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Evaluation of surgical approaches to infratemporal and pterygopalatine fossae

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Abstract

Background Tumors in the pterygopalatine fossa (PPF) and infratemporal fossa (ITF) are still challenging to surgeons because of their deep location and proximity to various arteries and cranial nerves. This study aimed to evaluate the access to infratemporal fossa and pterygopalatine fossa through anterior transmaxillary, modified endoscopic transnasal transmaxillary approaches. The study was a prospective comparative study conducted on 20 patients having a mass in pterygopalatine or infratemporal fossa. History, examination, computed tomography, and magnetic resonance imaging were performed for all patients. Nine patients were operated with anterior transmaxillary approach and eleven patients were operated with endoscopic transnasal transmaxillary approach. The operative duration, intraoperative blood loss, and operative difficulty were assessed. Patients were assessed 1 week postoperatively using a nasal surgical questionnaire for postoperative nasal symptoms. Endoscopic assessment of the nose was done 1 week postoperative to assess the degree of crusting and 4 weeks postoperative to assess nasal adhesions. Postoperative complications were assessed for both groups.

Results There was a significant difference between the two groups regarding operative duration and blood loss favoring the endoscopic group. There was a non-significant difference between the two groups regarding operative difficulty. There was a significant difference between the two groups regarding nasal obstruction, crustation, bleeding, sneezing, secretion, and nasal pain. There was a significant difference between the two groups regarding the endoscopic assessment for nasal crusting and adhesions. Facial swelling and numbness of the face were significantly more in the open group compared with the endoscopic group.

Conclusion Endoscopic endonasal transmaxillary approach had less trauma and lower complication rate while anterior transmaxillary was technically feasible and offered excellent surgical access with easy lateral expansion toward the infratemporal fossa. Both approaches had comparable operative difficulty and acceptable postoperative quality of life.

Keywords Angiofibroma, Endoscopic Approach, Infratemporal fossa, Pterygopalatine fossa, Sphenopalatine artery, Transmaxillary approach

Background

The infratemporal fossa (ITF) is a deep quadrangular area located beneath the middle cranial fossa. Important structure is related to ITF include the lateral and medial pterygoid muscles, branches of mandibular nerve and pterygoid segment of maxillary artery [1, 2]. The pterygopalatine fossa is a small fat containing inverted pyramid shaped area located behind the posterior wall of the maxillary sinus. Its contents include the pterygopalatine ganglion, vidian nerve, maxillary nerve (V2) and its branches, and branches of the maxillary artery [3, 4].

Otolaryngologists still struggle with tumors in the infratemporal and pterygopalatine fossae. Despite being benign tumors, lesions in this region like meningioma, schwannoma, or nasopharyngeal angiofibroma are still challenging to be safely and completely removed because

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of their deep position and close proximity to numerous arteries and cranial nerves tumors arise from PPF invades ITF and vice versa [5].

There are different approaches to PPF and ITF including the classic lateral approaches like the preauricular and postauricular approaches, which carry the drawbacks of a greater risk of hearing loss, facial nerve paresis, and temporomandibular joint dysfunction, making these approaches unsatisfactory for some patients [6]. More recent approaches included the anterior transmaxillary approach and modified endoscopic transnasal transmaxillary approach. One benefit of the anterior transmaxillary technique is the natural airspace that the sinus cavities provide as safety margins. Limited exposure to the infratemporal fossa and a distal entry point are disadvantages [6]. Small intranasal incisions are used in the endonasal endoscopic method, to access the pterygopalatine and infratemporal fossa. The benefit of this method is that it avoids cosmetic morbidity while still giving a clear view of the infratemporal fossa. One significant issue with this method is the difficulty to control the intraoperative hemorrhage [7]. The aim of this study was to evaluate the access to the infratemporal fossa and pterygopalatine fossae through the two recent approaches, the anterior transmaxillary and modified endoscopic transnasal transmaxillary approaches regarding operative details and postoperative outcomes.

Methods

The current study was a prospective comparative study conducted on twenty patients recruited from 2020 to 2023 after approval of the institutional review board and a written informed consent was taken from every patient or his guardian before participation in the study. To be included in the study every patient should be above 12 years, diagnosed as having a mass in pterygopalatine or infratemporal fossa and the lateral boundary of tumor did not exceed the mandibular ramus. Patients with their mass having an intracranial or orbital infiltration or surgical unfitness like bleeding tendency or uncontrolled systemic diseases like diabetes mellitus and hypertension were excluded from the study.

Preoperative assessment

All patients of the study were assessed by history taking to record personal data, main complaint, present and past history. Complete ENT examination was performed for all patients including an endoscopic examination of the nose and paranasal sinuses with examination of the oral cavity and pharyngeal structures.

All patients were subjected to full neurological examination and radiological evaluation by computed tomography (CT), magnetic resonance imaging (MRI) to confirm diagnosis and to delineate the approach to the target fossa.

Operative technique

All cases were operated on under general anesthesia with oral endotracheal intubation through two approaches according to surgeon preference.

Anterior transmaxillary approach [8]

Either sublabial incision or Weber Fergusson incision was used to expose the maxillary sinus (MS) anterior wall. The canine fossa served as the starting point of drilling to the MS cavity. A bone window approximately 2 cm × 2 cm was done in the MS anterior wall and the infraorbital foramen should be completely preserved. With the aid of surgical microscope, the posterior wall of MS was drilled from the point beneath the bundle of infraorbital artery and infraorbital nerve, and then enlarged to 1 cm by1 cm. After removal of the fat in the PPF, the lateral posterior wall of the maxillary sinus was removed carefully to expose branches of maxillary nerve, pterygoid muscles, and venous plexus with further access to the infratemporal fossa.

Modified endoscopic transnasal transmaxillary approach (modified Denker's approach) [8]

The nasal mucosa was compressed by surgical cotton infused with epinephrine using an endoscopic technique (Karl Storz, CA, USA) to minimize bleeding. To reveal the nasolacrimal duct eminence, the mucosa anterior to the inferior nasal concha was sliced perpendicularly. The mucosal nasolacrimal duct was moved to the midline with the nasal mucosa after drilling the bony nasolacrimal duct. The periosteum was preserved while the posterior wall of the maxillary sinus was meticulously removed. The periosteum was removed to expose the PPF anteriorly after the sphenopalatine artery and pterygopalatine ganglion were located. The terminal branches of the maxillary artery were located and cauterized, and the tumors in the PPF were removed piece by piece. Removal of the posterolateral wall of the maxillary sinus allowed access to the infratemporal fossa and mobilization of the tumors within this fossa.

Several intraoperative parameters were assessed including the operative duration from after intubation till nasal packing, the amount of intraoperative blood loss measured by the subtracting the amount of saline used for operative irrigation from the amount of fluid in the suction container during the operation. Surgical difficulty was assessed by the operator using an index of 1–10 with the following divisions: 1–3 low difficulty, 4–6 intermediate difficulty, and 7–10 high difficulty.

Postoperative assessment

Patients were assessed 1 week postoperatively using a nasal surgical questionnaire developed by Haye et al. [9] for postoperative nasal symptoms, where six nasal symptoms (nasal obstruction, crustation, bleeding, sneezing, secretion, and nasal pain were assessed either, none, mild, moderate, or severe. Endoscopic assessment of the nose was done 1 week postoperative to assess the degree of crusting and 4 weeks postoperative to assess the presence of nasal adhesions whether absent, mild, or severe. Postoperative complications including bleeding and ecchymosis, facial swelling, numbness of the face, paresthesia of the teeth, and periorbital edema were assessed for both groups.

Outcomes

Both surgical techniques were compared regarding the operative details including operative duration, operative blood loss, and operative difficulty. In addition, both techniques were compared regarding the postoperative quality of life regarding six nasal symptoms (nasal obstruction, crustation, bleeding, sneezing, secretion, and nasal pain), endoscopic assessment including nasal crusting and adhesions, and postoperative complications.

Statistical analysis

The data were collected, tabulated, statistically analyzed using an IBM personal computer with Statistical Package of Social Science (SPSS) version 22 (IBM Corp., Armonk, NY, USA). Descriptive statistics were expressed as mean, standard deviation (SD), range for quantitative data and numbers and percentages for qualitative data. Regarding analytical statistics, chi-square test ($\chi 2$) was used to study association between two qualitative variables. Fisher exact test was used to study association between two qualitative variables when expected cell count of 25% of cells less than five. Student's *t* test was used for comparison between two groups having quantitative variables normally distributed. Spearman's correlation: was used to assess correlation between two quantitative variables. *P* value of >0.05 was considered statistically non-significant. *P* value of <0.05 was considered statistically significant. *P* value of <0.001 was considered statistically highly significant.

Results

In the current study, the open group included 8(88.9%) males and 1(11.1%) female with an age range from 13 to 75 years and a mean age of 46.7 ± 24.4 SD. The endoscopic group included 9(81.8%) males and 2(18.2%) females with an age range from 14 to 70 years and a mean age of 39.3 ± 21.3 SD. The open group included 4 cases of juvenile nasopharyngeal angiofibroma (JNA), 3 cases of inverted papilloma one of which was recurrent, 1 case of squamous cell carcinoma (SSC) (Fig. 1), and 1 case of adenocarcinoma of maxillary sinus. The endoscopic group included 6 cases of JNA, 4 cases of inverted papilloma (Fig. 2) and 1 case of SSC. There were non-significant differences between the open and endoscopic

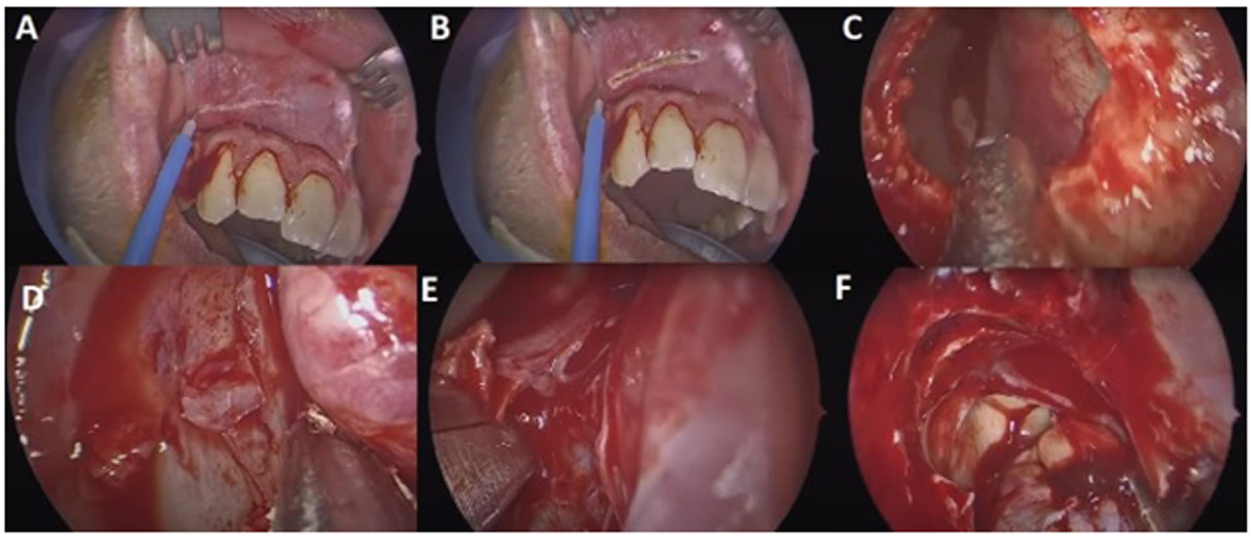

Fig. 1 A 50-year-old male patient with squamous cell carcinoma of the right pterygopalatine fossa and extending to the right infratemporal fossa operated with anterior transmaxillary approach with **A**, **B** right sublabial incision, **C** opening of the anterior wall of the right maxillary sinus, **D** exposure of the posterior wall of the right maxillary sinus, **E** opening the right pterygopalatine fossa, **F** excision of tumor of the right pterygopalatine fossa extending to right infratemporal fossa. A written informed consent was taken from the patient for publication of the photos

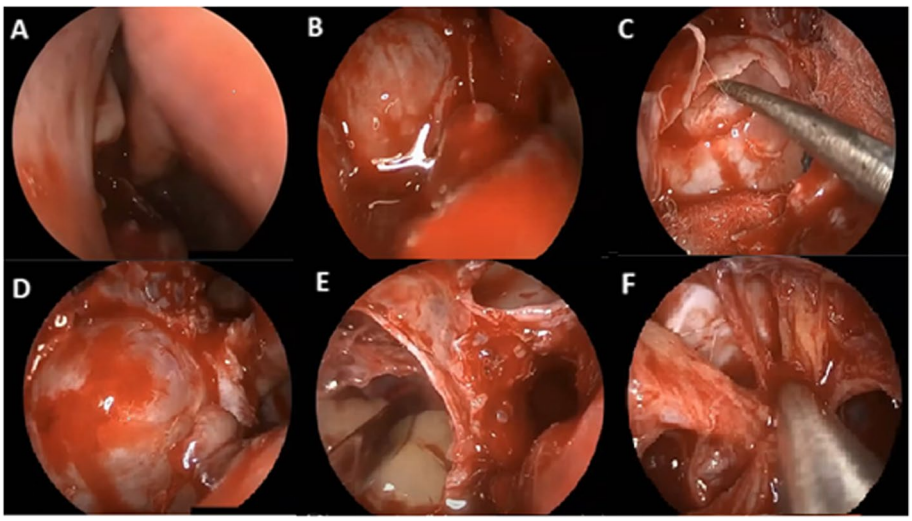

Fig. 2 A 45-year-old male patient with right inverted papilloma of the right pterygopalatine fossa subjected to right endoscopic transmaxillary excision with **A** wide middle meatal antrostomy, **B** exposure of the posterior wall of the right maxillary sinus, **C** opening the posterior wall of the right maxillary sinus, **D** exposure of the mass in the right pterygopalatine fossa, **E** excision of the right pterygopalatine fossa mass, **F** the right pterygopalatine fossa after mass excision. A written informed consent was taken from the patient for publication of the photos

groups regarding age and sex and pathological diagnosis ($p=0.478$, 0.660, and 0.895 respectively) (Table 1).

There was a significant difference between the open and endoscopic groups regarding operative duration and blood loss ($p=0.023$, and 0.007 respectively) favoring the endoscopic group. There was a non-significant difference between the two groups regarding the operative difficulty ($p=0.801$) (Table 2).

In the present study, nasal obstruction, crustation, and sneezing were significantly more in the endoscopic group compared with the open group ($p=0.014$, 0.014, and 0.047 respectively). However nasal pain was significantly more in the open group compared with the endoscopic group ($p=0.039$) and a non-significant difference between the two groups regarding nasal bleeding and nasal secretion ($p=0.375$ and 0.527 respectively). Endoscopic examination showed that nasal crusting and adhesions were significantly more in the endoscopic group compared with the open group ($p=0.047$ and 0.014 respectively) (Table 3).

There was a non-significant difference between the open and endoscopic groups regarding ecchymosis, hemorrhage, teeth paresthesia, and periorbital edema ($p=0.591$, 0.591, 0.19, and 0.218 respectively). Facial

Table 1 Socio-demographic data of the studied groups ($N=20$)

Studied variables	Open group (No = 9)	Endoscopic group (No = 11)	Test of significance	*P* value
Age/years				
Mean ± SD	46.7 ± 24.4	39.3 ± 21.3	*t* test 0.724	0.478
Range	13.0–75.0	14.0–70.0		
Gender	**No (%)**	**No (%)**	FE	0.660
Male	8(88.9)	9(81.8)		
Female	1(11.1)	2(18.2)	0.194	
Pathological diagnosis				
Juvenile nasopharyngeal angiofibroma	4(44.4)	6(54.5)	FE	0.895
Inverted papilloma	3(33.3)	4(36.4)	1.3564	
Squamous cell carcinoma	1(11.1)	1(9.1)		
Adeno carcinoma	1(11.1)	0		

No Number, % Percentage, *SD* Standard deviation, *FE* Fisher's exact test, *Chi* Chi-square test

Table 2 Comparison between the studied groups regarding the operative details

Studied variables	Open group (No = 9)	Endoscopic group (No = 11)	Test of significance	*P* value
Operative duration/min				
Mean ± SD	100.1 ± 27.5	65.1 ± 34.1	*t* test 2.47	**0.023***
Range	66.0–150.0	25.0–140.0		
Blood loss/ml				
Mean ± SD	334.4 ± 69.4	250.4 ± 53.0	*t* test 3.06	**0.007***
Range	190.0–400.0	185.0–350.0		
Difficulty				
Intermediate	6(66.7)	6(54.5)	Chi 0.0636	0.80083
High	3(33.3)	5(45.5)		

* Statistically significant

swelling and numbness of the face were significantly more in the open group compared with the endoscopic group ($p = 0.026$ for both) (Table 4).

Discussion

Rhinologists and skull-base surgeons must have a three-dimensional knowledge of the pterygopalatine fossa in order to control epistaxis and remove lesions from the skull base [10]. The most frequent entities in this area are adolescent nasopharyngeal angiofibroma, neurogenic tumors, a perineural extension of sinonasal malignancy, and meningoencephalocele [11]. Rhabdomyosarcoma, liposarcoma, fibrosarcoma, meningioma, hemangioma, and peripheral nerve sheath tumors originating from any of the local nerves are just a few of the neoplastic tumors that have been observed in the infratemporal fossa. The lingual and inferior alveolar nerves are located in this area, and as a result, schwannomas and neurofibromas are frequently discovered here. Hemangiomas growing from the pterygoid venous system. In this region, frequently situated between the lateral pterygoid and temporalis muscles, hemangiomas originating from the pterygoid venous plexus can also be seen [10]. The present study aimed to compare the operative details and postoperative outcomes between anterior transmaxillary and modified endoscopic transnasal approach to both pterygopalatine and infratemporal fossae. The study revealed that male gender and adolescence had an association with angiofibroma while advanced age was associated with malignancy. Also, males had more tumors predominance than females. There was a complaint variation among patients in the form of bleeding from the nose in cases of angiofibroma, while nasal obstruction, numbness and parathesis of face and teeth were present in malignancy.

Both techniques offered comparable surgical accessibility to the PPF and ITF in the current research. Avoiding sublabial incisions, decreasing trauma to soft tissue and bone, fewer complications, a lower incidence of neurologic damage, improving postoperative quality of life, and a quicker recovery period were all benefits of the endoscopic approach to PPF and ITF. According to El Hadi et al. [12], a particular approach's exposure area is a crucial element in confirming its benefits. There were no appreciable differences in the areas of exposure for the two approaches in their research. However, they reported that when neuro-endoscopy was used, the endoscopic transnasal transmaxillary method had the same extent of PPF and ITF exposure as the anterior transmaxillary approach.

Some studies have evaluated the anatomic access to both pterygopalatine and infratemporal fossae. The effectiveness of the transmaxillary route to reveal the infratemporal fossa's components was assessed by Roche et al. [13]. After creating a paralateronasal incision, the heads of five adult cadaver subjects were dissected on both sides. To move into the retroantral space and pterygopalatine fossa, the trigeminal nerve's maxillary branch acted as a superior landmark. These structures were identified: the maxillary artery, lateral pterygoid muscle, pterygoid venous plexus, foramen rotundum, and foramen ovale. The proximal retroantral fatty region was always the site to the anterior loop of the maxillary artery and the sphenopalatine artery which could be ligated without the use of an optical magnifier. At a mean distance of 44 mm from the opening, the maxillary nerve could be traced all the way to the foramen rotundum.

Twenty adult cadaveric specimens and five patients with tumors in the PPF and ITF were used in Xue et al. [8] study. The modified endoscopic transnasal transmaxillary approach was used on 10 of the cadaveric specimens, while the anterior transmaxillary method was used on ten of them. The major anatomical structures were measured and the exposure areas between the two groups were compared. Five patients with PPF and ITF tumors underwent surgery in order to validate

Table 3 Comparison between the studied groups regarding the postoperative quality of life and postoperative endoscopic assessment

Studied variables	Open group (No = 9)		Endoscopic group (No = 11)		χ^2	*P* value
	No	%	No	%		
Quality of life assessment						
Nasal obstruction						
No	6	66.7	0	0.00	10.5	0.014*
Mild	1	11.1	3	27.2		
Moderate	1	11.1	4	36.4		
Severe	1	11.1	4	36.4		
Crustation						
No	6	66.7	0	0.00	10.5	**0.014***
Mild	1	11.1	3	27.2		
Moderate	1	11.1	4	36.4		
Severe	1	11.1	4	36.4		
Bleeding						
No	3	33.3	8	72.7	3.10	0.375
Mild	2	22.2	1	9.10		
Moderate	2	22.2	1	9.10		
Severe	2	22.2	1	9.10		
Sneezing						
No	6	66.7	1	9.10	7.92	**0.047***
Mild	1	11.1	1	9.10		
Moderate	1	11.1	4	36.4		
Severe	1	11.1	5	45.5		
Secretion						
No	6	66.7	4	36.4	2.22	0.527
Mild	1	11.1	1	9.10		
Moderate	1	11.1	3	27.2		
Severe	1	11.1	3	27.2		
Nasal pain						
No	1	11.1	8	72.7	8.33	**0.039***
Mild	2	22.2	1	9.10		
Moderate	1	11.1	1	9.10		
Severe	5	55.6	1	9.10		
Endoscopic assessment						
Crustation						
No	6	66.7	1	9.10	7.92	**0.047***
Mild	1	11.1	1	9.10		
Moderate	1	11.1	4	36.4		
Severe	1	11.1	5	45.5		
Adhesion						
No	6	66.7	0	0.00	10.5	**0.014***
Mild	1	11.1	3	27.2		
Moderate	1	11.1	4	36.4		
Severe	1	11.1	4	36.4		

* Statistically significant

the anatomical data. Their study's findings demonstrated that the modified endoscopic transnasal transmaxillary approach offered the PPF and ITF the same amount of surgical exposure and good operability as the anterior transmaxillary approach. One patient with adenocystic carcinoma and four patients who had

Table 4 Comparison between the studied groups regarding the postoperative complications

Parameter	Open group (No = 9)	Endoscope group (No = 11)	*P* value
No complications	2(22.2)	4(36.4)	**0.642**
Ecchymosis	1(11.1)	3(27.3)	**0.591**
Facial swelling	4(44.4)	0(0.00)	**0.026**
Hemorrhage	1(11.1)	3(27.3)	**0.591**
Numbness of the face	4(44.4)	0(0.00)	**0.026**
Teeth paresthesia	2(22.2)	0(0.00)	**0.19**
Periorbital edema	0(0.00)	3(27.3)	**0.218**

schwannomas both underwent subtotal excision. The two major side effects were wisdom tooth pericoronitis and facial numbness. There was no permanent complications. They came to the conclusion that the modified endoscopic transnasal transmaxillary method was practical and efficient for the removal of tumors in the PPF and ITF, with important benefits for the patients in terms of less trauma and complications.

The endoscopic approach has some benefits, according to Alfieri et al. [14]. The surgeon has a great two-dimensional view of the area with the standard transmaxillary-transantral approach, but only a two-dimensional, dynamic image with the endoscope. This indicates that a look around the operating room is feasible. The endoscope's active movement can mimic the third dimension, giving the impression of depth.

According to Sobel and Califano [15], combining transnasal and transmaxillary approaches would improve surgical manoeuvrability and anatomical structure visibility. Greater surgical ergonomics, better operative triangulation, and access points from different angles are benefits of the combined approach. The postoperative outcome was improved by decreased postoperative pain, facial edema, and neurovascular complications. The avoidance of anterior facial disruption is the main benefit of fully transnasal approaches.

In the current study, the average operative time was 100 min, and 65 min in the open and endoscopic group respectively with a significant difference. This agrees with Ikida et al. [16] who found that the operative time in the open group was 86–34 min, and 60–29 min in the endoscopic group. In the current study, the average blood loss was 334.5 ml in the open group, and 250 ml in the endoscopic group. However, Ikida et al. [15] found that blood loss was 297–339 ml ln the open group and 53–71 ml in the endoscopic group. The large difference between this study and out study can be attributed to the fact that they evaluated only Caldwell-Luc operation without further extension to pterygopalatine and infratemporal fossa.

In the current study, we got total removal for all the benign lesions. Regarding postoperative quality of life assessment done 1 week after surgery, we found that in the endoscopic group had significantly more nasal crusts that can be attributed to more manipulation on mucosa, sneezing as a result of irritation of nasal mucosa and nasal obstruction due to presence of crusts. In the open group, there was significantly more facial pain due to involvement of the trigeminal branches including the infraorbital nerve. Postoperative endoscopic examination, showed that nasal adhesion and crusting were more with a significant difference in the endoscopic group.

We noted that postoperative complications differed between the open and endoscopic groups. In the open group, there was facial swelling in 33% due to interruption of lymphatics drainage and manipulation of face, numbness of face in 33% due to affection of sensory facial branches and infiltration by the tumor, also paresthesia of teeth in 11% as result of manipulation on inferior wall of maxillary sinus. While in the endoscopic group, there was ecchymosis of eye in 18%, periorbital edema in 28% due to manipulation on medial wall of orbit and lamina papyracea, also hemorrhage was present in 18% which is mucosal bleeding and from sphenopalatine artery also. There was is no complication in 36% in endoscopic compared with 22% in the open group. This agrees with Kasemsiri et al. [17] who found that with the wide spread use of neuroendoscopy, the modified endoscopic transnasal transmaxillary approach was feasible and effective for the resection of tumors located in PPF and ITF, which had significant advantages on less trauma and complications to the patients.

The limitations of our study included the rarity of cases of tumors in the pterygopalatine and infratemporal fossae in our hospital. Another limitation is the lack of navigation systems which play a crucial role in management of these cases. Long-term follow-up of cases with tumors should be done to assess the late tumor recurrence.

Conclusion

Endoscopic endonasal transmaxillary approach had less trauma and lower complication rate while anterior transmaxillary was technically feasible and offered excellent surgical access with easy lateral expansion toward the infratemporal fossa. Both approaches had comparable operative difficulty and acceptable postoperative quality of life.

Abbreviations

CT	Computed tomography
IFT	Infratemporal Fossa
MRI	Magnetic resonance imaging
PPF	Pterygopalatine Fossa
SCC	Squamous cell carcinoma

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Not applicable for this article.

Authors' contributions
EB provided the concept, design with the definition of the intellectual content, clinical studies, data collection, and manuscript editing. NB and AE conducted literature research, clinical studies, data collection, data analysis and manuscript preparation. All authors have read and approved the final manuscript.

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Availability of data and materials
The datasets used and/or analyzed during the current study are available from the corresponding author on reasonable request.

Declarations

Ethics approval and consent to participate
This study was approved by the institutional review board of Menoufia Faculty of Medicine under number 7/2020ENT25 on July 2020. Informed written consent to participate in the study was provided by all participants (or their parent or legal guardian in the case of children under 16).

Consent for publication
A written informed consent for the publication of details, age, gender, diagnosis, images relating to individual participants, was obtained from the participants (or from their parent or legal guardian in the case of children under 16).

Competing interests
The authors declare that they have no competing interests.

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