

La reconstruction totale de la chaîne ossiculaire "Mushroom technique"

Total ossicular reconstruction: The "mushroom technique"

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Résumé

Objectifs : la "mushroom technique" est introduite dans cet article comme une technique alternative pour reconstituer la chaîne ossiculaire en utilisant des greffes autologues quand l'utilisation des osselets du patient n'est pas possible, et pour colmater la fistule péri-lymphatique en cas de sa présence. **Matériels et méthodes :** il s'agit d'une étude rétrospective de 18 patients âgés de 26 à 72 ans, opérés entre Janvier 2006 et Mars 2012 par le même chirurgien en utilisant la voie d'abord rétro-auriculaire. Il y avait 13 hommes et 5 femmes, 12 oreilles droites contre 6 gauches. Le suivi postopératoire était de 6 mois jusqu'à 6,5 ans. Les trois osselets étaient endommagés chez les 18 patients, une fistule péri-lymphatique était associée dans 3 cas, et une perforation tympanique était présente dans deux oreilles. La "mushroom technique" a été réalisée pour les 18 patients; 11 post-traumatiques et 7 cholestéatomes. Le Rinne moyen audiométrique de chaque patient a été calculé (fréquence 500, 1000, 2000 et 4000 Hz) pré opératoire et 6 mois post opératoire. **Résultats :** il n'y a eu aucun rejet des greffes utilisées. Les 3 fistules péri-lymphatiques ont été colmatées, et les 2 perforations tympaniques fermées. Le Rinne moyen en postopératoire était 25 dB alors qu'il était de 45 dB avant la chirurgie. Le gain moyen est de 20 dB. Aucun aggravation de la perte auditive neurosensorielle n'a été retrouvée. **Conclusion :** cette technique a plusieurs avantages : le montage platine-fascia-tissus conjonctif-os-cartilage-périchondre-tympanum est solide et durable. La fermeture d'une fistule péri-lymphatique associée est assurée. Les résultats auditifs sont satisfaisants. Le coût est négligeable et la tolérance est excellente. Par contre le temps opératoire peut être long car cette procédure est délicate et précise.

Mots-clés : Mushroom technique, totale ossiculoplastie, fistule péri-lymphatique.

Summary

Objective: The "Mushroom technique" is introduced in this paper as an alternative technique to reconstruct the total ossicular chain by using autologous grafts where it is not possible to use the patient's ossicles, and to seal a peri-lymphatic fistula (PLF) if present. **Materials and methods:** This non randomized retrospective study covers 18 patients aged between 26 and 72 years, operated between January 2006 and March 2012 by the same surgeon using a retro-auricular approach. There were 13 males and 5 females, 12 right ears and 6 left ears. The three ossicles were damaged in 18 patients, a PLF was associated in 3 cases, and a tympanum perforation was present in 2 ears. Postoperative follow-up period was a minimum of 6 months and up to 6.5 years. The origin of 18 patient's disease was; post traumatic in 11 patients and post removal cholesteatoma in 7 patients. The "mushroom technique" was performed for all patients. The average Air Bone Gap (ABG) of each patient was calculated (frequencies 500, 1000, 2000 and 4000 Hz) both pre and 6 months postoperatively. **Results:** There were no extrusion of the composite graft. In the three cases of PLF; the leak was sealed. And in the two ears with tympanum perforation; the perforation was closed. The average post-operative ABG is 25 dB while it was 45 dB before surgery. Average gain is 20 dB. Non sensorineural hearing loss occurred. **Conclusion:** This technique has several advantages: The mounting footplate-fascia-connective tissue-bone-cartilage -perichondrium-tympanum is solid and long lasting, the rate of leak closure in case of PLF is improved; This technique closes the leak, the hearing results are satisfactory, the cost of autograft is null and the tolerance is excellent. On the other hand, it might be time consuming since it is a delicate looking procedure.

Key-words: Mushroom technique, total ossiculoplasty, perilymphatic fistula.

INTRODUCTION

For total ossicular chain reconstruction, the middle ear prosthesis such as titanium [1], ceramic [2] or hydroxyapatite [3] which are considered biocompatible are usually proposed. Autologous grafts have also been used

by different authors as autograft tympanum cartilage bone (incus) footplate technique [4].

To close a peri-lymphatic fistula (PLF), certain teams use tragal perichondrium bolstered either with Gelfoam [5], or with fibrin glue [6]. Others strictly use autologous grafts such as connective tissue [7], temporal aponeurosis [8], areolar tissue [9], or vein grafts [10]. Autologous blood can also be used to repair an inner ear window rupture [11].

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The "Mushroom technique" is an alternative technique to reconstruct the total ossicular chain by using autologous graft where it is not possible to use the ossicles of the patient, and to seal a PLF if present.

The assembly fascia-connective tissue-bone-cartilage-perichondrium resembles a mushroom, hence the name Mushroom technique (fig. 1).



Fig. 1: Mushroom technique: Fascia-connective tissue-bone-cartilage-perichondrium assembly.

MATERIALS AND METHODS

This non randomized retrospective study covers 18 patients aged between 26 and 72 years, operated between January 2006 and March 2012 by the same surgeon using a retro-auricular approach. There were 13 males and 5 females, 12 right ears and 6 left ears.

Postoperative follow-up period was a minimum of 6 months and up to 6.5 years.

The origin of the 18 patient's disease was:

- Post traumatic in 11 patients.
- Post removal cholesteatoma in 7 patients: in these cases the mushroom technique was performed immediately after total removal of cholesteatoma in 6 cases, and 15 years after the first surgery in 1 case.

The "mushroom technique" was performed for the 18 patients:

- 13 patients underwent a total ossiculoplasty for unilateral conductive hearing loss.
- 2 patients underwent a total ossiculoplasty with myringoplasty using fascia for unilateral conductive hearing loss with central perforation.
- 3 patients underwent an ossiculoplasty with sealing a perilymphatic fistula for unilateral mixed hearing loss with PLF.

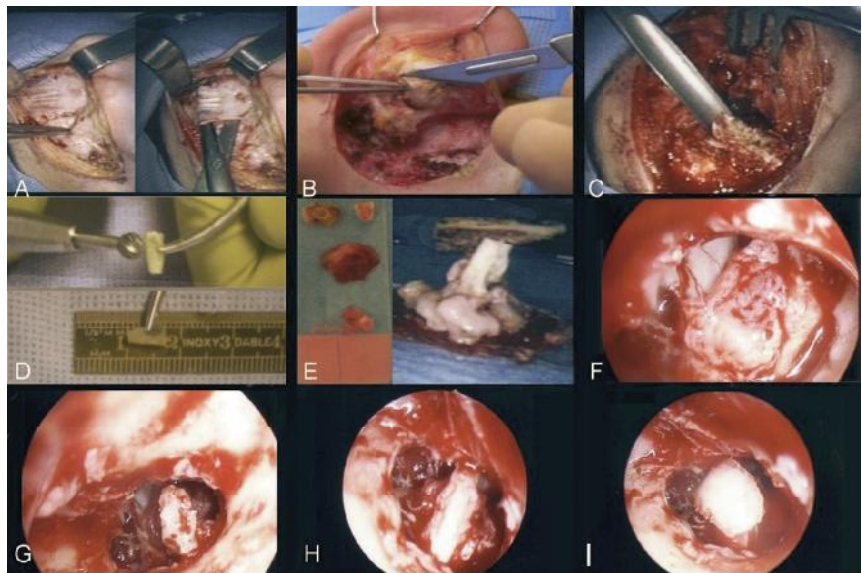
Pre- and postoperative pure tone audiometry was performed. The air bone gap (ABG) of each patient was calculated at the frequencies of 500, 1000, 2000 and 4000 Hz both pre and 6 months postoperatively.

Mushroom technique steps: (fig. 2)

- Take a temporal muscle aponeurosis and small fragments of retro-auricular connective tissue (fig. 2A).
- Take a small cartilaginous piece of the concha (fig. 2B).
- Take a small cortical mastoidian bone (fig. 2C).
- Drill the osseous fragment in order to obtain an isosceles trapezoid 7 mm height, and 2 and 4 mm for each base (fig. 2D).
- Place the fascia's inner side on the footplate covering its perimeter (fig. 2F).
- Place the trapezoid's small base on the footplate's large axis (fig. 2G).
- Support the trapezoid's small base by small fragments of retro-auricular connective tissue (fig. 2H).

Fig. 2: Mushroom technique steps:

- A) Take a temporal muscle aponeurosis and small fragments of retro-auricular connective tissue.
- B) Take a small cartilaginous piece of the concha.
- C) Take a small cortical mastoidian bone.
- D) Drill the osseous fragment in order to obtain an isosceles trapezoid 7 mm height, and 2 and 4 mm for each base.
- E) The assembly is held tight on the operating table.
- F) Place the fascia's inner side on the footplate covering its perimeter.
- G) Place the trapezoid's small base on the footplate's large axis.
- H) Support the trapezoid's small base by small fragments of retro-auricular connective tissue.
- I) Place the cartilage's internal side on the trapezoid's wide base.



- Place the cartilage's internal side on the trapezoid's wide base (fig. 2I).

RESULTS

There were no rejections of the composite graft. The tolerance was excellent.

In fact, the ears had healed up completely in 4 to 6 weeks. There were no facial injuries in this series.

Postoperatively, none of the patients had worsening of sensorineural hearing loss.

In the three cases of PLF; the leak is sealed. And in the two ears with tympanum perforation, the perforation is completely closed.

The results indicate good improvement of hearing. The average post-operative ABG is 25 dB while it was 45 dB before surgery. Average gain is 20 dB (table I, fig. 3).

TABLE I: Comparisons of pre- and 6 months post-operative air-bone gap pure tone audiometry.

Average ABG(dB)	Preoperative no. of patients	6 months postoperative no. of patients
≤ 10	0	1
11-20	0	3
21-30	0	10
31-40	2	4
≥ 41	16	0

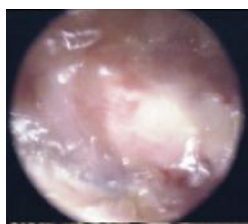


Fig. 3: The otoscopy 6 months post-operatively: the cartilage piece is in contact with the tympanic membrane.

The best four cases of the eighteen in term of hearing results are reviewed below to show that if this technique has done perfectly, it can lead to the best hearing results (fig. 4).

Case report 1 (fig. 4A, B, C)

A 30-year-old male patient presented with vertigo with head position changes, associated with nausea, sudden hearing loss, aural fullness and loud roaring tinnitus in the right ear. The patient confirmed that all symptoms began suddenly just after a slap over the right ear.

Fistula test and Valsalva manoeuvre precipitated dizziness, nausea, and minimal horizontal nystagmus towards the right ear. Audiometric evaluation revealed a hearing loss of 7.83 dB in the air conduction, and

40.83 dB in the bone conduction. The air bone gap (ABG) was 35 dB. The right tympanic membrane was normal. The videonystagmography (VNG) showed a right caloric hypo-excitability (47%). The CT scan revealed a suspected horizontal stapedovestibular fracture without pneumolabyrinth.

The patient was admitted to the hospital for bed rest with head elevation and treated with Carbogen inhalation, intravenous steroids, anti-emetics, vasodilators, anti-vertiginous medications, and diuretics. His symptoms worsened, so a surgical middle ear exploration was indicated.

In the right middle ear, the three ossicles were damaged, we found a non displaced fracture of the manubrium of the malleus, a suprastructure fracture of the stapes (the crura were fractured), and a non displaced horizontal footplate fracture. The incus was dislocated and not found.

Perilymphatic leakage was noted around the oval window. Its aspiration was followed by re-accumulation.

Postoperatively, the patient reported immediate and complete resolution of vertigo and nausea. In the right ear, the aural fullness sensation disappeared; the tinnitus was persistent but less intense. Six months after surgery; the VNG was normal, the audiogram revealed a gain of 42.50 dB in the air conduction, and 25 dB in the bone conduction. The air bone gap was closed to 17.50 dB.

Case report 2 (fig. 4D, E, F)

A 72-year-old man had an accidental penetration of the tympanic membrane of his right ear with a cotton tip. He had an immediate onset of sever earache, vertigo and vomiting.

Otoscopy examination of the right ear revealed a central traumatic tympanic perforation seen after removal of blood clots. A pure tone audiogram revealed a hearing loss of 72.85 dB in the air conduction, and 40 dB in the bone conduction. The air bone gap (ABG) was 32.85 dB in his right ear. Spontaneous nystagmus directed toward the involved ear was recognized.

Fistula test precipitated dizziness and nausea. The videonystagmography was normal.

The CT scan revealed ossicular dislocation with pneumolabyrinth (an air bubble in the vestibule). Exploratory tympanotomy was performed 8 days post-injury.

In the right middle ear, we found a displaced fracture of manubrium of the malleus, a suprastructure fracture of the stapes (the crura were fractured), and a non displaced horizontal footplate fracture.

The incus was subluxed, and damaged in its head.

The "mushroom technique" was performed. The myringoplasty was carried out using the fascia.

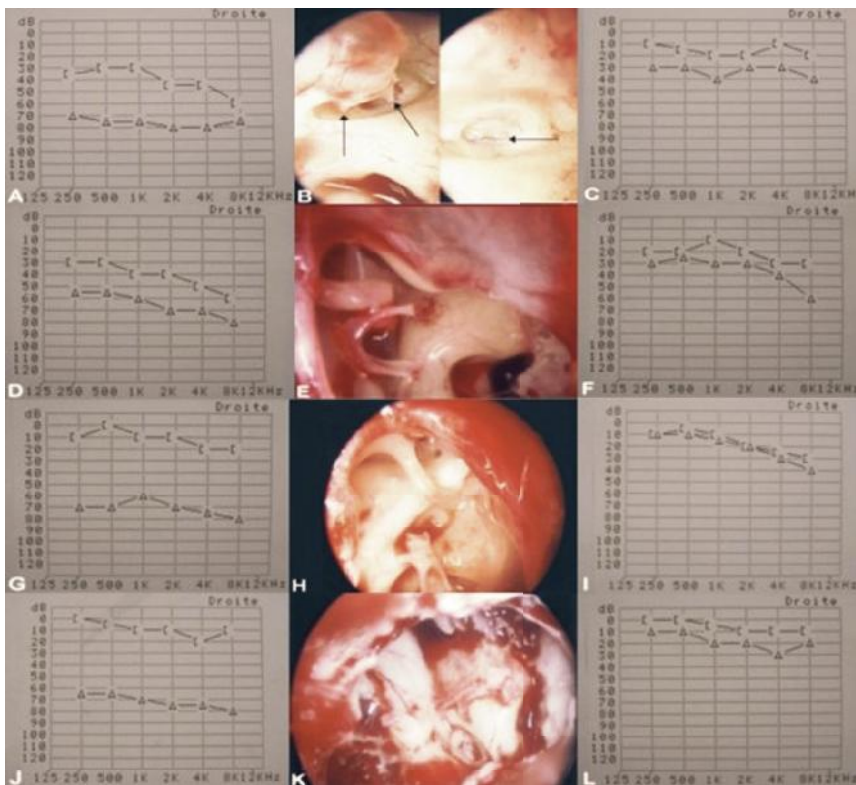


Fig. 4: Case reports.

Case 1: A- Preoperative audiogram, B- Peroperative view, C- Six months postoperative audiogram.
 Case 2: D- Preoperative audiogram, E- Peroperative view, F- Six months postoperative audiogram.
 Case 3: G- Preoperative audiogram, H- Peroperative view, I- Six months postoperative audiogram.
 Case 4: J- Preoperative audiogram, K- Peroperative view, L- Six months postoperative audiogram.

Postoperatively, the patient reported immediate and complete resolution of vertigo and nausea. The spontaneous nystagmus disappeared 3 days after the operation. The perforation was closed.

Six months after surgery; the audiogram revealed a gain of 37.85 dB in the air conduction, and 18.58 dB in the bone conduction. The air bone gap was closed to 13.57 dB.

Case report 3 (fig. 4G, H, I)

A 41-year-old man presented to the emergency room following a motor accident. The patient complained of decreased hearing in the right ear.

The head and neck examination revealed a post auricular right ecchymosis (battle's sign) with hemotympanum in the right ear without perforation.

The CT scan detected a longitudinal fracture and haematoma in the right temporal bone.

The initial audiogram demonstrated a right hearing loss of 72.14 dB in the air conduction. The ABG was 60.71 dB.

The conductive hearing loss persisted 3 months after injury despite resolution of the haematoma. Middle ear exploration was therefore indicated.

The three ossicles were damaged, the manubrium of the malleus was fractured, the inferior part of the long process of the incus is fractured, the footplate was intact, and the crura were fractured (a suprastructure fracture).

The "mushroom technique" was performed.

Six months after surgery; the audiogram revealed a gain of 53.57 dB in the air conduction. The air bone gap was closed.

Case report 4 (fig. 4J, K, L)

A 29-year-old female consulted for right hearing loss. She had a past history of right ear surgery 15 years ago. She had no medical report. Clinical examination revealed an old right post-auricular scar. The otoscopic examination revealed a right external auditory canal stenosis, and a transparent tympanum without malleus.

The patient was investigated by audiometry (the conductive right hearing loss was 72.85 dB, the ABG was 65.71 dB), and by temporal bone CT scan which confirmed that the

patient previously underwent a tympanoplasty with antroatticotomy. It also showed no evidence of residual cholesteatoma, and no ossicles in the tympanic cavity.

A right reoperation of the middle ear and mastoid cavities was performed using the same post-auricular approach. We found no residual cholesteatoma, and no ossicles. So the "mushroom technique" was performed.

Six months after surgery; the audiogram revealed a gain of 55.71 dB in the air conduction. The air bone gap was closed to 12.14 dB.

DISCUSSION

Since Matte's report of a myringostapedioplasty in 1901 (12), numerous methods have been attempted to bridge the gap between the tympanic membrane and the inner ear fluids. The modern era of reconstructive middle ear surgery began with reports by Zollner in 1955 (13) and Wullstein in 1956 (14). These early attempts focused on creating a sound pressure differential between the oval and round window by adapting the operation to the ossicular problem encountered. If the incus and the stapes

crura were missing, the graft was laid on the promontory, leaving a mobile footplate exposed, producing sound protection for the round window.

Since then, numerous materials have been used to recreate the middle ear sound-conducting mechanism including autograft, homograft, (15) and alloplastic materials (total ossicular reconstruction prostheses) such as Hydroxyapatite (16), and Titanium (17, 18).

The most commonly used autograft material has been the incus body (19), which is often reshaped to fit between the tympanic membrane and the footplate.

The "Mushroom technique" is an alternative technique to total ossicular reconstruction where it is not possible to use the ossicles of the patient in cases of:

- Previous middle ear surgery with no ossicles left.
- Erosion ossicles by chronic otitis media.
- Ear trauma when the three ossicles are damaged.
- In case of previous middle ear cholesteatoma, an ossicle may have microscopic squamous epithelium infiltration that precludes such use, so the risk of residual cholesteatoma may be increased.

This technique starts by sealing a perilymphatic fistula if present. Choosing the graft is essential. The fascia (temporal muscle aponeurosis) is a solid graft, ideal to clog the footplate breach. It should be large enough to not only cover the oval window and its perimetry but also the promontory and round window if necessary. Its inner side -sticky- and compatible with the middle ear mucosa must be facing the oval window. It successfully closes the window rupture by directly sealing it and by facilitating the formation of granulation at the margin of the rupture (20, 21).

The osseous fragment taken of cortical mastoidian bone is drilled in order to obtain an isosceles trapezoid between 6 to 8 mm height, and 2 and 4 mm for each base. We put its smaller base on the footplate's large axis; its wider base should not touch the edges of the middle ear cavity.

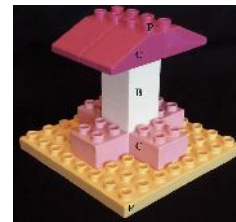
Support the trapezoid's small base by small fragments of retro-auricular connective tissue is necessary. These buttresses guarantee the stability of the osseous-cartilaginous assembly, and reinforce the fascia to ensure leak closure if a PLF is present. The connective tissue's importance comes from its capacity to stick spontaneously giving good stability to the assembly. Moreover, it loses volume with time, and merges and integrates progressively with the fascia.

The cartilage piece taken from concha has two faces: The internal surface, which is stripped of the perichondrium whereas the external surface is covered with it. It is prepared in the form of circle (6 mm diameter) and a central partial chondrectomy of the inner surface

(the same dimensions of the trapezoid's wide base) is performed. We put the cartilage's internal side on the mastoidian bone. They are assembled as a mortise and tenon joint. This system guarantees their stability, and prevents the osseous fragment from moving.

The intact perichondrium layer of the external cartilage face is in contact with tympanic membrane and prevents cartilage displacement.

In fact, these pieces are unit like building cubes (bricks of Lego), and are held tight even on the operating table. Moreover, they are held like a sandwich between the footplate and the eardrum, which makes the ossiculoplasty more solid and durable.



On the other hand, to total ossicular reconstruction; the graft should be sufficiently rigid to transmit vibration (22), and it matches the impedance or stiffness of the natural ossicular system (23). The mounting footplate-fascia-connective tissue-bone-cartilage-perichondrium-tympanum is rigid, and provides vibratory transmission of sound with impedance matching. This reconstruction is made of different parts, so the sound transmission is good thanks to shock absorber effect.

Finally, the "mushroom technique" uses the patients' own tissues, so no rejection occurs. The long-term result of this procedure in 18 selected cases indicates that this surgical procedure is practical, and achieves predictable levels of hearing improvement. But the operative time is prolonged; it takes time even in good hands.

CONCLUSION

The "Mushroom technique" is an alternative technique to total ossicular reconstruction where it is not possible to use the ossicles of the patient, and to seal a PLF (if present).

This technique has several advantages: the mounting footplate-fascia-connective tissue-bone-cartilage-perichondrium-tympanum is solid and long lasting, the rate of leak closure (in case of PLF) is improved, the hearing results are satisfactory, the cost of autograft is null and the tolerance is excellent.

On the other hand, it has one disadvantage; it might be time consuming since it is a delicate procedure.

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