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The sphenopalatine foramen in man: anatomical, radiological and endoscopic study

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Background: *Epistaxis is a frequent problem otorhinolaryngologists faces of in their practice. The variations of the sphenopalatine foramen (SPF) and consequently the artery may be one of the major sources of such bleeding. The present work aimed to localise the site of SPF and also to illustrate its different shapes, number and any other variation.*

Materials and methods: *In the current study, 20 adult skulls of both sexes with total 40 half skulls were used in addition to 20 heads of adult living subjects of both sexes aged between 30 and 60 years examined with multislice helical computed tomography with 3-dimensional reconstruction of SPF. Then, examination of another ten dried skulls with endoscope was performed.*

Results: *The number of the SPF is varied being single in nearly 80% and multiple in 20% of examined cases. The shape of the foramen also is varied; regular in 67.5% and irregular in 32.5% of all cases. The site of the foramen on the lateral nasal wall is placed in the superior meatus in most of examined skulls (62.5%) while in the rest (37.5%) they are found in the superior meatus and extending to the middle one.*

Conclusions: *There are variation of the number, shape and site of the SPF, and consequently of the branches of the sphenopalatine artery, and this may explain the surgical failure in management of severe epistaxis. The data obtained from the current work support the predication of more than one sphenopalatine arteries and gives ample knowledge on the endoscopic study of the lateral nasal wall and consequently the surgical treatment of severe epistaxis.* (Folia Morphol 2018; 77, 2: 345–355)

Key words: sphenopalatine foramen site, sphenopalatine foramen number, sphenopalatine foramen radiology, sphenopalatine foramen endoscopy

INTRODUCTION

Epistaxis is a frequent problem otorhinolaryngologists face in their practice; severe cases are considered as a medical emergency [6]. An essential step is to identify the sphenopalatine vessels; topographic diagnosis should be as precise as possible [3]. The topographic diagnosis and surgical treatment of severe epistaxis require the surgeon to have an adequate knowledge of the lateral nasal wall anatomy [18]. The most frequent site of sever epistaxis is the

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postero-lateral wall of the nose, below the middle nasal concha, followed by the posterior part of nasal septum [3, 11]. Branches of the sphenopalatine artery irrigate this region. This artery enters the nasal cavity through the sphenopalatine foramen, and its branches are the posterior lateral and septal nasal arteries [19].

The shape of the sphenopalatine foramen (SPF) predicts the size of the sphenopalatine artery [15]. The SPF consists of a notch on the superior border of perpendicular plate of the palatine bone, between the orbital and sphenoid processes; this notch becomes a foramen at the point where the palatine bone articulates with the sphenoid bone in the lateral nasal wall. It may be a complete orifice or traversed by one or more bony spicules, suggesting more than one orifice [24].

Lee et al. [14] studied the numerical variation of the SPF and found that 61.5% were single and 38.5% were multiple. Based on these numbers he suggested that there may be an anatomical variant in the branching pattern of the sphenopalatine artery, where in 95% of cases it divides close to the SPF and in the rest of cases in the pterygopalatine fossa. This may depend on the number of foramina and may be the cause of failure in the treatment of severe epistaxis or failure in arterial ligature [24]. It is essential that surgeons possess ample knowledge of the anatomy, surgical techniques and complications, among other requirements, to undertake arterial ligature and other endoscopic procedures in the nasal cavity to avoid possible failures [10, 16]. Thus, the purpose of the current study is to describe the number, shape and site of the SPF and to elucidate any other variation.

MATERIALS AND METHODS

Dry bone study

The current study involved 20 adult skulls of both sexes. Each skull was sectioned midsagitally to expose the lateral wall of the nasal cavity. All half skulls (40) were examined for any anatomical variation or previous surgery and the broken ones were excluded. The skulls obtained from the Department of Anatomy and Embryology, Faculty of Medicine, Cairo University. The SPF was identified and examined for the site, number and shape. The site of the foramen was determined by identifying the position of the bony crest of the middle concha (MC) in relation to the foramen; accordingly the SPF was considered to be located in:

— the superior meatus (SM) when the posterior tip of the bony crest of the MC pointed to the anterior and inferior borders of the SPF;
— the middle meatus (MM) when the bony crest of the MC pointed to the anterior and superior borders of the SPF;
— between the superior and middle meatuses (SM--MM) when the bony crest of the MC pointed to the middle of the SPF. The parts that contained the bony crest of the superior concha (SC) relative to the SPF were also identified.

Measurements of the SPF were done using a sliding calliper (Vernier) measured in mm according to Wareing and Padgham [25]:

— height: the maximum vertical diameter;
— width: the maximum anteroposterior diameter.

In case of multiple foramina, the larger one was measured. In case of irregular foramen anatomical observations to locate the SPF relative to adjacent nasal cavity structures were done.

Radiological study

Multi-slice helical computed tomography (CT) with three-dimensional (3D) reconstruction for the SPF on both sides were done for 20 heads of adult living subjects of both sexes aged between 30 and 60 years old. All cases were obtained from the Department of Radiology, Kasr Al Aini Hospital, Faculty of Medicine, Cairo University, Egypt. The cases are patients attending to the hospital, complaining of headache of unknown aetiology and selected randomly, with no nasal disease or disorder. The CT was done as a part of their investigations.

Endoscopic study

The endoscopic study comprised bilateral examination of 10 complete dried skulls with a total of 20 foramina. The skulls were positioned on its back and the foramen examined endoscopically in a position simulating that in the operation room. The SPF and related region was explored using 4 mm × 18 cm, rod-lens endoscopes (Karl Storz and Co., Tuttlingen, Germany), with 0- and 30-degree lenses.

The endoscope was connected to a light source through a fibre optic cable and to a video camera coupled to a 21-inch monitor. High quality digital files were produced utilising a video camera connected to a digital recording system. Digital pictures were reproduced by coupling the digital video camera to a computer video capture system. The SPF was approached through transnasal endoscopy.

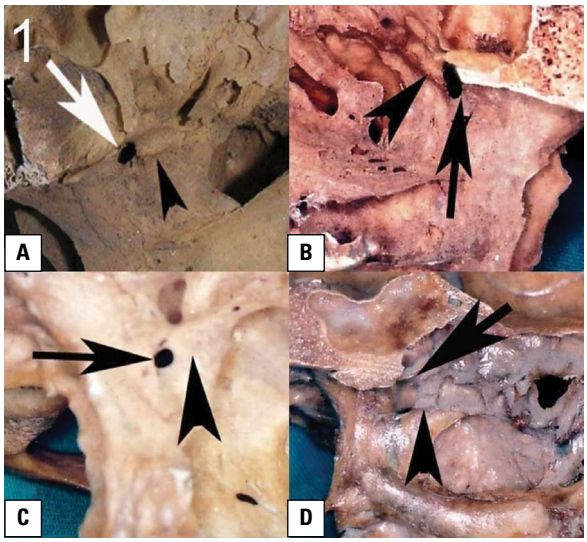

Figure 1. Sagittal section of the skull; the lateral wall of the nasal cavity showed: **A, B.** Left bony nasal cavity showing a single, oval-shaped sphenopalatine foramen (arrows). The foramen lies completely in the superior meatus above the level of bony crest of middle nasal concha (arrow head). Left (**C**) and right (**D**) bony nasal cavities showing a single, rounded shaped sphenopalatine foramen (arrow). Note that the foramen lies completely in the superior meatus above the level of bony crest of middle nasal concha (arrow head).

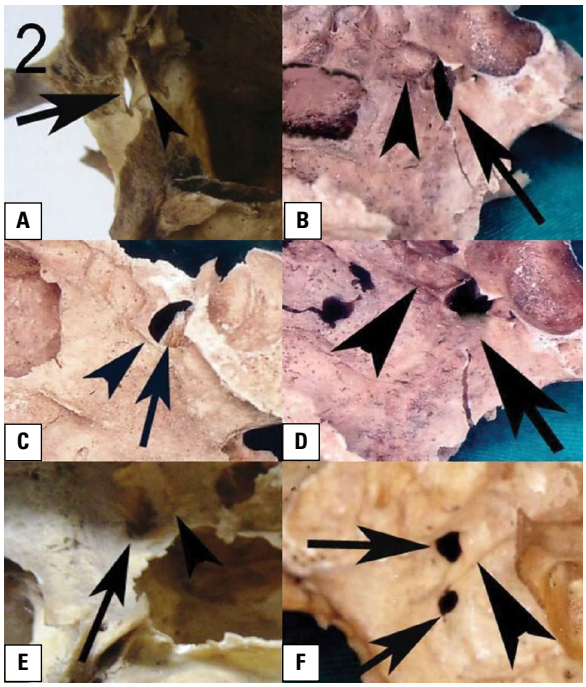

Figure 2. Sagittal section of the skull with the lateral wall of left (**A**) and right (**B**) bony nasal cavities showing a single, elliptical-shaped sphenopalatine foramen (arrows). The foramen lies in the superior meatus and extends to the middle. Note the bony crest of middle nasal concha (arrow head). **C.** Right nasal cavity showing a single, semilunar-shaped sphenopalatine foramen (arrow). The foramen lies completely in the superior meatus above the level of bony crest of middle nasal concha (arrow head). Right (**D**) and left (**E**) bony nasal cavity showing a single sphenopalatine foramen of irregular shape (arrows). The foramen lies in the superior and middle meatuses. Note the bony crest of middle nasal concha (arrow head). **F.** Double, round-shaped sphenopalatine foramina (arrows) arranged one above the other. The foramina are of nearly equal size, the upper placed in the superior meatus while the lower placed in the middle meatus. Note the bony crest of middle nasal concha (arrow head).

RESULTS

Dry bone study

On examination of dry bone specimens, it was showed that the number of SPF was variable; being single in 80% (Figs. 1A, B; 2D, E), double in 17.5 % (Fig. 3A–C) and triple in 2.5% (Fig. 3C). Thus, eight specimens presented more than one orifice (20%). In case of double foramina, they were arranged either one above the other (Fig. 2F) or one in front the other (Fig. 3A). They were of nearly equal size (Fig. 2F) or with larger upper one (Fig. 3B). In case of triple foramina, they were arranged one above the other (Fig. 3C).

The shape of the SPF was seen variable; oval in 22.5% (Fig. 1A, B), circular (rounded) in shape in 20% (Fig. 1C, D), elliptical in 7.5% (Fig. 2A, B), semilunar in 5% (Fig. 2C), triangular in 12.5% (Fig. 3B) and irregular in 32.5% (Fig. 2D, E). The irregular foramina were characterised by the presence of bony spicules of different grades which divide the foramen incompletely into compartments that were classified in the current study into two types:

— **type I:** bony spicules which divide the SPF incompletely into 2 compartments (bicompartmental). These spicules are either single, arising from posterior margin of the foramen (Fig. 3D–F), or double, arising from anterior and posterior margins of SPF (Fig. 4A);

— **type II:** bony spicules which divide the SPF incompletely into 3 compartments (tricompartmental) (Fig. 4B, C). There are either three spicules: two arising from the anterior margin of the foramen and one from the posterior margin (Fig. 4B), or two spicules: one arising from the anterior margin of the foramen and the other from inferior margin (Fig. 4C).

The number of bony spicules were variable in each foramen; single (Fig. 3D–F), double (Figs. 2D; 4A) or triple (Fig. 4B).

A study of the location of the SPF on the lateral nasal wall relative to the bony crest of MC

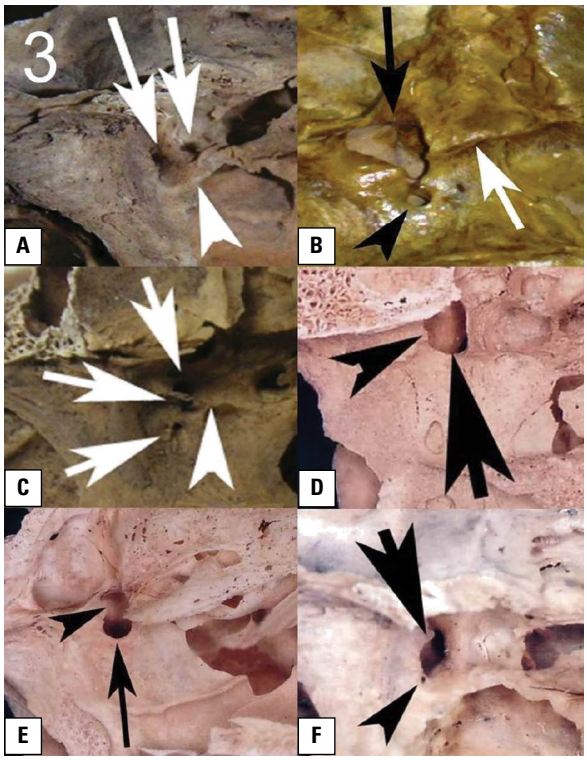

Figure 3. Sagittal sections of the skull with the lateral wall of left bony nasal cavity showing: **A.** Two round-shaped sphenopalatine foramina (arrows) arranged one anterior to the other. The foramina are of nearly equal size and they lie completely in the superior meatus above the level of bony crest of middle nasal concha (arrow head); **B.** Two sphenopalatine foramina arranged one above the other. The foramina are of different size, the upper foramen (arrow) is triangular in shape and larger while the lower (arrow head) is rounded in shape and small. The upper foramen placed in the superior meatus extends to the middle while the lower is placed totally in the middle meatus. Note the bony crest of middle nasal concha (white arrow); **C.** Left bony nasal cavity showing small, triple, oval-shaped sphenopalatine foramina (arrows). Note the foramina are arranged one above the other. The upper foramen lies in the superior meatus, the lower in the middle meatus while the middle foramen lies at the junction between superior and middle meatuses. Note the bony crest of middle nasal concha (arrow head); **D.** A single sphenopalatine foramen of irregular shape (arrow). Note the bony spicule (arrow head) that divides the foramen incompletely into two compartments (bicompartmental). One spicule arises from posterior margin of the foramen; **E.** A single sphenopalatine foramen of irregular shape (arrow). Note the bony spicule (arrow head) that divides the foramen incompletely into two compartments (bicompartmental). One spicule arises from posterior margin of the foramen; **F.** A single sphenopalatine foramen of irregular shape (arrow). Note the bony spicule (arrow head) that divides the foramen incompletely into two compartments (bicompartmental). One spicule arises from posterior margin of the foramen.

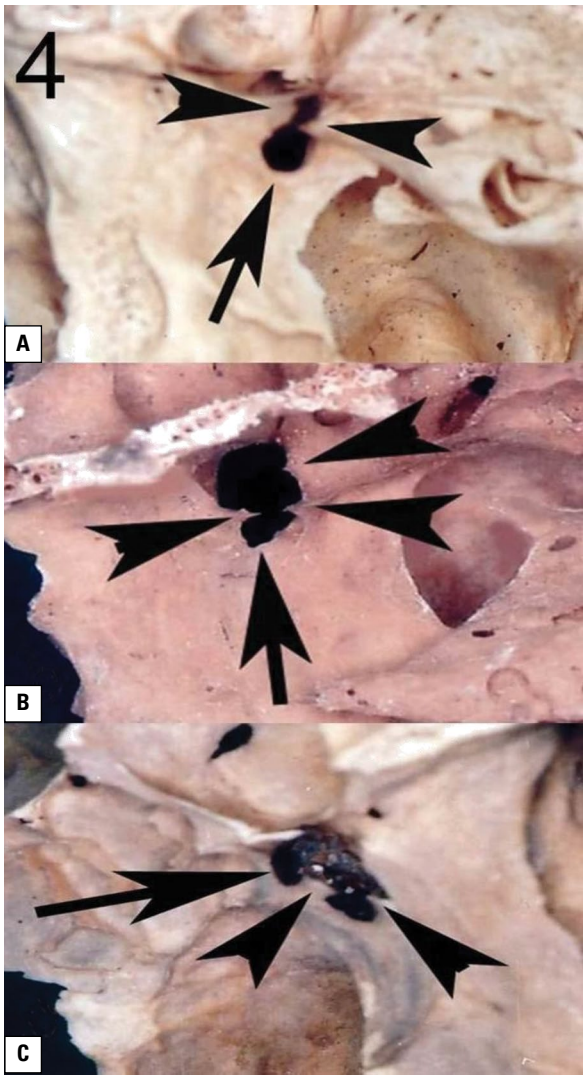

Figure 4. Sagittal section of the skull with the lateral wall of left bony nasal cavity showing: **A.** Single sphenopalatine foramen of irregular shape (arrow). Note the bony spicules (arrow heads) that divide the foramen incompletely into two compartments (bicompartmental). Two spicules arise from anterior and posterior margins of the foramen. Left (**A**) and right (**B**) bony nasal cavities showing a single sphenopalatine foramen of irregular shape (arrows). Note the bony spicules (arrow heads) that divide the foramen into three compartments (tricompartmental). The foramen lies mainly in the superior meatus and extends downward to the middle meatus. Three bony spicules appear; two arise from the anterior margin of the foramen and one arises from the posterior margin in panel **B**. In panel **C** two bony spicules appear arising from anterior and inferior margins of the foramen.

revealed that in 67.5% the bony crest of the MC pointed to the inferior border of the SPF, placing it in the superior meatus (Figs. 1C, D; 2C). The foramen was found in the superior meatus and extended to the middle one in 32.5% (Figs. 2A, B, D, E). The different positions of the SPF in relation to the bony crest of middle concha in the examined specimens were presented in Table 1.

In case of specimens with equal size, double SPF, it was found that these foramina were placed one

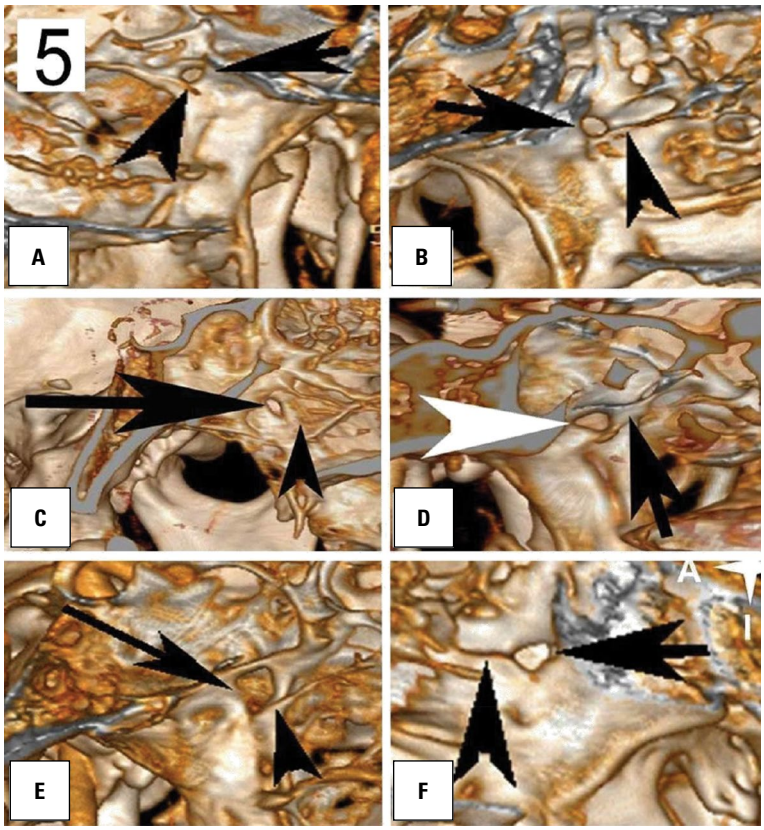

Figure 5. Multi-slice helical computed tomography with three-dimensional reconstruction of sagittal sections of the skull with the lateral wall of right (**A**) and left (**B**) nasal cavities showing a single round-shaped sphenopalatine foramen (arrows). The foramen lies completely in the superior meatus above the level of bony crest of middle nasal concha (arrow head) in panel **A** while in panel **B** the foramen lies in the superior and middle meatuses. Left nasal cavity showing a single oval-shaped sphenopalatine foramen (arrow) in panel **C** and (arrow head) in panel **D**. The foramen lies completely in the superior meatus above the level of bony crest of middle nasal concha (arrow head) in panel **C** while in panel **D** the foramen lies in the superior and middle meatuses at the level of bony crest of middle nasal concha (arrow). Left (**E**) and right (**F**) nasal cavities showing a single quadrangular-shaped sphenopalatine foramen (arrows). The foramen lies completely in the superior meatus above the level of bony crest of middle nasal concha (arrow head) in panel **E** while in panel **F** the foramen lies in the superior and middle meatuses.

Table 1. Variation of the position of the sphenopalatine foramina (SPF) in relation to the bony crest of middle nasal concha of the examined dry specimens

Position	SPF above the crest (in the superior meatus)	SPF opposite the crest (midway between superior and middle meatuses)	SPF below the crest (in the middle meatus)
Cases	27 (67.5%)	13 (32.5%)	0 (0%)

above the other; the upper one was located in the SM while the lower one was placed in the MM (Fig. 2F). If the foramina were placed one anterior to the other both were located in the SM (Fig. 3A). In case of specimens with unequal size, double SPF, the upper one was large and was placed in the SM extending to the MM while the lower one was small and was placed totally in the MM (Fig. 3B).

On measuring the SPF, it was found that the height ranged 3–9 mm with a mean of 6 ± 2 mm while the width ranged 3–8 mm with a mean of 5.5 ± 1 mm (Table 2).

Table 2. Measurements of the sphenopalatine foramina in mm in the examined dry specimens

Measurement	Range [mm]	Mean ± SD [mm]
Height	3–9	6 ± 22
Width	3–8	5.5 ± 13

SD — standard deviation

Radiological study

Multi-slice helical CT with 3D reconstruction of the SPF revealed that the number of SPFs was variable; being single in 82.5% (Fig. 5) and double in 17.5 % (Fig. 6A–C). In case of double SPF they were arranged one above the other in all studied cases, of nearly equal size (Fig. 6A–C). Triple SPF could not be detected radiologically.

The shape of the SPF was also variable; it was oval in 35%, circular (rounded) in 25% (Figs. 5A–D), quadrangular in 7.5% (Fig. 5E, F) and irregular in 32.5% (Fig. 6D; 7A–C). The irregular one was characterised by

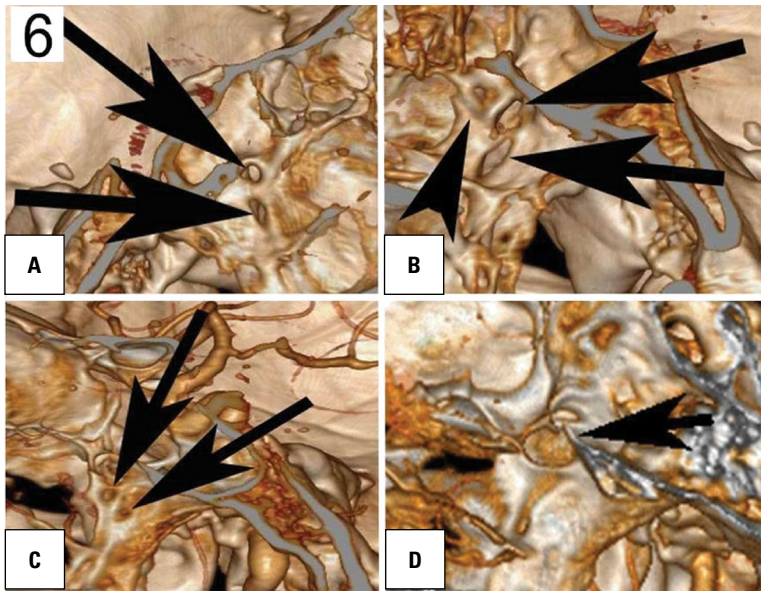

Figure 6. Multi-slice helical computed tomography with three-dimensional reconstruction of sagittal sections of the skull with the lateral wall of left (**A**) and right (**B, C, D**) nasal cavities showing: **A.** Double oval-shaped sphenopalatine foramina (arrows) arranged one above the other vertically. The foramina are of nearly equal size; **B.** Double oval-shaped sphenopalatine foramina (arrows) arranged one above the other vertically. The foramina are of nearly equal size and the upper lies completely in the superior meatus above the level of bony crest of middle nasal concha (arrow head) while the lower lies in the middle meatus; **C.** Double round-shaped sphenopalatine foramina (arrows) arranged one above the other obliquely. The foramina are of nearly equal size; **D.** Single irregular shaped sphenopalatine foramen. Note the bony spicule (arrow) that divides the foramen incompletely into two compartments (bicompartmental). One spicule arises from posterior margin of the foramen.

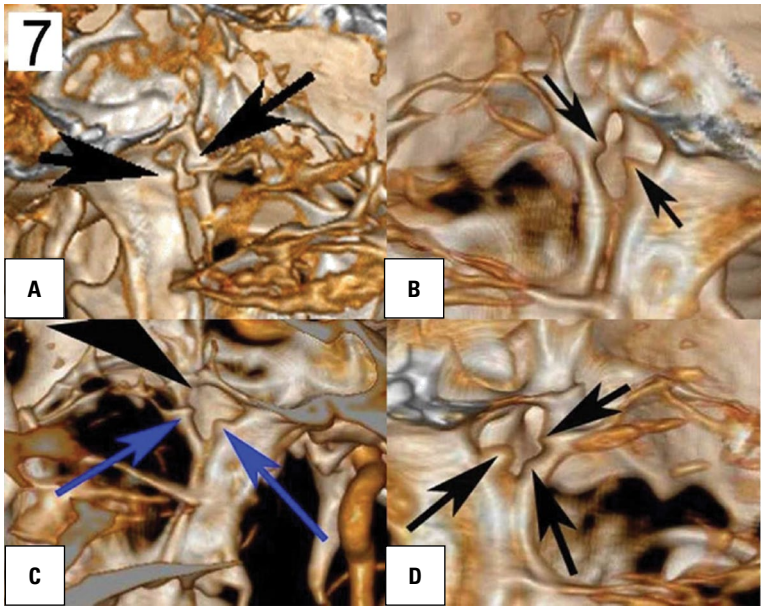

Figure 7. Multi-slice helical computed tomography with three-dimensional reconstruction of sagittal sections of the skull with the lateral wall of right (**A**, **B**) and left (**C**, **D**) bony nasal cavities showing a single sphenopalatine foramen of irregular shape. Note the bony spicules (arrows) that divide the foramen into (**A–C**) two compartments (bicompartmental). Two spicules arise from anterior and posterior margins of the foramen in panels **A** and **B** while in panel **C** the spicules arise from the anterior and inferior margins of the foramen; **D.** Three compartments (tricompartmental). The spicules arise from anterior, inferior and posterior margins of the foramen.

the presence of bony spicules of different grades which divide the foramen incompletely into compartments that were classified in the current study into two types:

— **type I:** bony spicules which divide the SPF incompletely into 2 compartments (bicompartmental) (Fig. 6D; 7A–C). These spicules are single arising from posterior margin of the foramen (Fig. 6D) or double arising from anterior and posterior margins of SPF (Fig. 7A, B) or double arising from anterior and inferior margin of SPF (Fig. 7C);

— **type II:** bony spicules which divide the SPF incompletely into 3 compartments (tricompartmental) (Fig. 7D). These spicules are three in number, arising from the anterior, inferior and posterior margin of the foramen (Fig. 7D). The number of bony spicules was variable in each foramen; single (Fig. 6D), double (Fig. 7A–C) or triple (Fig. 7D).

A study of the location of the SPF on the lateral nasal wall relative to the bony crest of MC revealed that in 62.5% the bony crest of the MC pointed to the inferior border of the SPF, placing it in the superior meatus (Fig. 5A, B, E). The foramen was found in the superior meatus and extended to the middle one in 37.5% (Fig. 5D, F). The different positions of the SPF in relation to the bony crest of middle concha in the examined specimens were presented in Table 3.

Table 3. Positions of the sphenopalatine foramina (SPF) in relation to the bony crest of middle nasal concha in the radiologically examined specimens

Position	SPF above the crest (in the superior meatus	SPF opposite the crest (midway between superior and middle meatuses)	SPF below the crest (in the middle meatus)
Cases	25 (62.5%)	15 (37.5%)	0 (0%)

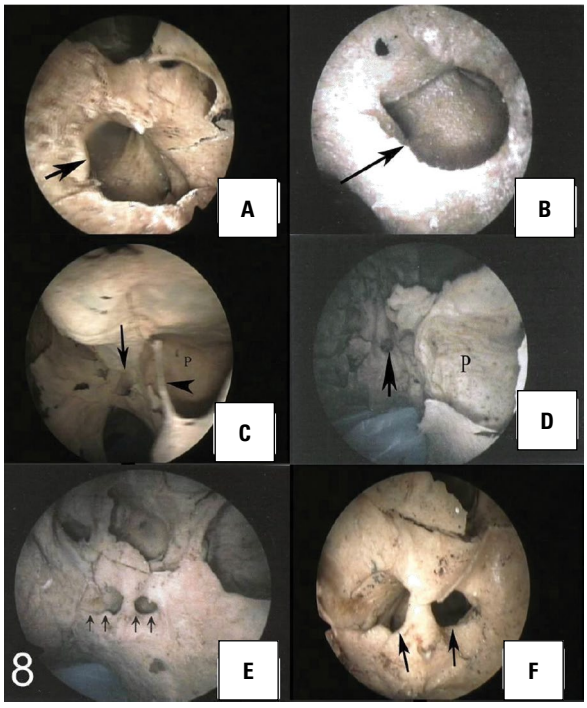

Figure 8. Endoscopic endonasal view showing: **A–D.** Single oval sphenopalatine foramen (arrow) in panels **A** and **B** while in panel **C** most of the medial wall of left maxillary antrum was removed leaving only a small piece of bone (arrow head) exposing its posterior wall (P). Note the oval-shaped sphenopalatine foramen (arrow) in the peripendicular plate of palatine bone. In panel **D** complete removal of medial wall of the left maxilla exposing its posterior wall (P). Note the rounded, single sphenopalatine foramen (arrow) (0-degree endoscope); **E, F.** Two separate, complete, oval sphenopalatine foramina (arrows). The foramina lay one anterior to the other. The anterior foramen nearly oval in shape while the posterior one is irregular (0-degree endoscope).

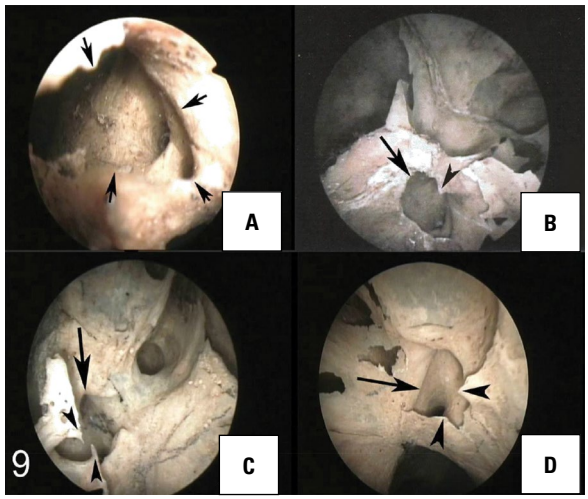

Figure 9. Endoscopic endonasal view showing: **A.** Single triangular--shaped sphenopalatine foramen (arrows) (0-degree endoscope); **B.** Single irregular sphenopalatine foramen (arrow) with a single bony spicule (arrow head) projecting through the foramen from the posterior margin (arrow head) (30-degree endoscope); **C.** Single irregular sphenopalatine foramen (arrow) with two bony spicules (arrow heads) from anterior and posterior margins dividing the foramen into two compartments (0-degree endoscope); **D.** Single irregular sphenopalatine foramen (arrow) with two bony spicules (arrow heads) from posterior and inferior margins dividing the foramen into two compartments (0-degree endoscope).

In case of specimens with equal size, double SPF, it was found that these foramina were placed one above the other; the upper one was located in the SM while the lower one was placed in the MM (Fig. 6B).

Endoscopic study

Endoscopic endonasal bilateral examination of SPF in 10 skulls revealed that the number of the SPF was seen variable; being single in 80% (Fig. 8A–D) and double in 20% (Fig. 8E, F). In case of double foramina, they were arranged one in front the other (Fig. 8E, F) in all studied cases and of nearly equal size. Triple SPF could not be detected endoscopically.

The shape of the SPF was also observed variable; it was seen oval in 60% (Fig. 8A–C), circular (rounded) in 10% (Fig. 8D), triangular in 10% (Fig. 9A) and irregular in 20% (Fig. 9B–D). The irregular one was characterised by the presence of bony spicules of different grades which divide the foramen incompletely into two compartments (Fig. 9B–D). The bony spicules were single arising from the posterior margin of the foramen (Fig. 9B), double arising from the anterior and posterior margin of the foramen (Fig. 9C) or double arising from the posterior and inferior margin of the foramen (Fig. 9D).

The overall number and different shapes of the sphenopalatine foramina in all studied cases are presented in Tables 4 and 5.

Table 4. The distribution of single, double and triple sphenopalatine foramina in studied cases

	Dry bone	Radiology	Endoscopy
Single	32 (80%)	33 (82.5%)	16 (80%)
Double	7 (17.5%)	7 (17.5%)	4 (20%)
Triple	1 (2.5%)	0 (0%)	0 (0%)
Total	40 (100%)	40 (100%)	20 (100%)

Table 5. Shapes and percentages of sphenopalatine foramina in studied cases

	Dry bone	Radiology	Endoscopy
Regular:			
Oval	9 (22.5%)	14 (35%)	12 (60%)
Circular	8 (20%)	10 (25%)	2 (10%)
Triangular	5 (12.5%)	0 (0%)	2 (10%)
Elliptical	3 (7.5%)	0 (0%)	0 (0%)
Semilunar	2 (5%)	0 (0%)	0 (0%)
Quadrangular	0 (0%)	3 (7.5%)	0 (0%)
Irregular	13 (32.5%)	13 (32.5%)	4 (20%)
Total	40 (100%)	40 (100%)	20 (100%)

DISCUSSION

The sphenopalatine artery is the largest branch of the maxillary artery. It is located within the pterygopalatine fossa and passes through the SPF on the lateral nasal wall. Epistaxis from this artery is potentially life threatening and may urgently require endonasal endoscopic occlusion [19].

Choosing the endoscopy is a safe manipulation to observe SPF due to the fact that this foramen is small, lies at the middle part of the skull base and is difficult to reach by classic surgical procedures in addition to fewer complications associated with this technique [1]. Transnasal approach is performed because it offers easy accessibility to the foramen, avoids external incisions, osteotomies and bone resection required in open procedures [7]. The use of the endoscope requires angled endoscope, such as 0, 30-, 45-, and 70-degrees endoscopes, and specialised curved instruments [21].

In the current work, the overall results showed that the SPF was single in nearly 80% and double or triple in 20%. The shape of the foramen was regular in 67.5% and irregular in 32.5% of all cases. Comparable findings were reported by Scanavine et al. [22] who concluded that the SPF was single in 87% of the specimens, and more than one orifice was present in 13%. In the present study, it can be concluded that nearly in 1/3 of cases, the foramen is irregular in shape, which may affect or even compress the artery causing its stenosis. Moreover, the presence of bony spicules may promote the arterial injury. The same opinion was described by Scanavine et al. [23] who added that several compartments of the SPF may cause its stenosis and consequently, insufficiency of nasal supply. However, the SPF may be affected by the branching pattern of the sphenopalatine artery.

In the current study measuring the SPF, it was found that the height ranged 3–9 mm with a mean of 6 ± 2 mm while the width ranged 3–8 mm with a mean of 5.5 ± 1 mm. Identical findings were observed by Schawartzbauer et al. [24] as they found that the SPF was 6.13 mm high (5.24–6.84 mm) and 5.75 mm wide (4.3–7.2 mm). The wide range of height and width of SPF in the present work may be explained by racial differences, as African skull has larger diameters of foramina and consequently the sphenopalatine artery which results in profuse bleeding in case of its injury. In the present work, there is no marked difference in the number and percentages of the SPF between different studies. Although the discrepancy in the shapes and percentages of SPF in different studies could not be explained, it may be due to the presence of soft tissue and mucus membranes on radiological images that may alter the shape of the foramen. Also, the absence of some shapes in radiological and endoscopic studies may be due to rare types and/or limited number of cases.

Different studies [7, 22] have shown that the shape of the SPF may vary, being oval, square, triangular or piriform. In the study of Scanavine et al. [22] — regarding the number of the SPF — it was found that single orifices were present in 87%, double orifices in 11.1%, and a triple foramen in 1.9%. Thus, 7 specimens presented more than 1 orifice (13%). Scanavine et al. [23], when studying the location of the SPF on the lateral nasal wall relative to the bony crest of middle nasal turbinate, revealed that in 81% the bony crest of the middle nasal turbinate pointed to the inferior border of the SPF, placing it in the superior nasal meatus. In 14.8% the bony crest of the middle nasal turbinate pointed to the middle of the SPF, placing it between the middle nasal meatus and the superior nasal meatus. In 1.8% the bony crest

of the middle nasal turbinate pointed to the superior border of the SPF, placing it in the middle nasal meatus. Identification of the site was not possible in one case. The data of the current study agreed with those of Rezende et al. [20] who observed that the ethmoidal crest was present in 96% of the cases and was located anteriorly to the SPF in most cases. They added that the SPF was located in the transition area between the middle and the superior meatus in all cases.

Herrera Tolosana et al. [12] studied 32 half-skulls and accurately described the location of the SPF. In their sample, the most superior portion of the SPF was located at the same level as the higher portion of the choana in 62.5% of the cases. The other 32.5% had the medial portion of the SPF on the same level as the higher portion of the choana. Such data was supported by the current study

The present observations support the data in the available literature about the variation of the number of the SPF [13, 17, 18] by recording specimens with more than one foramen. Most samples in the present study had a single orifice (80%); the remaining had more than one orifice (20%). These percentages disagreed with those observed by Bagatella [4] and Padua and Voegels [18] who found that 10% of cases had double orifice, and data of Wareing and Padgham [25] who reported double orifice in 12% of cases in a 220-specimen sample. There was one specimen only (2.5%) in the current work with a triple orifice, a finding which is nearly similar to those of Wareing and Padgham [25] where the foramen was tripled in 1.9%. Another value was presented by Scanavine et al. [22] who in their vast sample found 39 specimens (5.5%) with three orifices. It is difficult to explain the reason for such differences, but it may be presumed that these findings reveal different evolutionary paths of the foramen in human populations with diverse genomic features.

It is recognised that the variation in number of the SPF is probably the main element explaining the failure of surgery when ligating the branches of the sphenopalatine artery in the treatment of nasal bleeding. The same opinion was shared by Wareing and Padgham [25]. This hypothesis is based on the fact that anatomical variants and number variation may occur at the entrance point of the main arterial branches of the septal artery and the posterior lateral nasal artery [17]. Lee et al. [14] recently demonstrated the presence of 2 to 4 branches of the sphenopalatine artery before the opening of the SPF. Accordingly, with the findings in the current study it is thus reasonable to assume that, anatomically and surgically, the number variation of the SPF corresponds to branch variants of the sphenopalatine artery; this may be, therefore, a complicating factor for surgery. Schwartzbauer et al. [24] noted that surgery may fail if dissection is not carried out up to the posterior portion of the SPF, due to the presence of arterial branches exiting through accessory foramina. On the other hand, Gras-Cabrerizo et al. [8] — in their study — found 4 (7%) accessory SPF (7%) and suggested that in most cases only 1 or 2 branches of sphenopalatine artery are found in these foramina. They added that the accessory SPF was always smaller and inferior to the main foramen and most authors agree that the foramen presence varies from 5% to 13%, which is less than found in the current work (20%). However, Rezende et al. [20] reported that the accessory SPF was seen in 21% of their cases, which is nearly the same as in the current work. Moreover, they mentioned that most nasal fossae of their cases presented a single bilateral arterial trunk emerging from the SPF and in other cases, arterial trunks emerged bilaterally from the SPF.

In the current study of the location of the SPF on the lateral nasal wall relative to the bony crest of MC, it was revealed that in 67.5% the bony crest of the MC pointed to the inferior border of the SPF, placing it in the superior meatus. The foramen was found in the superior meatus and extended to the middle one in 32.5%.

The above observed findings in the present study regarding the site of SPF were disagreed to those reported by Wareing and Padgham [25] who found that SPF opened in most of their studied cases between middle and superior meatus. They further subdivided the site of the SPF into classes, where in class I (35%) the opening of the SPF was seen totally into the superior meatus with a notch or foramen in the middle turbinate/ethmoidal crest of the palatine bone; in class II (56%) the SPF spanned the ethmoidal crest (i.e., opened into both the superior and middle meatuses); and in class III (9%) there were two separate openings into the superior and middle meatuses. The authors added that these findings may explain the route of the artery to the inferior turbinate and indicate the need for care in dealing with the posterior end of the middle turbinate. They also suggested

a potential site for dealing with "difficult" epistaxis via an intranasal route. Wareing and Padgham [25] suggested that a mucoperiosteal flap had to be made above and below the middle nasal turbinate, about one centimetre from its posterior tip, in surgery for ligating or cauterising branches of the sphenopalatine artery, to avoid missing any of the foramina. The results of the present work support these authors, and suggest the same surgical approach. Contrary, Alherabi et al. [2] declared that since SPF frequently extends below ethmoidal crest, the mucoperiosteal flap should be extended below the inferior edge of this crest to avoid missing the middle meatal part of SPF or any accessory foramina.

Identical findings to the present work were reported by Scanavine et al. [22] who found the position of the SPF in the superior nasal meatus in most of their studied cases. However, if its position on the lateral nasal wall is established by the relation with the ethmoidal crest of the palatine bone, onto which it joins the posterior portion of the middle nasal concha, other studies locate it in the middle and/or superior nasal meatuses [24]. This position is used as an anatomical landmark in endoscopic surgery [5]. The latter author mentioned that apart from the comments about the bony crest of the middle nasal turbinate, it was also noted that in 30 (55.6%) specimens the bony crest of the superior nasal turbinate was pointing towards the superior border of the SPF. This finding has also been reported by (Li et al. [15]. In addition, ethmoidal crest was present in 100% of the cadavers, being anterior to the SPF in 98.4% of the cases [18]. The most frequent SPF location was the transition of the middle and superior meatus (86.9%) [18].

Identifying the bony ethmoidal crest of the palatine bone, to which the middle nasal turbinate is linked, is cases an anatomical and surgical landmark for locating the SPF in an endonasal access [9]. The results obtained by Gui et al. [9] revealed that in 44 (83%) specimens the distal tip of the bony crest of the middle nasal turbinate pointed towards the inferior margin of the SPF, locating it in the superior nasal meatus; the SPF was located between the superior and middle nasal meatuses in 8 (15.1%) specimens and the foramen was fully located in the middle meatus in only 1 (1.9%) specimen. The above-mentioned results agreed with the results of the present work but disagreed with those that place the SPF only in the superior nasal meatus [9, 22, 26]. On the other hand, the observed data in the present study were comparable to those stated by Bagatella [4] that 85% of SPF was located in the superior nasal meatus, 5% in the middle nasal meatus, and 10% between both meatuses.

CONCLUSIONS

It can be concluded from the current work that variation of the SPF, and consequently of the branches of the sphenopalatine artery, may explain the surgical failure in management of severe epistaxis. It can be predicted from the current work, the presence of many SPF, the sphenopalatine artery can be stenosed if passes in the narrower one. Attention should be taken in transmaxillar endoscopic approach to the pterygopalatine fossa for the multiplicity arrangement of the branches of the sphenopalatine artery at SPF.

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