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Is Septal Cartilage Graft via Transmastoid Approach Safe Enough in the Repair of Large Tegmen Defects?

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Keywords

Tegmen defect · Meningoencephalic herniation · Cerebrospinal fluid leakage · Septal cartilage · Transmastoid approach

Abstract

Introduction: Tegmen defect (TD) has a potential of intracranial spread of middle ear infection, meningoencephalic herniation (MEH), and cerebrospinal fluid leakage (CSFL). Especially the defects >1 cm with MEH or CSFL are generally repaired via the classical middle fossa or minicraniotomy technique. The aim of this study was to show the efficiency of the intracranial, extradural placement of the septal cartilage graft in the closure of the TD larger than 1 cm via the transmastoid (TM) approach. ***Methods:*** The demographic, preoperative, intraoperative, and postoperative data of 11 patients with chronic otitis media (COM) who had TD larger than 1 cm were reviewed retrospectively. Hospitalization time and hearing preservation with respect to MEH or CSFL were analyzed. ***Results:*** The most common etiology of TD was cholesteatoma (82%), and 91% of the patients had multiple COM surgery history. The mean TD size was 15.4 (10–25) mm. Fifty-five percent of the patients presented with either MEH or CSFL. The mean follow-up of the patients was 22.5 (8–42) months. There was no significant difference between preoperative and postoperative mean bone conduction thresholds. Mean hospitalization time was 5.2 (3–10) days. There was no significant difference in the hospitalization time between patients with MEH or CSFL and without MEH or CSFL. Neither recurrence nor graft infection was encountered. ***Conclusion:*** Extradural grafting with the septal cartilage in the large TD up to 25 mm can be repaired efficiently via the TM approach without application of a lumbar drainage.

Introduction

Tegmen defect (TD) is the bony dehiscence between the middle ear (ME) and middle fossa (MF). The etiology is classified into iatrogenic, which accidentally occurs during mastoid drilling, especially in patients with a low-

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er dural plate, chronic ME infections with or without cholesteatoma; traumatic; and congenital (spontaneous) [1–3]. It has clinical importance that this defect can result in serious morbidities, not only intracranial spread of ME infection but also meningoencephalic herniation (MEH) and cerebrospinal fluid leakage (CSFL) into the ME [4, 5]. Gupta et al. [6] classified the spontaneous bony defects into 4 classes with respect to the presence of MEH, CSFL, and meningitis, regardless of the defect size (class A: bony dehiscence without MEH and CSFL, class B: bony defect with MEH and without CSFL, class C: dehiscence with CSFL without meningitis, and class D: MEH with meningitis).

The presence of active infection or cholesteatoma in chronic otitis media (COM) increases not only the risk of intratemporal and intracranial complications but also the risk of surgery-related complications [7–9]. Bone erosion capacity enables the cholesteatoma to invade the bony labyrinth, facial canal, or bony tegmen [10, 11]. Although tegmen dura is highly thicker, cholesteatoma can penetrate it directly or indirectly with an inflammatory reaction [5, 10].

There are mainly 3 approaches for the surgical treatment of the TD which are transmastoid (TM) route, MF approach (classical or minicraniotomy technique), ME obliteration techniques, and their combinations [3]. The surgical method depends on the size and localization of the defect and the presence of herniation or CSFL [3, 12]. In the literature, there are diverse opinions about the classification of the TD size and the route of the approach in surgical management. Some authors calculate the size of defect in terms of area, while others measure it in length. Arìstegui et al. [13] defined the defect area as small (<1 cm^2), medium (1–2 cm^2), and large (>2 cm^2). They used the TM approach with a minicraniotomy or classical MF route in medium or large TD closure [13]. Semaan et al. [11] and Carlson et al. [14] classified TD into 3 groups with respect to length in centimeters (<1, 1–2, and >2 cm), whereas Gonen et al. [12] and Wootten et al. [15] defined the defects which were >1 cm in length as large defects and advocated the MF approach in these large TDs. Moreover Bodenez et al. [16] retrospectively analyzed 42 COM patients with TD and used the combined or suprapetrous minicraniotomy approach in the defects >1 cm (supracentimetric) in length. Even though the minicraniotomy is much more noninvasive than the classical one, the MF approach has some disadvantages such as prolonged surgery and hospitalization time and neurological complications such as meningitis, headache, seizure, aphasia, and subdural hematoma [12].

There are several autograft, homograft, and allograft materials used in the TD closure. These are bone dust, fascia, muscle, bone graft, cartilage graft, homologous dura, hydroxyapatite, and titanium mesh. These materials are generally used in the larger defects via the MF approach [14, 17–19]. In the literature, there is only one study about the septal cartilage graft (SCG) usage in the MEH surgical management. Aristequi et al. [13] reported 27 patients with various sizes of TDs with MEH. They used the TM plus minicraniotomy or classical MF approach for 15 patients with >1 cm^2 defects. There was only one postoperative meningitis in a patient with post-traumatic herniation. They concluded that in the larger, anteriorly located defects with an active infection, septal cartilage usage via the MF route reduces the risk of postoperative intracranial infections [13]. This study aimed to show the efficiency of the intracranial, extradural placement of the SCG in the closure of the TD larger than 1 cm via the TM approach.

Materials and Methods

This retrospective study included 11 patients with COM who had TD larger than 1 cm in a tertiary referral center between 2016 and 2019. The patients underwent tympanomastoidectomy plus repair of TD with the SCG via the TM approach. All the surgeries were performed by the first author (K.K.). Demographic, preoperative, intraoperative, and postoperative data were analyzed. The preoperative hearing level, type of ME infection, side of surgery, and previous otologic surgery history were recorded. Intraoperatively, the presence of cholesteatoma, type of surgery (intact canal or canal wall down), localization and size of the defect, presence of CSFL, and MEH were collected. Postoperatively, hospitalization time and follow-up time were analyzed. The patients were followed up with radiological and endoscopic examination for the graft infection, resorption, and displacement.

Preoperative and postoperative bone conduction pure tone thresholds (average of 500–1,000–2,000 Hz) were compared to evaluate the effect of this technique on the hearing level. Moreover, the influence of CSFL or MEH on hospitalization time was statistically analyzed.

Surgical Technique

If the diagnosis of the herniation or the TD is confirmed preoperatively with radiological evaluation, harvesting of the SCG is performed before the mastoid surgery. The septal cartilage graft is harvested via caudal hemitransfixion incision, and nasal splints are replaced. The posterior part of the septal cartilage, which is the thicker portion, should be preferred [20]. The patient is repositioned for the otologic surgery. After a standard retroauricular incision, the intact canal or canal wall down mastoidectomy is performed, and the pathology of the ME is resected. In the MEH, the herniated tissue is coagulated from the stalk and excised. In cases with prolapsus of the intact dura, bipolar coagulation of the dura permits sufficient reduction for the exposure of the entire bone

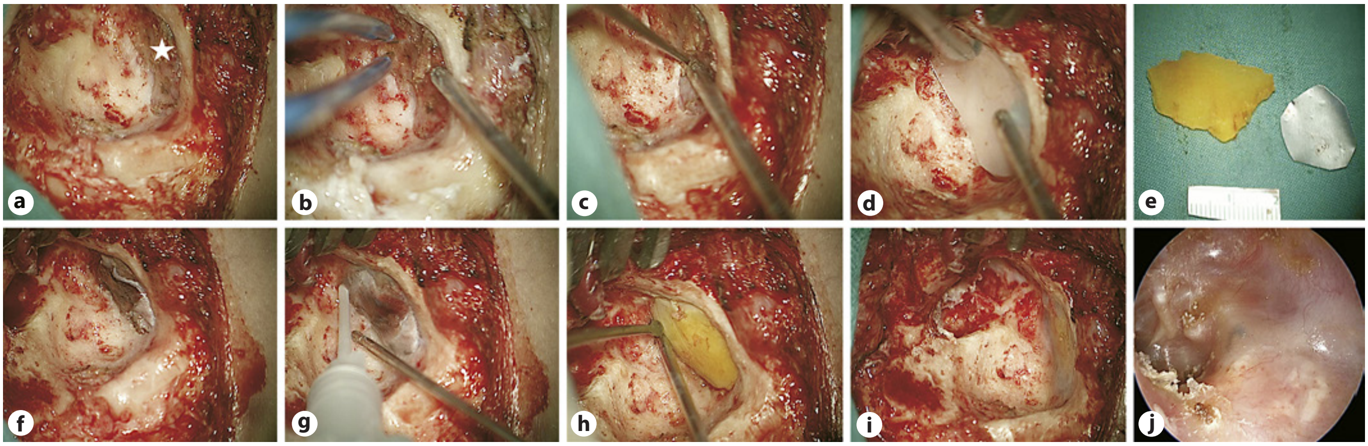

Fig. 1. a Intra- and postoperative findings of patient no. 11. 19 mm TD (white asterisk). **b** Bipolar coagulation of granulation tissue over damaged dura. **c** Extradural elevation of the dura from the tegmen bone for the cartilage graft. **d** Measurement of the defect size with the template. **e** Shaping of the septal cartilage with respect to the template. **f** Closure of dural defect with the fascia. **g** Stabilization of the fascia with fibrin glue. **h** Placement of the septal cartilage graft. **i** View of the mastoid cavity after tegmen repair. **j** Postoperative view of mastoid cavity after 8 months of surgery. TD, tegmen defect.

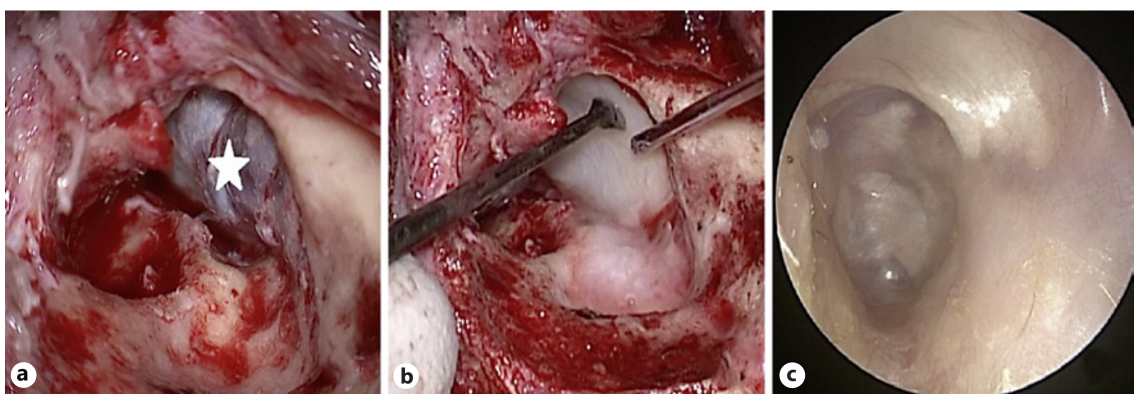

Fig. 2. a Intra- and postoperative findings of patient no. 2. 25 mm TD due to MF cholesteatoma with CSFL (white asterisk). **b** Closure with the fascia lata, fibrin glue, and septal cartilage graft. **c** Postoperative view of the mastoid cavity after 40 months of surgery. TD, tegmen defect; CSFL, cerebrospinal fluid leakage; MF, middle fossa.

defect, and then, the dura is elevated from the tegmen in the extradural plane for the graft placement. The size and the shape of the defect are measured with a template of a sterile suture package paper. If there is an additional CSFL, the dural defect is grafted initially with a temporalis muscle fascia or a fascia lata. The fascia and the cartilage graft are contoured approximately 1 mm oversized circumferentially with respect to the template. Overundermining of the dura from tegmen should be avoided to prevent malposition of the fascia during cartilage graft placement. Furthermore, the fascia should be stabilized and secured with fibrin glue and small pieces of absorbable oxidized cellulose, and then, the bony defect is closed with the cartilage intracranially and extradurally. The bending capacity permits the septal cartilage for grafting with the underlay technique. While positioning the graft in the TM approach extradurally, firstly the medial edge should be introduced. Then, clockwise in the left ear, and counterclockwise manipulation in the right ear is more practical to use the maximum bending capacity of the cartilage without breaking it. The final position of the fascia is reconfirmed before the insertion of the last edge of the SCG. After the closure of the TD, if necessary, tympanoplasty is performed. No lumbar drainage was used in the cases with the CSFL after the surgery (shown in Fig. 1a–j, 2a–c, 3a, b).

Statistical Analyses

Statistical analyses were performed with the IBM SPSS for Windows version 22.0. Numerical variables were summarized as mean ± standard deviation or median (minimum-maximum). Categorical variables were given as frequencies and percentages. Differences between the groups according to continuous variables were determined by the Mann-Whitney U test. Related measures were compared by a paired *t* test. A *p* value <0.05 was considered significant.

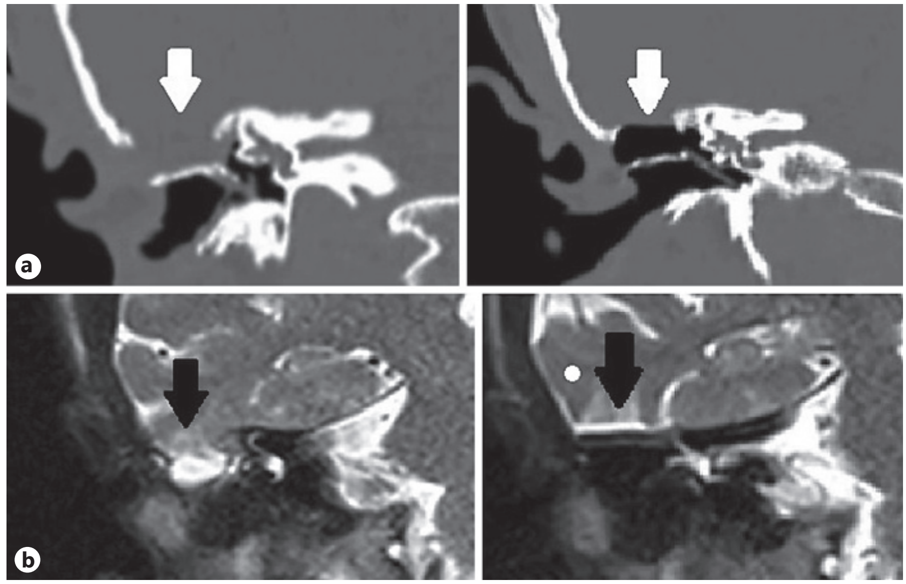

Fig. 3. a Pre- and postoperative radiological findings of the patient no. 1. Preoperative and postoperative computerized tomography coronal view (white arrow: 16-mm TD). **b** Pre- and postoperative magnetic resonance imaging coronal T2 sequences (black arrow: MEH). TD, tegmen defect; MEH, meningoencephalic herniation.

Results

Demographic and Preoperative Data

There were 7 male and 4 female patients with a mean age of 43.6 (21–66) years. Four of them had right side and the remaining had left side pathology. According to the etiology of the TD, 9 of them (82%) were due to cholesteatoma and 2 (18%) were iatrogenic. Only 1 patient (9%) had a primary surgery, and the remaining had multiple surgery history (91%) (Table 1). The preoperative mean bone conduction threshold was 32.2 ± 22.7 dB (decibels).

Intraoperative Data

The mean TD size was 15.4 (10–25) mm. The most common localization of the defect was mastoid tegmen (11 patients). Tegmen antri localization was found in 9 patients and tegmen tympani in 2 patients. There were 4 patients (36%) with CSFL, and MEH was found in 5 patients (45%). Six patients (55%) had either CSFL or MEH. Nine of the patients (82%) underwent canal wall down tympanomastoidectomy, and in 2 patients (18%), intact canal tympanomastoidectomy was performed (Table 1).

Postoperative Data

The mean postoperative hospitalization time was 5.2 (3–10) days (Table 1). There was no statistically significant difference in hospitalization time with respect to the presence of CSFL or MEH ($p = 0.247$). The patients were followed up with a mean of 22.5 (8–42) months (Table 1). The postoperative mean bone conduction threshold was 31.9 ± 22.8 dB at the end of the follow-up, and there was no statistically significant difference between preoperative and postoperative bone conduction thresholds ($p = 0.879$). None of the patients experienced intracranial or otogenic complication, graft displacement, infection, MEH, or CSFL recurrence during the hospitalization and follow-up.

Discussion

Meningoencephalic herniation and CSFL are the serious complications of the TD, which results in highly morbid, even mortal, intracranial infectious complications such as meningitis, abscess, aphasia, and epilepsy due to the herniation of brain tissue [13]. Regardless of the approach used, all the defects should be closed layer by layer. If there is an only bony defect with an intact dura, the tegmen should be propped up with a cartilage or a bone graft in an underlay fashion. In case of the MEH or CSFL, there is an additional dural defect; therefore, dural grafting with a fascia is indicated. Consequently, multilayer closure in a water-tight fashion with or without using fibrin glue is indispensable [14, 16, 21].

This study aimed to emphasize the use of the SCG with the TM approach in the TD larger than 1 cm. We reviewed 11 COM patients with a mean TD size of 15.4 mm. The vast majority of the etiology was cholesteatoma, and 91% of them had multiple surgical history. We exhibited neither recurrence nor complications related to this sur-

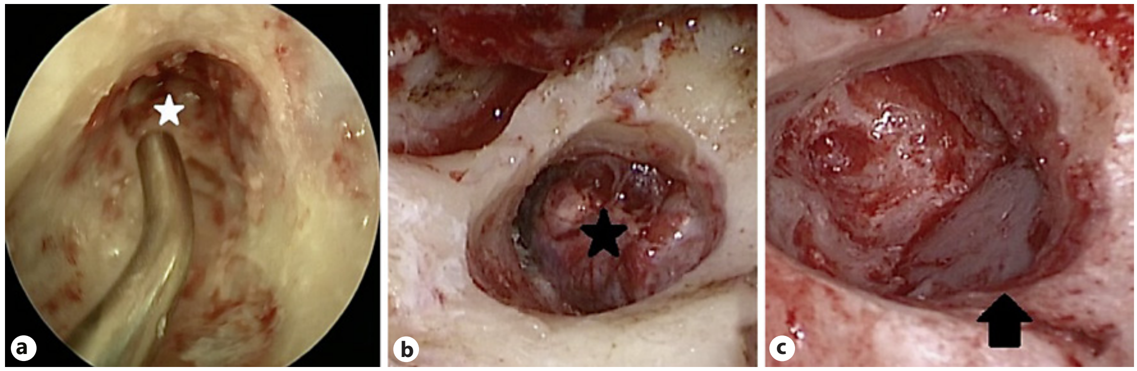

Fig. 4. a Intraoperative findings of the patient no. 3. View of left side intact canal mastoidectomy (white asterisk: lateral semicircular canal). **b** MEH (black asterisk) obliterating the mastoidectomy cavity during the second look procedure. **c** Resection of herniation and repair of 11-mm TD with the septal cartilage graft (black arrow). TD, tegmen defect; MEH, meningoencephalic herniation.

Table 1. Demographic, preoperative, intraoperative, and postoperative findings of 11 patients

Patient no.	Age, years	Sex	Etiology	Surgical history	Side	Defect size, mm	Type of surgery	Localization of TD	CSF leakage	MEH	Hospitalization time, days	Follow-up time, months
1	21	M	I	Multiple	R	16	IC	Ma + A	–	+	4	42
2	66	F	C	Multiple	L	25	CWD	Ma + A + T	+	–	10	40
3	31	F	I	Multiple	L	11	IC	Ma + A	–	+	5	34
4	60	M	C	Multiple	R	15	CWD	Ma + A	–	–	5	30
5	56	M	C	Multiple	R	15	CWD	Ma + A	+	+	5	27
6	64	M	C	Multiple	R	12	CWD	Ma + A	+	–	7	22
7	24	F	C	Primary	L	16	CWD	Ma + A + T	–	+	3	14
8	39	M	C	Multiple	L	16	CWD	Ma + A	–	–	4	14
9	38	F	C	Multiple	L	15	CWD	Ma	–	–	5	9
10	55	M	C	Multiple	L	10	CWD	Ma	–	–	3	8
11	26	M	C	Multiple	L	19	CWD	Ma + A	+	+	6	8

M, male; F, female; I, iatrogenic; C, cholesteatoma; R, right; L, left; IC, intact canal; CWD, canal wall down; Ma, tegmen mastoideum; A, tegmen antri; T, tegmen tympani; CSF, cerebrospinal fluid; TD, tegmen defect; MEH, meningoencephalic herniation.

gical technique such as CSFL and meningitis after a mean follow-up time of 22.5 months. There was no significant difference between pre- and postoperative bone conduction pure tone thresholds. Furthermore, we also analyzed the effect of the MEH or CSFL on hospitalization time, and no significant difference was found. Bodenez et al. [16] exhibited the average hospitalization time as 3 days for the TM approach and as 5 days for MF or combination approaches. Thus, the SCG via the TM approach is a safe, convenient, and minimally invasive method in the defects >1 cm.

Even though small spontaneous defects may lead to herniation and leakage, it is not clear that which size of the TD in COM can complicate in MEH [7, 14, 16, 22, 23]. Inadvertent drilling or dissection of the granulation tissue from the tegmen during mastoidectomy can cause inconspicuous dural violence which may further eventuate with herniation or CSFL [7, 13, 21]. It should be noted that some defects are perceived incidentally during surgery, especially in patients with multiple surgical history [5, 7, 13, 16]. Patient no. 3 was an instructive case. Endoscope-assisted intact canal tympanomastoidectomy was performed for the left atticoantral cholesteatoma. After 1 year of follow-up, the second-look procedure was done. The mastoidectomy cavity was obliterated with a soft tissue mass. After the skeletonization of the tegmen, there was an 11-mm bony defect accompanying MEH. This is an unexpected and bothersome situation both for the patient and for the surgeon. Even though the tegmen was thinned, there was no apparent bony or dural defect in the

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previous surgery. The herniated tissue was fulgurated, and the defect was repaired with a fascia lata and SCG (shown in Fig. 4a–c.). Even if, video recordings of previous surgeries are available, the radiological evaluation is essential for the revision cholesteatoma surgeries. Meticulous assessment with computerized tomography and magnetic resonance imaging to rule out the TD and herniation is highly recommended [5, 13, 22]. Consequently, all the bony and the dural defects should be repaired after the end of dissection in order to prevent further undesirable, serious morbidities [5].

Many authors indicated the reliable use of the cartilage graft in the anterior skull base defect repair with minor infectious complication rates [24, 25]. However, the studies with the cartilage graft concerning the lateral skull base are relatively limited. A bone graft ensures rigid support for the tegmen floor. Most of the authors propose the classical or minicraniotomy MF approach for bone grafts in the larger TD [12]. A split-thickness bone graft is mostly harvested from the inner cortical side of the temporal bone squamosal part. Thus, there is a need of titanium mini-plate fixation of the bone flap during wound closure, which can prolong the operation time and increase the surgical and the harvest site complications [14, 26–29]. Furthermore the bone graft has a resorption risk which was shown by a study about the repair of orbital floor fracture [26]. On the other hand, most neurotologists prefer using connective tissue or cartilage grafts, instead of a bone graft [3, 11, 13, 30].

The cartilage graft is mostly harvested from the auricula or septum. Semaan et al. [11] retrospectively analyzed 31 transpetrous encephalocele patients treated with the TM extradural-intracranial approach using the conchal cartilage. Eighty percent of the patients were in the spontaneous group. They used the same technique as ours with an extra overlay fascia grafting in 14 patients with the defect size <1 cm and in 17 patients with the defect size >1 cm. They concluded that this technique is safe and effective, with no recurrence in a mean follow-up time of 30 months [11]. The auricular cartilage is more flexible, but less rigid than the septal cartilage [20]. Thus, it may have a risk of fracture during the graft placement in the TM underlay technique, which may result in a reduction of the structural support of the tegmen. On the other hand, a straighter and thicker cartilage is more available in the septum than auricula, unless the patient has a septoplasty history [22]. The more elastic, resilient, and bending properties enable the SCG to fix in a precise and stable underlay position. Wahba et al. [31] pointed out successful results in iatrogenic TD 12 patients with a mean size of 5.6 mm. They used the conchal cartilage, temporalis muscle, and fascia via the TM approach. Bayat et al. [32] compared the SCG with the auricular cartilage graft in the surgical management of the orbital floor blowout fracture and reported significantly better reconstructive results with the septal cartilage. However, there is no similar comparison of the septal cartilage with the auricular cartilage in the TD repair up to date.

This study and this technique have some limitations. This is a retrospective study with a limited amount of patients. Although no technique-related complication was experienced, we have no data of the MF approach to compare with. Despite a requirement of an extra incision out of surgical field to harvest the SCG, we consider that this is less invasive and has minor donor-site morbidity than the MF approach incision and craniotomy. Some TDs had irregular outline; thus, we used the maximum length of the defect, instead of the defect area. Moreover, multiple defects with the eggshell bony rim are technically challenging for the TM underlay cartilage graft placement. Although more dural elevation and manipulation are needed, combined technique (TM plus minicraniotomy) can be preferred for the multiple defects with irregular shape which are mostly seen in spontaneous TD. When necessary, retroauricular incision can be extended anterosuperiorly to obtain a sufficient exposure for the minicraniotomy. Precise identification of the TD site and size via the TM approach allows for optimal planning of the minicraniotomy dimension and localization. Care must be taken during craniotomy and extradural elevation to prevent CSFL and dural violation [14, 16].

As a conclusion, this study exhibited an efficient and practical use of the SCG in the TD up to 25 mm via the TM approach. This technique had no side effect on the cochlear function. Furthermore, the presence of the MEH and CSFL did not prolong the hospitalization time, and there was no requirement for the lumbar drainage. By using this technique, TD >1 cm can be repaired with the TM approach, and the requirement of MF route is supposed to be reduced. Future studies comparing the SCG with the bone graft via MF and TM approaches will clarify the reliability and the stability of the TM SCG placement.

Statement of Ethics

A written informed consent was obtained from each patient. The study protocol was approved by the local Ethics Committee (No. 59/21-04.02.2019). The study was conducted in accordance with the principles of the Declaration of Helsinki.

Conflict of Interest Statement

The authors have no conflicts of interest to declare.

Funding Sources

There is no financial disclosure to declare in this study.

Author Contributions

Kemal Keseroglu: study conception; data acquisition, analysis, and interpretation and drafting, revision, and final approval of the manuscript. Mehmet Murat Gunay: data acquisition and interpretation, and revision and final approval of the manuscript. Sibel Alicura Tokgoz and Bulent Ocal: data acquisition and interpretation, and revision and final approval of the manuscript. Mehmet Hakan Korkmaz and Cem Saka: study conception; data analysis and interpretation; and revision, and final approval of the manuscript.

References

1 Montgomery WW. Dural defects of the temporal bone. Am J Otol. 1993;14(6):548–51.
2 Genc S, Genc MG, Arslan IB, Selcuk A. Location of the middle cranial fossa dural plate in patients with chronic otitis media. J Laryngol Otol. 2014;128(1):60–3.
3 Sanna M, Fois P, Paolo F, Russo A, Falcioni M. Management of meningoencephalic herniation of the temporal bone: personal experience and literature review. Laryngoscope. 2009;119(8):1579–85.
4 Golding-Wood DG, Williams HO, Brookes GB. Tegmental dehiscence and brain herniation into the middle ear cleft. J Laryngol Otol. 1991;105(6):477–80.
5 Mosnier I, Fiky LE, Shahidi A, Sterkers O. Brain herniation and chronic otitis media: diagnosis and surgical management. Clin Otolaryngol Allied Sci. 2000;25(5):385–91.
6 Gupta K, Sabry HA, Dogan A, Coppa ND, McMenomey S, Delashaw JB, et al. Classification of middle fossa floor dehiscence syndromes. J Neurosurg. 2015;122(3):557–63.
7 Manolidis S. Dural herniations, encephaloceles: an index of neglected chronic otitis media and further complications. Am J Otolaryngol. 2002;23(4):203–8.
8 Migirov L, Eyal A, Kronenberg J. Intracranial complications following mastoidectomy. Pediatr Neurosurg. 2004;40(5):226–9.
9 Khan SU, Tewary RK, O'Sullivan TJ. Modified radical mastoidectomy and its complications: 12 years' experience. Ear Nose Throat J. 2014;93(4–5):E30–6.
10 Schwarz D, Gostian AO, Shabli S, Wolber P, Hüttenbrink KB, Anagiotos A. Analysis of the dura involvement in cholesteatoma surgery. Auris Nasus Larynx. 2018;45(1):51–6.
11 Semaan MT, Gilpin DA, Hsu DP, Wasman JK, Megerian CA. Transmastoid extradural-intracranial approach for repair of transtemporal meningoencephalocele: a review of 31 consecutive cases. Laryngoscope. 2011;121(8):1765–72.
12 Gonen L, Handzel O, Shimony N, Fliss DM, Margalit N. Surgical management of spontaneous cerebrospinal fluid leakage through temporal bone defects: case series and review of the literature. Neurosurg Rev. 2016;39(1):141–50.
13 Arìstegui M, Falcioni M, Saleh E, Taibah A, Russo A, Landolfi M, et al. Meningoencephalic herniation into the middle ear: a report of 27 cases. Laryngoscope. 1995;105(5 Pt 1):512–8.
14 Carlson ML, Copeland WR 3rd, Driscoll CL, Link MJ, Haynes DS, Thompson RC, et al. Temporal bone encephalocele and cerebrospinal fluid fistula repair utilizing the middle cranial fossa or combined mastoid-middle cranial fossa approach. J Neurosurg. 2013;119(5):1314–22.
15 Wootten CT, Kaylie DM, Warren FM, Jackson CG. Management of brain herniation and cerebrospinal fluid leak in revision chronic ear surgery. Laryngoscope. 2005;115(7):1256–61.
16 Bodénez C, Bernat I, Vitte E, Lamas G, Tankéré F. Temporal breach management in chronic otitis media. Eur Arch Otorhinolaryngol. 2008;265(11):1301–8.
17 Baron SH. Herniation of the brain into the mastoid cavity. Post surgical, postinfectional, or congenital. Arch Otolaryngol. 1969;90(6):779–85.
18 Khan A, Lapin A, Eisenman DJ. Use of titanium mesh for middle cranial fossa skull base reconstruction. J Neurol Surg B Skull Base. 2014;75(2):104–9.
19 Kveton JF, Goravalingappa R. Elimination of temporal bone cerebrospinal fluid otorrhea using hydroxyapatite cement. Laryngoscope. 2000;110(10 Pt 1):1655–9.
20 Sajjadian A, Rubinstein R, Naghshineh N. Current status of grafts and implants in rhinoplasty: part I. Autologous grafts. Plast Reconstr Surg. 2010;125(2):40e–9e.
21 McMurphy AB, Oghalai JS. Repair of iatrogenic temporal lobe encephalocele after canal wall down mastoidectomy in the presence of active cholesteatoma. Otol Neurotol. 2005;26(4):587–94.
22 Jackson CG, Pappas DG Jr, Manolidis S, Glasscock ME 3rd, Von Doersten PG, Hampf CR, et al. Brain herniation into the middle ear and mastoid: concepts in diagnosis and surgical management. Am J Otol. 1997;18(2):198–6; discussion 205–6.
23 Kutz JW Jr, Husain IA, Isaacson B, Roland PS. Management of spontaneous cerebrospinal fluid otorrhea. Laryngoscope. 2008;118(12):2195–9.
24 Ting JY, Metson R. Free graft techniques in skull base reconstruction. Adv Otorhinolaryngol. 2013;74:33–41.
25 Chang C. Septal cartilage plug technique in spontaneous cerebrospinal fluid rhinorrhea postoperatively diagnosed with partial empty sella syndrome. J Craniofac Surg. 2014;25(4):1408–9.
26 Talesh KT, Babaee S, Vahdati SA, Tabeshfar Sh. Effectiveness of a nasoseptal cartilaginous graft for repairing traumatic fractures of the inferior orbital wall. Br J Oral Maxillofac Surg. 2009;47(1):10–3.
27 Jeevan DS, Ormond DR, Kim AH, Meiteles LZ, Stidham KR, Linstrom C, et al. Cerebrospinal fluid leaks and encephaloceles of temporal bone origin: nuances to diagnosis and management. World Neurosurg. 2015;83(4):560–6.
28 Hoang S, Ortiz Torres MJ, Rivera AL, Litofsky NS. Middle cranial fossa approach to repair tegmen defects with autologous or alloplastic graft. World Neurosurg. 2018;118:e10–7.
29 Alwan M, Ibbett I, Pullar M, Lai LT, Gordon M. Hearing improvement following middle cranial fossa floor defect repair utilizing a modified middle fossa approach and reconstructive techniques. Otol Neurotol. 2019;40(8):1034–9.
30 Marchioni D, Bonali M, Alicandri-Ciufelli M, Rubini A, Pavesi G, Presutti L. Combined approach for tegmen defects repair in patients with cerebrospinal fluid otorrhea or herniations: our experience. J Neurol Surg B Skull Base. 2014;75(4):279–87.
31 Wahba H, Ibrhaim S, Youssef TA. Management of iatrogenic tegmen plate defects: our clinical experience and surgical technique. Eur Arch Otorhinolaryngol. 2013;270(9):2427–31.
32 Bayat M, Momen-Heravi F, Khalilzadeh O, Mirhosseni Z, Sadeghi-Tari A. Comparison of conchal cartilage graft with nasal septal cartilage graft for reconstruction of orbital floor blowout fractures. Br J Oral Maxillofac Surg. 2010;48(8):617–20.