomy should be reviewed during careful preoperative CT review, as a critical step in the preoperative planning for ESS ⁽¹²⁾.

Severe epistaxis that usually arises from the posterior portion of the nose is potentially life-threatening and mostly requires surgical intervention. Because SPA provides the main blood supply to the posterior nose, its endoscopic ligation or cauterization is the currently favored and popular intervention to control intractable posterior epistaxis ⁽⁴⁾.

On the other hand, injury to the SPA during sinonasal operations may delay the progress of surgery and excessive bleeding could increase the risk of orbital complications by disturbing the operating field. In addition, in some cases, bleeding may make it hard to continue the surgery. So, it is highly important to precisely localize the SPA preoperatively. Moreover, the knowledge of SPA location is inevitable in transnasal neurosurgery ⁽¹⁵⁾.

Traditionally, endoscopic SPF localization basically depends on identifying the ethmoidal crest of the palatine bone, onto which the middle turbinate is attached ⁽¹⁰⁾. However, the SPF may open purely in the superior meatus, above the middle turbinate and the ethmoidal crest of the palatine bone (class I), the SPF may span the ethmoidal crest to open at the transition of the superior and middle meatus (class II), or two distinct SPFs open on either side of the ethmoidal crest (class III) ⁽¹⁶⁾. Such anatomical variations of the SPF or its surroundings can result in failure of operative SPF identification. In addition, SPF identification becomes more difficult during active epistaxis, under medical anticoagulation therapy, with the mucosal friability after repeated nasal packing or recent surgical interventions attempts ⁽⁷⁾ or with changes caused by different nasal pathology. Thus, SPF localization in relation to reliable fixed bony landmarks is essential for optimum and harmless endoscopic approaches.

However, SPF identification via bony landmarks is poorly documented in the literature, with most available data relying on cadaveric dissection ^(15, 17) with limited surgical application ⁽¹⁰⁾.

The used cadavers in such studies can be subject to artifactual damage and it is harder to

detect the SPF in cadavers with artifactual tissue preservation ^(10, 17). On the other hand, even though endoscopic studies are helpful in expecting the site of the SFA, such studies do not provide actual SPF localization for the operated patient himself as can do the patient's preoperative CT. Thus, depending on preoperative CT for SPF localization definitely provides accurate and real SPF relations to the endoscopically detectable fixed bony landmarks of same patients before and during the surgical intervention.

So recently, authors, directed to CT studies searching for dependable SPF landmarks ^(7, 10, 11). Nalavenkata et al ⁽¹⁰⁾ suggests the posterior fontanel and inferior turbinate attachment as reliable surgical landmarks for endoscopic approaches to the SPF. Although, inferior turbinate attachment is easily detected on CT, it is not easily nor accurately localized during ESS because inferior turbinate has large non bony part (mucosa and submucosal tissue) particularly medially and the inferior turbinate is the most susceptible turbinate to enlargement ⁽¹⁸⁾. So we could not consider the inferior turbinate attachment as a consistent endoscopic landmark. Later, Maxwell et al ⁽⁷⁾ proposed utilizing the CT expected distances from SPF to five simple endoscopic bony landmarks as guides to the most likely site of the SPA⁽⁷⁾. These landmarks were selected because of easy endoscopic localization and their expected presence, even after previous trauma or operation ⁽⁷⁾. In current study, we assessed these five landmarks plus the posterior fontanel in our population as landmarks for the SPF.

Because the maxillary sinus reaches its mature size approximately at the age of twenty years after full development of the permanent teeth ^(13, 19), only subjects older than 20 years were included in current study.

In our study, we found that the SPF was 25.6 ± 2.4 mm above the nasal floor, 8.5 ± 1.38 anterior to choanal arch, 36.4 ± 2.6 posterior to maxillary line, 34.6 ± 4.26 posterior to anterior

head of middle turbinate, 8.1 ± 1.27 from basal lamella and 13.7 ± 1.7 posterior to the posterior fontanel. Current measured distances are near to the distances reported before^(7, 10).

Distances between SPF and the nasal floor, choanal arch, posterior fontanel were significantly longer in males than females, in accordance with the larger dimensions of the nasal cavity typically seen in males^(7, 20). While no significant differences were detected between both sexes as regard distances from SPF to maxillary line, anterior head of middle turbinate and basal lamella.

The results of current study, in agree with Maxwell et al⁽⁷⁾ reported the choanal arch and basal lamella are the most reliable landmarks, as evidenced by their small standard deviations, perhaps because of their close proximity to the SPF and the SPF is nearly situated in the midpoint between the choanal arch and basal lamella. Thus the quickest initial way to localize the SPF in initial ESS is to first identify the basal lamella and choanal arch as was suggested by Maxwell et al⁽⁷⁾ and this particularly beneficial during direct transnasal approach to SPF. We also found that posterior fontanel is also a reliable landmark for the same reasons and is especially valuable when maxillary antrostomy performed during SPF localization. But we think that even in the situation of maxillofacial abnormality, previous surgery or trauma with disturbed anatomy, choanal arch, maxillary line and nasal floor will be the most untouched reliable landmark for endoscopic approaches to the SPF. However all these landmarks need to be investigated in revision cases.

The described radiographic measurements may be used to direct the mucosal flap assignment during SPA ligation so elevate a smaller flap directly toward the SPF or coagulate directly on top of it⁽⁷⁾.

Distance between posterior fontanel and SPF is few millimeters (about 4 mm) longer than distance measured before by El-Anwar et al⁽¹³⁾ from MSO to posterior maxillary wall (9.2± 3.4 mm). Thus we insure that widening the MSO posteriorly should be cautiously done using cutting instrument to avoid traction on the SPA⁽¹³⁾ particularly in females who showed significantly nearer SPF (p< 0.0001).

We believe that identification of these reliable fixed bony landmarks that are easily identified on CT of the paranasal sinuses will be useful for all Rhinologist who endoscopically manage sever intractable epistaxis when the field is usually obscured by excessive bleeding or during ESS to avoid iatrogenic SPA. In addition, preoperative accurate radiological localization of the SPA through these landmarks will minimize the operative time used for intraoperative identification of the site of the SPA

The addition of the described simple and dependable surgical landmarks to localize the SPF would be valuable beside the traditional reliance on the crista ethmoidalis. So we recommend adding these measurements to the preoperative check list particularly for patients had severed epistaxis or vascular pathology as angiofibroma.

Conclusion

Preoperative CT can provide multiple easily detected, reliable and simple bony landmarks that can help SPF endoscopic localization. Thus we recommend adding these measurements to the preoperative CT checklist for patients scheduled for SPA ligation and/or excision of vascular lesions such as angiofibroma..

Conflict of interest statement: The authors declare no conflict of interest.

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Figures legends:

Figure 1: Computed tomography measurements for distances between sphenopalatine foramen and nasal floor (A), choanal arch (B), maxillary line (C), anterior head of the middle turbinate (D), basal lamella (E) and posterior fontanel (F).

Table 1: Different measurements of the sphenopalatine foramen and its relations

	Side	Range (mm)	Mean± SD	T test	P value
Distance between SPF & nasal floor	Right	20.1- 30.8	25.6± 2.41	0.3928	0.6951
	Left	20.6- 31	25.76± 2.41		NS
Distance between SPF & Choanal Arch	Right	5.3- 12.3	8.48± 1.33	0.9306	0.3537
	Left	5.2- 11.2	8.68± 1.21		NS
Distance between SPF & Maxillary line	Right	29.8- 45	36.4± 2.619	0.0678	0.9461
	Left	28.4- 42.2	36.37±2.619		NS
Distance between SPF & anterior head of middle turbinate	Right	22.8- 48.7	34.4± 4.17	0.6960	0.4876
	Left	26.6- 49.6	34.89± 4.16		NS
Distance between SPF & basal lamella	Right	5.5- 11.2	7.98± 1.29	1.2723	0.2054
	Left	5.5- 11.2	8.25± 1.22		NS
Distance between SPF & posterior fontanel	Right	9.4- 16.6	14± 1.29	1.8273	0.0698
	Left	8.8-15.6	13.6 ± 1.3		NS

SD: standard deviation, mm: millimeters, NS: non-significant

Table 2: different measured distances between SPF and different landmarks in different sexes

Measured distance (mm)		Overall	Males	Females	T test	P value
Distance between SPF & nasal floor	Range	20.1- 31	20.5- 31	20.1- 27.1	3.4087	0.0011 S
	Mean± SD	25.6± 2.4	26.28± 2.35	24.3± 1.9		
Distance between SPF & Choanal Arch	Range	5.2- 11.3	6.2-12.3	5.2-10.5	2.0338	0.0459 S
	Mean± SD	8.5± 1.38	8.6± 1.37	7.9± 1.19		
Distance between SPF & maxillary line	Range	28.4- 45	28.4- 45	30.3-41.1	0.5888	0.5579 NS
	Mean± SD	36.4± 2.6	36.5 ± 2.7	36.1±2.36		
Distance between SPF & anterior head of middle turbinate	Range	22.8- 49.6	22.8- 49.6	27.7-41.3	0.1795	0.8581 NS
	Mean± SD	34.6± 4.26	34.4± 4.3	34.87±4.1		
Distance between SPF & basal lamella	Range	5.5- 11.2	5.5-11.2	6.4-10.9	1.8841	0.0638 NS
	Mean± SD	8.1± 1.27	7.9± 1.2	8.5± 1.27		
Distance between SPF & posterior fontanel	Range	8.8- 16.6	10.1-16.6	8.8-15.5	4.0319	0.0001 S
	Mean± SD	13.7± 1.7	14.17± 1	12.56± 2.36		

SPF: Sphenopalatine foramen, SD: Standard deviation, mm; millimeter, S: Significant, NS: Non-significant

