Article

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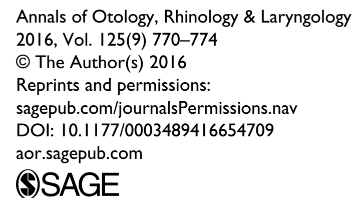

Composite Vascular Pedicled Middle Turbinate Flap for Reconstruction of Sellar Defects

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Abstract

Objectives: Herein, we describe our experience in simple harvest of the vascular pedicled middle turbinate flap (MTF) sufficient for sellar defect reconstruction.

Methods: An anatomical feasibility study is done in 10 sides of 5 preserved injected cadaveric heads. The middle turbinate is separated from the skull base and the basal lamella with or without retrograde dissection of its tail as a composite flap based on the middle turbinate and posterolateral nasal arteries. The technique was applied in 25 cases of cerebrospinal fluid (CSF) leak after endoscopic transsphenoidal surgery.

Results: The mean area of MTF with and without medial mucosal dissection was 9.53 cm^2 and 7.6 cm^2, respectively. The mean length between anterior end of MT and basal lamella and the latter and the sella was 3.67 cm and 2.33 cm, respectively. The mean area of sella was 2.2 cm^2. The MTF covered the sella, planum, and tuberculum sella corridors in 10 head sides. Partial dissection of MT medial mucosa was needed in 3 head sides to cover sella, planum, and tuberculum sella. Follow-up for 26 to 37 month revealed control of CSF leak in 24 cases.

Conclusion: Composite MTF is a simple rapid reproducible option for sellar defects reconstruction.

Keywords

endoscopic sinus surgery, endoscopic skull base surgery, minimally invasive CSF leak closure, minimally invasive skull base surgery, nasal and sinus surgery, surgery, surgical outcomes

Introduction

The pedicled middle turbinate flap (MTF) is one of the vascular nasal flaps used for reconstructing skull-base defects after an expanded endonasal approach. The middle turbinate receives most of its blood supply from the middle turbinate artery, which arises from the posterolateral branch of the sphenopalatine artery (SPA).[1] Prevedello et al[2] were the first to describe the technique of MTF harvest in an anatomical study. The mucoperiosteum of the MT is elevated and the conchal bone removed. They admitted that harvesting the MTF is technically difficult and must follow some critical steps. Unlike the inferior turbinate, the MT is not a separate bone but part of the ethmoidal complex and is relatively unstable. Destabilization of its bony attachment prior to dissection of the MTF renders the dissection even more difficult. Traction is strongly avoided since it may lead to uncontrolled fracture of ethmoidal cells, which could in turn cause an unnoticed cerebrospinal fluid (CSF) leak. Furthermore, elevating a flap laterally is difficult due to the rough surface of the MT concha. Anatomical variations of the MT can occur in as many as 25% of subjects, which may further increase the difficulty of harvesting the pedicled MTF. The author therefore tried to describe an instructional anatomical model for simple harvesting of the MTF sufficient to cover skull base defects in the sellar region and adjoining areas.[2]

Methods

Anatomical Study

Ten sides of formaldehyde-preserved, hemisectioned heads injected with red latex were used. The middle turbinate was completely mobilized from the skull base and the lateral nasal wall and its vascular pedicle located. Figures 1 and 2 show the steps of mobilizing the anterior, middle, and posterior parts. The medial mucosal surface was

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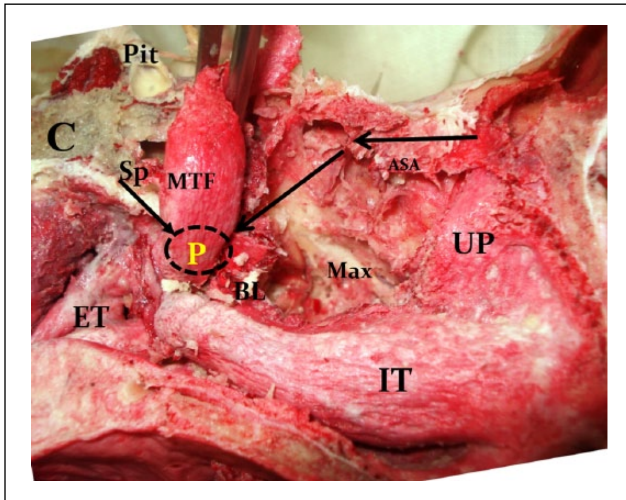

Figure 1. The middle turbinate was completely mobilized from the skull base and the lateral nasal wall and its vascular pedicle located. The right 2 black arrows show sharp separation of middle turbinate anterior sagittal attachment (ASA) and middle attachment. The left black arrow shows blunt retrograde separation of middle turbinate toward pedicle. The black interrupted circle shows pedicle (P) position behind basal lamella (BL).
Abbreviations: C, clivus; ET, Eustachian tube; IT, inferior turbinate; Max, maxillary sinus; MTF, middle turbinate flap; Pit, pituitary; Sp, sphenoid sinus; UP, uncinate process.

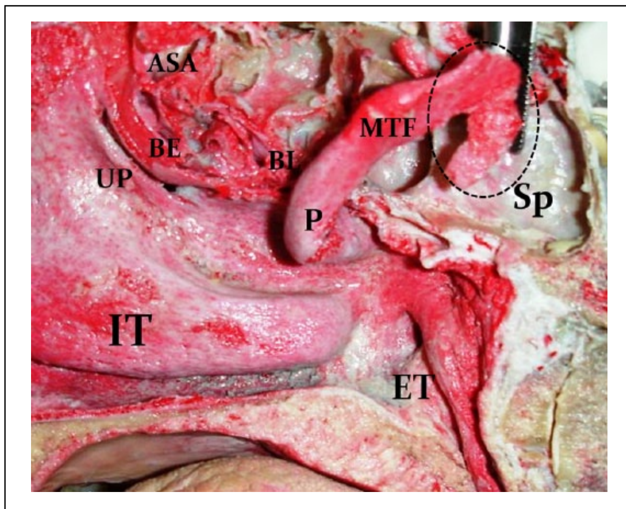

Figure 2. Middle turbinte flap (MTF) was rotated, and its suitability to cover the sella was tested. The black interrupted circle shows plenty of mucosa covering sella and adjoining areas.
Abbreviations: ASA, anterior sagittal attachment; BE, bulla ethmoidale; BL, basal lamella; ET, Eustachian tube; IT, inferior turbinate; P, pedicle; SP, sphenoid sinus; UP, uncinate process.

removed or partially dissected. Finally, the MT was rotated, and its suitability to cover the sella was tested. Dimensions of the MT and sella and the distance between them were obtained.

Surgical Technique

During an extended sphenoidotomy, preservation of the SPA pedicle can be achieved by dissection of the mucoperosteum over the sphenoidal face until the sphenopalatine foramen and clivus of the contralateral side are reached. Subperiosteal drilling of the sphenoidal face facilitates later rotation of the MT. The MT was slightly medialized to visualize the basal lamella and estimate the approximate location of the SPA (Figure 3A). The distance between anterior end of MT until approximate pedicle is compared with that between pedicle and sella. The medial mucosal surface was then ablated by diathermy or partially dissected if more surface area was needed. The mucoperiosteum in front of the basal lamella was elevated to identify the orbital process of the ethmoidal crest of the perpendicular plate of the palatine bone and hence the SPA. The anterior sagittal part of the MT was cut a few millimeters below the skull base (Figure 3B). The middle part was mobilized by a vertical incision of the medial aspect of the basal lamella at the transition between the sagittal and coronal planes of the MT, taking care to stay at least 1 cm above the inferior free edge of the basal lamella to avoid disruption of any SPA branches. Further medial mobilization of the MTF at this point allows visualization of the superior meatus and helps in avoiding injury of the SPA branches. Visualization of the posterolateral nasal artery allows complete separation of the basal lamella from the lateral nasal wall. The posterior part was mobilized retrograde by blunt and mucoperiosteal dissection backward to the SPA. This increases the arc of rotation of the flap. The MT was then rotated either laterally or posteriorly to cover the sellar defect (Figure 3C). Posterior rotation is not preferred in a hyperpneumatized sphenoid as it requires tucking the pedicle into the clivus. The osseous component of the flap is usually thin and susceptible to minifractues. Thick conchal bone can be thinned out with a microdebrider or a large diamond burr. This permits its easy application to the skull base defect. Large pituitary defects were plugged with fat graft. The flap was fixed in its place by applying a few pledgets of Surgicel.

Results

Anatomical Study

The MT artery was located in all 10 specimens. It arises from posterolateral nasal branch of the SPA. The vascular pedicle lies behind the basal lamella of the perpendicular plate of the palatine bone (Figure 1). Table 1 shows various measurements of the MT and sella. Mean length of the MT was 4.73 cm, and the mean length from the most anterior end of the MT to the upper and lower part of the basal lamella was 3.2 cm and 3.67 cm, respectively. The mean surface area of the MTF with and without partial dissection of its medial mucosal side was 9.5 cm^2 and 7.6 cm^2, respectively, whereas

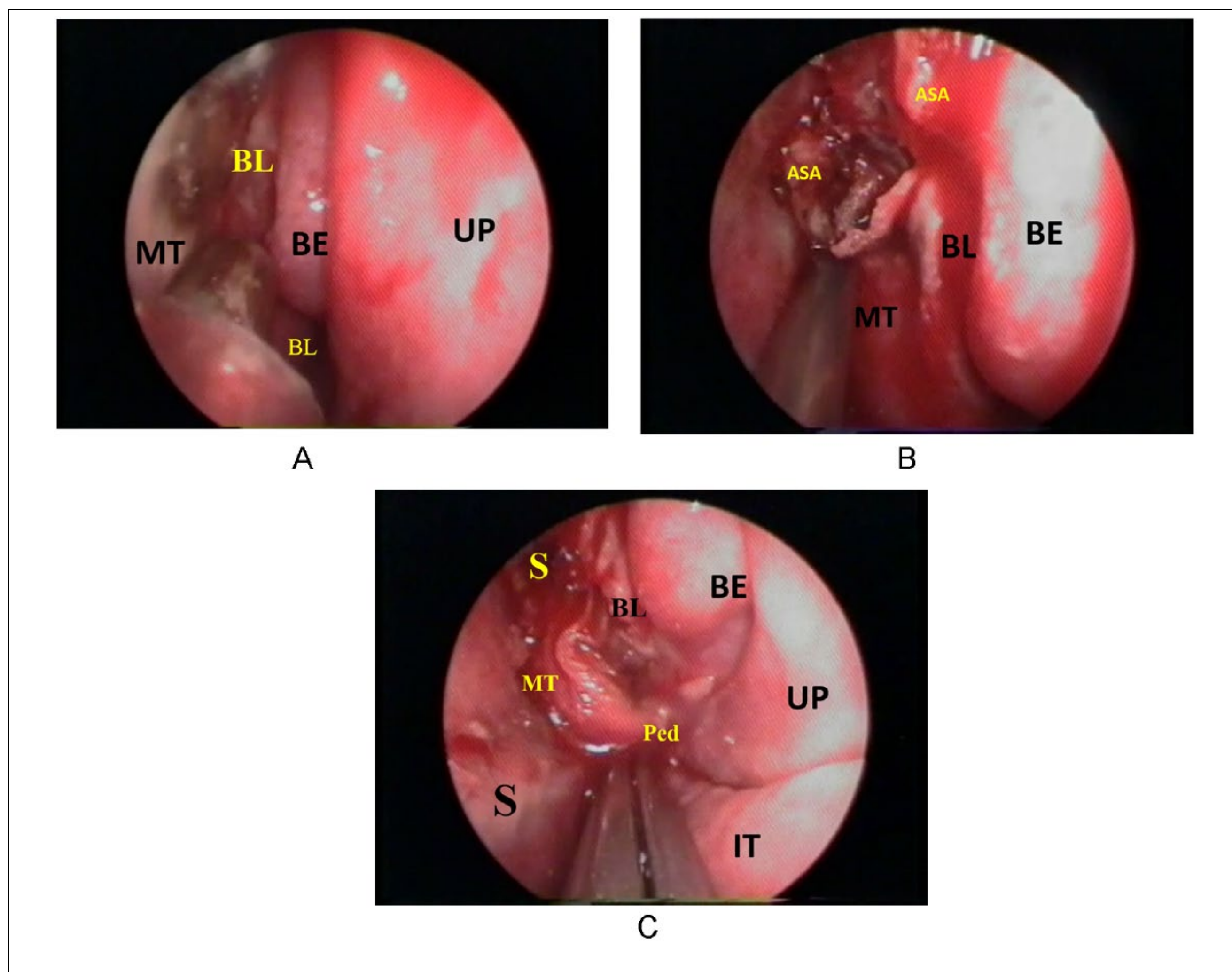

Figure 3. (A) The middle turbinate (MT) is medialized to expose basal lamella (BL) and approximate location of vascular pedicle. The sphenopalatine artey and posterolateral arteries are then exposed. (B) The anterior sagittal attachment (ASA) of MT was cut a few millimeters below the skull base. (C) The middle part of MT was mobilized by a vertical incision of the medial aspect of the BL at the transition between its sagittal and coronal planes. The MT flap is then rotated to sphenoid sinus (Sp) to cover sellar defect.
Abbreviations: BE, bulla ethmoidale; IT, inferior turbinate; UP, uncinate process.

the mean sella area was 2.2 cm^2. The anterior third of MT provided most of its medial surface area. Ablation of the medial mucosa of the MT did not affect the likelihood of the flap covering the sella of 10 head sides. The MTF covered the sella, planum, and tuberculum sella completely on 10 head sides (Figure 2). Partial dissection of the MT medial mucosa was needed on 3 head sides to cover the sella, planum, and tuberculum sella simultaneously.

Patients and Surgical Results

The composite MTF (CMTF) was used to manage the 25 cases of CSF leak following transsphenoidal, endoscopic pituitary surgery. The group consisted of 11 females and 23 males with mean age 43 years (range, 30-55 years). Twenty-three cases were pituitary macroadenomas, 1 was a Rathke's cleft cyst, and 1 was a craniopharyngioma. Twenty macroadenomas were nonfunctioning, 1 case of prolactinoma and 2 cases growth hormone secreting. Two cases were revision, and the remaining were de novo. The mean parasellar intercarotid distance was 2.44 cm (range, 2-2.7 cm). The mean size of pituitary macroadenomas was 21.2 cm^3 (range, 7.8-36 cm^3). In 17 cases, there was a definite continuous CSF leak. In the remaining cases, there was a probable CSF leak observed by the washout sign or using the Valsalva maneuver. The MTF is favored in large sellar cavities with a ballooned diaphragmatic sella wherein a fat plug seems insufficient to avoid a late CSF leak. Two cases were high-flow, and the remaining cases were low-flow CSF leaks. In 24 cases, the follow-up interval ranged from 26 to

Table 1. Dimension of MT and Sella and Distances Between Them.

Measurement	Range	Mean
Length of MT (cm)	4-5.2	4.73
Distance between anterior end of MT and upper part of BL (cm)	2.9-3.5	3.2
Distance between anterior end of MT and lower part of BL (cm)	3.2-4	3.67
Upper part of BL to optic chiasm (upper sella) (cm)	2.5-3	2.8
Upper part of BL to most bulging point (mid) of sella (cm)	2.2-2.7	2.4
Upper part of BL to lower sella or clivus (cm)	2.9-3.2	3.1
Lower part of BL to optic chiasm (upper sella) (cm)	2.4-2.8	2.63
Lower part of BL to most bulging point (middle) of sella (cm)	2.1-2.5	2.33
Lower part of BL to lower sella or clivus (cm)	2.6-3.1	2.9
Posterior end of MT to upper part of Sella (optic chiasm) (cm)	2.4-2.6	2.5
Posterior end of MT to most bulging point (middle) of sella (cm)	1.9-2.2	2.06
Posterior end of MT to lower sella or clivus (cm)	1.9-2.1	2
Area of sella turcica window (cm^2)	2-2.42	2.204
Surface area of MTF without medial mucosal dissection (cm^2)	5.5-9.2	7.6
Surface area of MTF with medial mucoal dissection (cm^2)	6.4-11.7	9.53

Abbreviations: BL, basal lamella; MT, middle turbinate.

37 months. The operative reconstruction time ranged from 6 to 10 minutes and did not require extensive laboratory training. None of the cases required increasing the MTF surface by dissection of its medial mucosa. No postoperative complications such as bleeding, adhesion, or symptoms suggesting sinusitis occurred. The CSF leak was controlled in 24 cases. One case was reported as having symptoms suggestive of CSF leak 6 months postsurgery. The patient was abroad, and the authors could not verify it.

Discussion

Sellar defects after endoscopic, transsphenoidal pituitary surgery are rather voluminous than having large surface area. The size of pituitary tumours doesn't affect markedly size of resulting skull base defect which is bounded by both parasellar internal carotid arteries (ICA), optic chiasm, dorsum Sella and clivus. Lateral extension of pituitary tumours occurs towards the medial compartment of the cavernous sinus which is by definition still medial to the parasellar ICA. Extension to the lateral compartment of the cavernous sinus is in the extradural space. A transplanum or transdiaphragmatic extension does not markedly increase the size of the defect.

The nasoseptal flap (NSF) is better saved for large skull-base defects or sometimes not available due to previous posterior septectomy. The MTF is suitable for relatively small defects. The randomized MTF has long been used for CSF leak repairs. Reconstruction of skull base defects with vascularized tissue is, however, superior to other methods.[3] The pedicled MTF has not gained much popularity because it is technically demanding.

Dissection of the mucoperiosteum is difficult. Destabilization of the MT concha may hinder the harvest or lead to a CSF leak. Prevedello et al[2] first described the MTF in an anatomical study highlighting its technical difficulty. The length of the flap pedicle is more important than its surface area for adequate coverage of sellar defects.[2,4] Simal et al[5] reported similar technical difficulties in a clinical study of MTF necessitating specific training with a cadaver. The average reconstruction operative time was 27 minutes.[5] Chen et al[6] modified the MTF harvest to increase its surface area and cover the nasopharyngeal defects, yet the average operative reconstruction time was 110 minutes.

Reviewing the available literature revealed that the MTF has not gained much popularity, and few reports are available compared with the NSF. The authors have therefore tried to provide an anatomical instruction model for simple, rapid, and safe harvest of the MTF, sufficient to cover the sellar defects and not necessitating extensive cadaver training. The rationale for the CMTF is that the classic technique is lengthy and difficult and may lead to a CSF leak.[2] In this study, the small area of sellar corridor (mean, 2.2 cm^2) supports the finding that the success of MTF depends on length rather than surface area. However, none of the CMTFs failed to cover the sella, planum, and tuberculum sellae. The mean distance between the anterior ends of the MT to the lower part of the basal lamella (3.67 cm^2) exceeded the mean distance between the latter and the sella (2.33cm^2). The fact that the vascular pedicle of the MT lies behind the basal lamella shows that in most cases the MTF will cover the sellar corridor. In the study of Prevedello et al,[2] there was a discrepancy between the mean area of the MTF (5.6 cm^2) compared with the mean width (2.8 cm) and mean length (4.1 cm). In the current study, the mean area of the CMTF with and without medial mucosa dissection was 9.53 cm^2 and 7.6 cm^2, respectively, and the mean MT length was 4.73 cm. The author therefore suggests that removal of conchal bone leads to retraction of the covering mucoperiosteum. The bone allows stable reconstruction, especially in large sellar defects.[7] The MT is not as bulky as is the inferior turbinate. The MT concha is thin and susceptible to minifractures, so should be thinned out with a diamond burr or microdebrider and therefore can easily accommodate sellar defects.

Branches of the SPA, entering its posterior aspect, supply most of the MT. The anterior portion of the MT provides most of its mucosal surface while the posterior

portion tapers posteriorly in a pediclelike fashion, in close proximity to the anteroinferior aspect of sphenoid sinus.[8] The vascular pedicle of the MT consists of the SPA, the posterolateral nasal artery (PLNA), and finally the MT artery. The endoscopic and surgical landmarks of these arteries are well recorded in the literature and therefore can be approximately located to avoid their injury before or during MTF harvest. The PLNA is consistently noted in cadaveric studies, showing division into middle and inferior turbinate arteries.

The PLNA lies on the lower part of the perpendicular plate of the palatine bone, approximately 1 cm anterior to the posterior end of the middle turbinate and 1.5 cm anterior to the posterior end of the inferior turbinate.[8] It can therefore be concluded that the MT pedicle is close to the posterior end of the inferior turbinate and that separation of the MT from the skull base and lateral nasal wall does not affect its vascular pedicle. Visualization of the pedicle allows complete separation of the basal lamella and better rotation of the MTF.

Reconstructive time using the CMTF is 6 to 10 minutes and does not necessitate specific training. The osseous component of the flap confers better stability to the recipient site, particularly with the presence of a fat graft or large ballooned diaphragm underneath.

Compared with the NSF, no bioadhesive materials or ballooned catheters are needed to fix the flap in place.

The authors' experience supports that NSF and CMTF are equally effective for reconstruction of sellar defects. The authors previously used the NSF for management of CSF leak following transsphenoidal surgery. It is highly versatile and provides larger surface area in comparison with the relatively small sellar defects. The NSF may require additional bone or cartilage to support added fat plug, particularly in large voluminous sellar defects with ballooned diaphragm sella. The NSF may not be readily available in revision cases due to posterior septectomy. The use of NSF unless necessary seems a waste for relatively small sellar defects. The use of fat grafts or synthetic biomaterials alone without vascularized flap seems not sufficient to manage a life-threatening definite CSF leak. The authors emphasize that although CMTF is a relatively quick technique, CSF leak is a life-threatening condition that needs meticulous and careful surgical management.

The effects of MT resection have been thoroughly investigated in the literature. Studies show no effect on olfaction or sinus complication. In the current study, no sinus complication, bleeding, nasal synechia, or hyposmia were noticed over the follow-up period.

The clinical part of this study lacks correlation of size and flap defect location as in the anatomical feasibility study. This was beyond the scope of this study. The MT size and shape can be evaluated endoscopically. The distance between anterior end of MT until approximate pedicle location is compared with that between pedicle and sella. The expected size of sellar defect can be assessed by MRI preoperatively. All these data help assessing the feasibility of CMTF.

One disadvantage of this study was the use of formalin-preserved cadavers. This might have affected the medial mucosal dissection of the MT. However, most of the measurements were between bony landmarks.

Conclusion

The CMTF is an effective and quick technique for sellar reconstruction. Proper knowledge of anatomy rather than extensive cadaveric training is needed to develop a CMTF. Its osseous component adds to better reconstruct and stability. The CMTF can be used for sellar reconstruction, sparing the generous NSF for larger skull-base defects.

Declaration of Conflicting Interests

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References

1. French C, Goyal P. Submucosal resection of the middle turbinate. *Laryngoscope*. 2013;123(8):1845-1848.
2. Prevedello DM, Barges-Coll J, Fernandez-Miranda JC, et al. Middle turbinate flap for skull base reconstruction: cadaveric feasibility study. *Laryngoscope*. 2009;119:2094-2098.
3. Kimple AJ, Leight WD, Wheless SA, Zanation AM. Reducing nasal morbidity after skull base reconstruction with the nasoseptal flap: free middle turbinate mucosal grafts. *Laryngoscope*. 2012;122(9):1920-1924.
4. Soler ZM, Khalid AN, Smith TL. Middle turbinate hinge flap for frontal recess obliteration following prior cranialization. *Laryngoscope*. 2009;119:1403-1405.
5. Simal JJA, Miranda LP, Cárdenas R-VE, Barges CJ, Beltrán GA, Botella AC. Middle turbinate vascularized flap for skull base reconstruction after an expanded endonasal approach. *Acta Neurochir (Vienna)*. 2011;153(9):1827-1832.
6. Chen MY, Wang SL, Zhu YL, et al. Use of a posterior pedicle nasal septum and floor mucoperiosteum flap to resurface the nasopharynx after endoscopic nasopharyngectomy for recurrent nasopharyngeal carcinoma. *Head Neck*. 2012;34(10):1383-1388.
7. Fabiano AJ, Rigual NR, Belber CS, Endoscopic sellar floor reconstruction with concha bullosa bone autograft and nasal septal flap: technical case report. *Minim Invasive Neurosurg*. 2009;52(2):86-88.
8. Lee HY, Kim HU, Kim SS, et al. *Laryngoscope*. 2002;112(10):1813-1818.