Outcomes of Middle Turbinate Flap in the Reconstruction of Non-tumorous Ventral Skull Base Defects - an Institutional Review

Original Investigation ▶

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Abstract ▶

Objective: Middle turbinate (MT) flap, based on the branches of sphenopalatine artery is one of the commonest mucosal flaps used in endoscopic skull base surgery. The objective of this study is to analyze the outcomes of the MT flap in the reconstruction of non-tumorous ventral skull base defects.

Methods: A retrospective review of patients was done from 2010-19. Patients who underwent reconstruction for non-tumorous ventral skull base defects using middle turbinate (MT) flap were included in the study. The parameters assessed include patient demography, primary etiology, site of the defect, size of the defect, graft materials used, outcomes and postoperative complications.

Results: A total of 13 patients who met the study criteria were included. Three (23.07%) of the patients had meningo-encephalocele, while the remaining 10 (76.93%) had CSF fistula. Isolated foveal defect

(53.8%) was the most common site involved, followed by isolated cribriform, combined cribriform-foveal and combined foveal-planar defects. Graft materials used were fascia lata, fat and septal cartilage. MT flap was successfully harvested in 11 (84.6%) patients, with successful outcome in 10/11 patients. Hypoplastic MT was present in two patients, who subsequently required Hadad flap for defect closure. No major complications were reported in the postoperative period.

Conclusion: The MT flap is effective in the reconstruction of selective skull base defects. Appropriate surgical technique and expertise are required for successful harvest. Further studies are required to analyze its outcomes in various skull base defects.

Keywords: Middle turbinate, skull base, surgical flap, reconstruction, endoscopic surgical procedure

Introduction

Multi-layered reconstruction is preferred for reconstructing skull base defects associated with cerebrospinal fluid (CSF) rhinorrhoea. Mucosal flaps based on nasal septum, middle turbinate (MT) and inferior turbinate (IT) are the common intra-nasal flaps used for the reconstruction of skull base defects (1, 2). External incision and osteotomies are not required for harvesting these flaps, in contrary to pericranial and temporoparietal fascia flaps (3). Currently, nasoseptal flap based on the posterior septal artery (Hadad-Bassagasteguy) (HB) is the most popular and versatile flap used in ventral skull base reconstruction (4). However, many authors consider the dissection needed to

harvest and use of HB flap as excessive for small to medium sized skull base defects.

The MT flap, based on the middle turbinate branch of the sphenopalatine artery is another robust flap used to repair small defects in the olfactory groove and sella (5). MT is a leaf like structure attached to the cribriform plate, lamina papyracea and perpendicular plate of palatine bone. As most of encephaloceles and CSF fistulas occur in cribriform and foveal areas, this flap can be considered in reconstructing the defects in these areas (6, 7). Smaller surface area and harvesting difficulties are considered as the main limitations of this flap. Very few studies are available in the literature describing the role of MT in skull base reconstruction. This study

Turk Arch Otorhinolaryngol 2020; 58(4): 214-9

Manimaran et al.
Middle Turbinate Flap in Skull Base 215

was designed to analyze the outcomes of middle turbinate flaps in endoscopic reconstruction of non-tumorous ventral skull base defects.

Methods

Institutional ethical committee approval was obtained from Sri Ramachandra Institute of Higher Education and Research (Approval Date: February 17, 2020; Approval Number: 23/2020). Details of patients who underwent skull base reconstruction using MT flap in the period from 2010 to 2019 were collected from the medical records. Patients in whom other pedicled flaps were harvested because of a failed attempt to harvest the MT flap were also included in the study. These patients were included to analyze their causes of failure. The following details were analyzed from the records: demography, primary etiology, site of the defect, size of the defect, graft material used, presence of CSF leak during surgery, outcomes, and complications. The

use of other vascular flaps and open craniotomy were considered as exclusion criteria and those patients were excluded from the study.

Harvest of Middle Turbinate (MT) Flap

Written informed consent was obtained from all patients prior to their procedures. The MT flap was harvested based on the technique described by Prevedello et al (8). Under general anaesthesia, after positioning the patient, the nasal cavity was decongested using 1:1000 adrenaline patties. The MT was in-
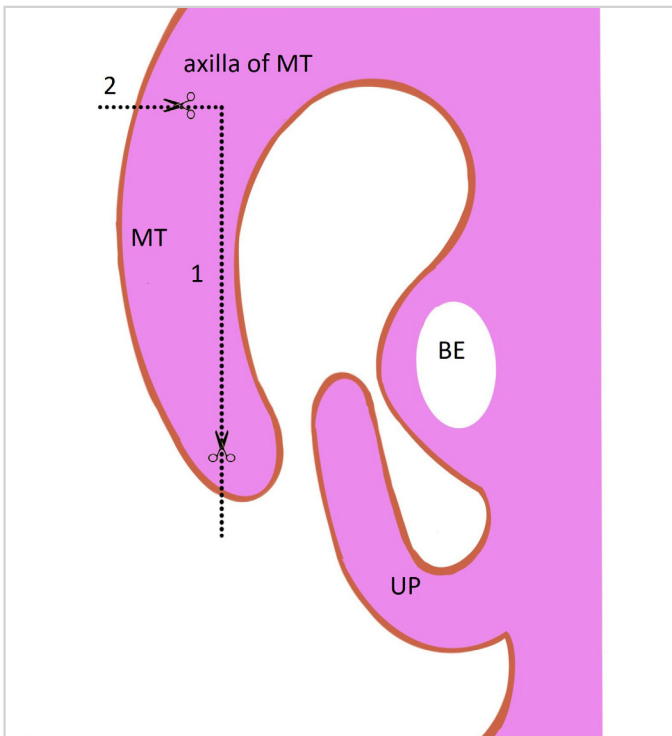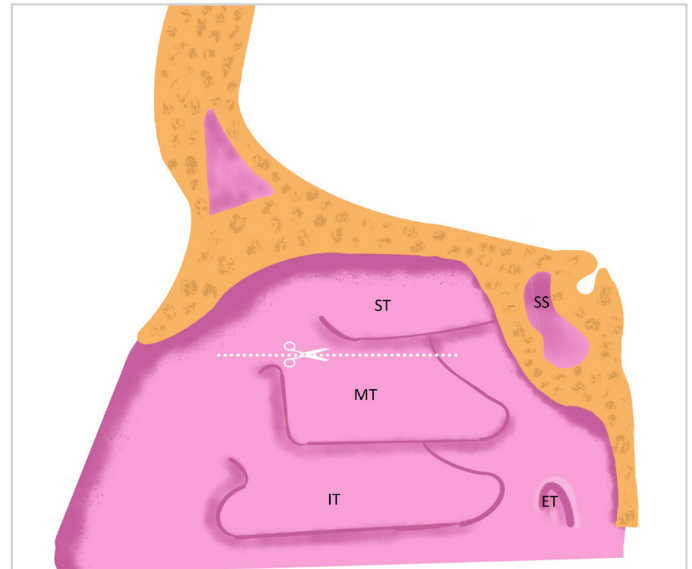

Figure 2. Diagram showing the horizontal incision extending along the medial surface of middle turbinate
ST: superior turbinate; MT: middle turbinate; IT: inferior turbinate

Figure 1. Diagrammatic representation of osteomeatal complex on left nasal cavity (coronal view)
*: represents the axilla of middle turbinate. Pink and brown shaded areas represent bony and mucoperiosteum, respectively. 1: represents the first vertical incision made over the caudal part of middle turbinate. 2: represents the horizontal incision made along the medial surface of middle turbinate
MT: middle turbinate; BE: bulla ethmoidalis; UP: uncinate process

Main Points

- Middle turbinate flap was successfully harvested in 11/13 (84.6%) patients. Hypoplastic middle turbinate was the cause for failure in two patients.
- Defect was successfully closed in 10/11 (90.9%) patients with no major complications.
- Middle turbinate flap can be effectively used in non-tumorous skull base defects with less morbidity.
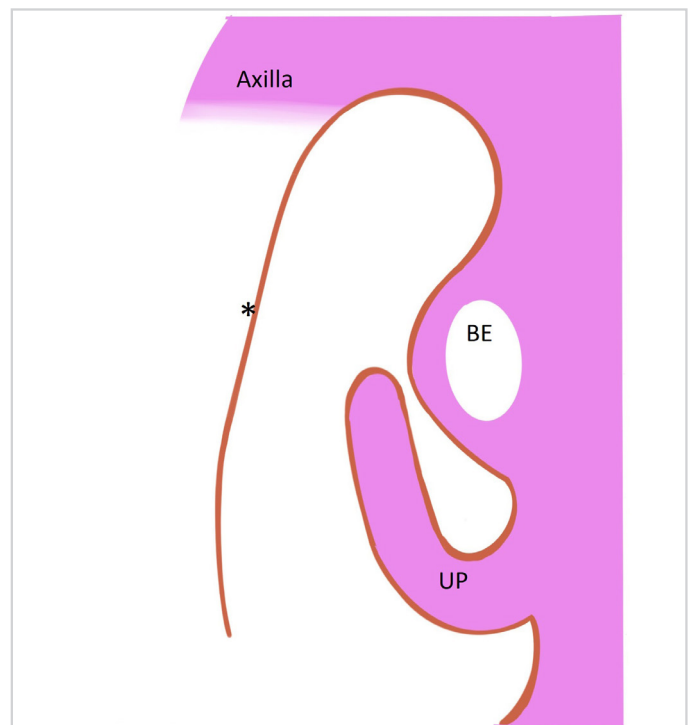

Figure 3. Diagram showing the vascularized MT flap attached to its pedicle after removal of bony segments of MT
MT: middle turbinate; BE: bulla ethmoidalis; UP: uncinate process.

filtrated using 2% xylocaine and adrenaline to facilitate hydro-dissection. A vertical incision was made in the rostral part of the MT starting from the axilla. A second incision was made horizontally along the medial surface of the MT, close to its superior attachment, respecting the cribriform plate (Figures 1, 2). The mucoperiosteum was elevated and the bone was removed in piecemeal. The axilla was cut using endoscissors detaching the MT from the skull base. This cut was continued posteriorly up to the vascular pedicle. The mucoperiosteal flap remained attached only at its pedicle and unfolded like and open book (Figure 3). Prior to harvesting the flap, the maxillary sinus ostium was widened, and the sphenopalatine artery was identified at its exit point in the sphenopalatine foramen. The pedicled MT flap was rotated and placed either inside the maxillary sinus or the nasopharynx.

Once the flap was harvested, the primary etiology was addressed. The defects were delineated and repaired in multiple layers. Fascia lata was used in all cases, while fat and cartilage were used as grafts additionally in selected cases. The grafts were placed in the following order: at (in selected cases) followed by fascia lata (interlay-tucked between dura and bone), cartilage (in selected cases) and fascia lata (overlay-overlying the bone). If cartilage was not used, only one layer of fascia lata was used. The MT flap was reinforced over these graft layers which was further reinforced with oxidized regenerated cellulose strips (Surgicel, original haemostat, Ethicon; Mumbai, India) and fibrin sealant (Tisseel, Baxter; Westlake, California, USA) (Figure 4). The nasal cavity was packed, and the pack was removed after 48 hours.

All patients received acetazolamide tablet 250 mg thrice a day in the postoperative period. No patients underwent lumbar drainage in the postoperative period.

Statistical Analysis
The data was entered and analyzed in MS-Excel software, version 2005. Qualitative data was expressed in percentages and quantitative data was expressed in mean±standard deviation.

Results

Demography
A total of 13 patients who satisfied the study criteria were included. The mean age of study cohort was 39.8±11.8 years. Male-to-female ratio in the study was 6:7 (Table 1).

Etiology
The primary etiology of the patients in this study were either meningo-encephalocele or CSF fistula. In three (23.07%) patients, meningo-encephalocele was the aetiology, while the remaining 10 (76.93%) had CSF fistula alone. None of the patients in the study cohort had tumor as primary etiology, and all defects following skull base tumor removal were reconstructed with HB flap or other pedicled vascular flaps.

Site and Size of the Defect
In this study, seven patients (53.8%) had isolated foveal defect, three patients (23.07%) had isolated cribriform defect, two patients (16.6%) had combined foveal and cribriform defect, and

Table 1. Table showing demographic details, defect area, size of defect, layers of reconstruction, outcome and follow up

Seq. no	Age	Sex	Primary etiology	Defect area	Size of the defect (cm²)	Graft used	Outcome	Follow-up (months)
1	43	F	Meningo-encephalocele (without CSF leak)	Fovea	3.2	Fascia lata, Cartilage	Success	18
2	34	F	Spontaneous CSF leak	Fovea	3.2	Fat, Fascia lata, Cartilage	Failure, converted to HB flap	N/A
3	45	M	Traumatic CSF leak	Fovea	2.1	Fat, Fascia lata.	Success	24
4	32	M	Traumatic CSF leak	Cribriform and fovea	3.7	Fat, Fascia lata, Cartilage	Failure, converted to HB flap	N/A
5	36	F	Traumatic CSF leak	Cribriform	2.9	Fat, Fascia lata	Success	27
6	42	F	Spontaneous CSF leak	Cribriform	3.1	Fat, Fascia lata, Cartilage.	Failure	12
7	15	M	Traumatic CSF leak	Fovea	4.2	Fat, Fascia lata, Cartilage	Success	20
8	24	M	Meningo-encephalocele (without CSF leak)	Cribriform and fovea	4.5	Fascia lata, Cartilage	Success	17
9	34	F	Spontaneous CSF leak	Fovea	2.4	Fat, Fascia lata, Cartilage	Success	10
10	54	M	Traumatic CSF leak	Cribriform	3.9	Fat, Fascia lata, Cartilage	Success	12
11	45	F	Spontaneous CSF leak	Fovea	2.9	Fat, Fascia lata, Cartilage	Success	19
12	54	M	Meningo-encephalocele (without CSF leak)	Fovea and planum sphenoidale	3.1	Fascia lata, Cartilage	Success	23
13	46	F	Spontaneous CSF leak	Fovea	2.3	Fat, Fascia lata, Cartilage	Success	10

M: male; F: female; HB: Hadad-Bassagasteguy flap; CSF: cerebrospinal fluid; N/A: not applicable

Turk Arch Otorhinolaryngol 2020; 58(4): 214-9

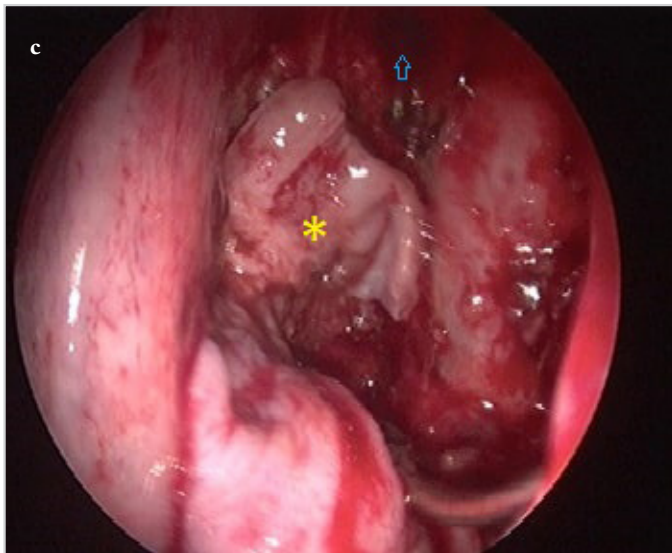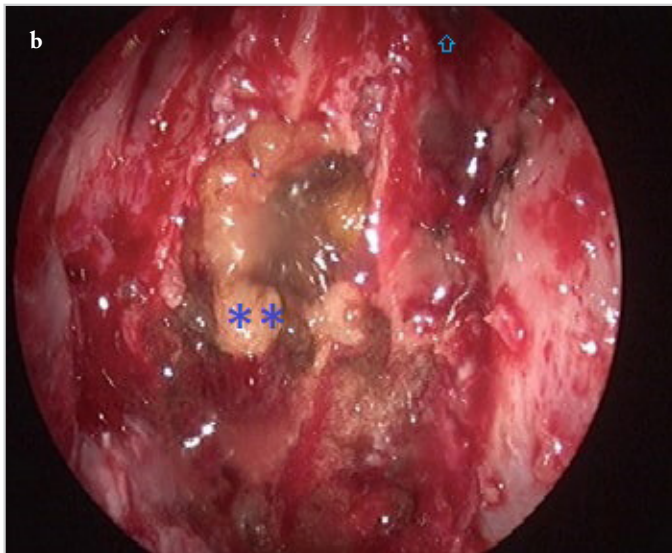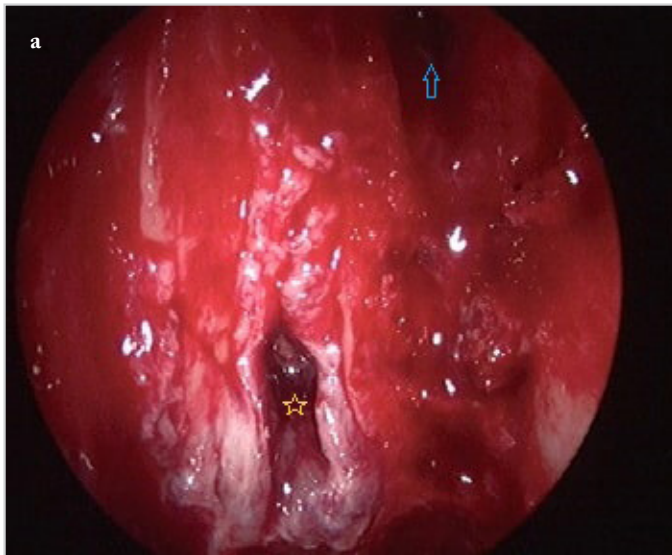Manimaran et al.
Middle Turbinate Flap in Skull Base 217

Figure 4. a-c. Intraoperative photographs showing (a) a defect in the cribriform plate of left nasal cavity, (b) the defect was closed with fat and fascia lata and (c) the grafts reinforced with MT flap
Blue arrow: frontal recess; yellow star: defect in cribriform plate; double blue asterisk: fat graft; yellow asterisk: middle turbinate flap

one patient (7.6%) had combined foveal and planar defect. Mean defect size was 3.19±0.72 cm².

Graft Materials
Fat was used in all patients with CSF fistula. Septal cartilage was used in 11 of 13 (84.6%) patients. Fascia lata was used in all patients irrespective of etiology.

Flap Harvest
MT flap was successfully harvested in 11 of 13 (84.6%) patients. HB flap was harvested in two patients, in whom the MT flap could not be harvested successfully. Ten of 11 (90.9%) patients with MT flap cover had successful outcome with no evidence of recurrence. The reason for failure in harvesting an MT flap in the two patients was hypotrophied middle turbinate. There was destabilization of MT during the procedure, which lead to unsuccessful attempt. No iatrogenic CSF leak was reported.

One patient had recurrent CSF leak after 12 months. The patient was advised revision surgery but lost to follow up. The primary etiology of that patient was benign intracranial hypertension.

Follow-up and Complications
The average follow-up period of the study cohort was 17.45±5.87 months. No haemorrhagic or non-haemorrhagic complications were reported in the postoperative period.

Discussion

Endonasal endoscopic approaches are preferred for ventral skull base defects associated with CSF leak or meningo-encephaloceles. Multi-layered reconstruction using autologous grafts, flaps and synthetic materials are required for successful outcome (9, 10). Various intranasal and extranasal flaps have been described for this purpose. Pedicled vascular flaps augment and strengthen the grafts, thereby reduce the chances of failure. Commonly used intranasal flaps are the HB flap, the IT flap and the MT flap (1).

HB flap remains the workhorse flap for various ventral skull base reconstructions. The main advantages of this flap are its availability in large quantity and its less demanding surgical technique. It is ideal for larger skull base defects, especially for defects after tumor removal. The disadvantages of this flap are its unavailability in patients with septal perforation and prior nasal surgeries (11, 12). Tamura et al. (5) have demonstrated that inferior turbinate flaps can be effectively used in the reconstruction of sellar and clival defects. However, its utility in cribriform and planar defects requires further research.

MT flap for the reconstruction of skull base defects was first described in cadavers by Prevedello et al (8). They demonstrated the utility of MT flap in cadavers and concluded that it is suitable for medium sized cribriform, foveal and planar defects. According to the literature, the average cross-sectional area of this flap is 5-9 cm², which is sufficient to reconstruct medium sized defects (13, 14). Reports also emphasized that preventing

destabilization of the MT while harvesting is critical for success and prevention of CSF leak. Harvesting an MT flap requires expertise, as MT is not a firm structure. Open book technique is the most preferred approach for MT flap harvest. The authors prefer Plester's knife, which is a common instrument used in ear surgeries, to elevate the mucoperiosteum over the MT. The knife is flag shaped and helps in elevation of mucoperiosteum in the medial surface of MT without causing excessive traction.

Identification of the main trunk of SPA before harvesting the flap helps in creating a pedicle up to the posterior attachment of MT to perpendicular plate of palatine bone. It also ensures that the surgeon does not cut the pedicle accidentally. Creating a longer pedicle aids a bigger arc of rotation, thereby reaching to the more anterior parts of cribriform plate. Adequate widening of the maxillary sinus ostium helps in placing the flap temporarily inside the sinus during the surgery.

However, MT flap is difficult to harvest in situations like concha bullosa, paradoxical middle turbinate and hypoplastic turbinate (15). MT flap was unsuccessful in two patients in this study. Both had hypoplastic middle turbinate, which lead to the destabilization of the MT bone. Anatomical deformities can be identified preoperatively by CT scans and nasal endoscopy. Though they are not absolute contraindications for MT flap harvest, surgeon should be aware of such difficult situations and should have an alternative.

Simal Julián et al. (14) have analyzed outcomes of the MT flap in the reconstruction of ventral skull base defects. All the patients in their study were operated on for either pituitary macroadenoma, or arachnoid cyst, or Rathke's cleft cyst. George et al. (16) reported 100% success rate with MT flap reconstruction in their study of 20 patients. All their patients had small to medium sized defects. In our study, we only included patients with medium sized defects. Smaller defects do not require pedicled flap reconstruction while larger defects with tumors require a larger flap like nasoseptal flap. Role of mucosal flaps in medium sized defects is based on the pathology, site of the defect, and the surgeon. In this study, mucosal flap was used in all cases irrespective of etiology, as mucosal flaps help in stability and fixation of grafts along with faster healing of mucous membranes in the surgical area.

Carrabba et al. (17) reported the incidences of recurrent CSF leak and tension pneumocephalus after MT flap reconstruction as 24% and 6%, respectively. However, the results of their study were based on the reconstruction of clival defects. In our study, 10/11 (90.9%) patients had successful outcomes without any notable complications. The results of our study show that MT flaps can be used effectively in cribriform and foveal defects with less morbidity.

The authors emphasize that MT can be a viable option for defects in sphenoethmoidal recess, as it is closer to the defect. Many studies in the literature have reported successful outcomes with MT flaps in sellar and clival defects. However, the authors have no experience on sellar and clival defects. Smaller sample size and retrospective nature of the study makes comparison with control groups difficult. Skull base tumors were not included in the study as the authors do not have much experience in such cases. However, the authors are conducting a study in skull base reconstruction following tumor removal, and the results will be published in the near future. The grafting technique used to reconstruct was not similar leading to lack of standardization in surgical technique. We recommend a prospective study with standard surgical techniques to assess the outcomes.

Conclusion

We conclude that the MT flap is effective in the reconstruction of ventral skull base defects. Appropriate surgical technique is critical for the successful harvest of the flap. Further studies with larger sample sizes are required to analyze its outcomes in various skull base lesions.

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Turk Arch Otorhinolaryngol 2020; 58(4): 214-9

Manimaran et al.
Middle Turbinate Flap in Skull Base 219

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