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THE ENDOMEATAL APPROACH (EMA) SUBCORTICAL ENDOMEATAL MASTOIDECTOMY WITH INTEGRATED CAVITY WITHOUT MEATOPLASTY SEMI-OPEN TECHNIQUE

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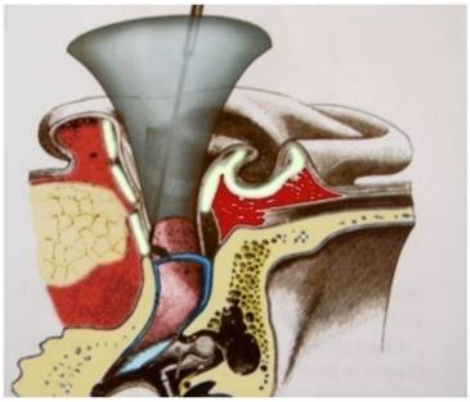

AIM

Endomeatal approach is treated as a current access pathway to the cholesteatoma, since it meets all the conditions of an optimal approach.
The aim is to show the usefulness of this approach in removing the cholesteatoma, without reconstruction and integrating the mastoid cavity, conducting a semi-open technique through an autostatic ear speculum.

Highligts

A-Conditions for a good surgical approach

A natural pathway should be used, taking advantage of this natural space to obtain access to the anatomical structures, without having to create a further surgical additional space. The approach should be as simple and direct as posssible.
Healthy tissue should be respected to a maximum and further lesions should not be caused, beyond those caused by the pathology itself.
It should provide access and control to all the compromised anatomy, since the cholesteatoma is an invasive pathology that involves the anatomical recesses.
It should try to preserve the function of all the structures involved by the approach, and restore it at the same time.

B-Endomeatal approach.Reverse technique.

Following a reverse way from the inner part of the external auditory canal (EAC), the Endomeatal Approach (EMA) starts in the atticus and ends in the mastoid.
Just as a tympanic pocket retraction is treated to prevent Cholesteatoma, with an EMA tympanostomy tube insertion ,surgery is carried out when it is already present, even if it is a simple attical invagination, or a large cholesteatoma.
It consists of starting the dissection from its attical origin, up to the involved anatomical point, whichever that is, but always from the inner side to the outside.
This will enable, by the endomeatal pathway, controlling the extension of the approach, not to go beyond its size, preventing wide approaches to solve small cholesteatomas, and at the same time, leaving a size cavity matching the cholesteatoma, with no need of extensive incisions, that imply more injuries and the formation of an additional surgical space; understanding for this, the surgical space that needs and requires the surgical technique to eliminate the pathology. If this surgical space matches the pathology itself is considered like a noninvasive surgery,

meanwhile if it is not, is considered as a minimum or maximum invasive surgery, depending on the extension of injuries caused by the technique. The EMA is a minimum invasive surgical technique.

C-Semi-Open Technique

Preserving the EAC posterior wall is not a guarantee of removal of the cholesteatoma, but it may also be the cause of a residual cholesteatoma, and moreover, it is not necessary for the safeguard of hearing. Therefore, preserving it has always been a controversial issue.
This is not a closed technique(cwu), but neither is an open technique(cwd), in any case, a **semi-open** technique, because the tympanic cavity is closed attically, by conducting a tympanoplasty, and the mastoid cavity remains open, for subsequent control.
The characteristics of these two independent cavities are:

D-Characteristics of endomeatal epitympanic-mastoid cavity

a-The Mastoid Cortical bone is preserved: to be able to conduct an appropriate epithelization, in a cavity with all its bone perimeter preserved.

b-The External access which coincides with the approach pathway: and not to practice an extrameatal approach, to perform later an endomeatal cavity control, as it happens in the conventional retroauricular approach.
This coincidence of cavity access with approach pathway enables performing a mastoid cavity respecting the external auditory meatus, and that is what renders the meatoplasty unnecessary, with a correct aeration, recurrence control, and chance of cleaning the mastoid cavity.

c-Preserving the external auditory meatus: the meatoplasty becomes necessary when the mastoid cortical bone has been removed. It is practiced as a response to a maximal size cavity, that extends from the mastoid aditus and antrum, sinodural angle and retrosigmoid space, up to the superficial planes of skin and subcutaneous tissues by demolition of the cortical bone, leaving an external limit that is a muscular plane, which in turn delineates a cavity in its maximal extension, and therefore, will require more ventilation and cleaning. Fig.1
A mastoid cavity (MC) whose external limit is located at the same level as the external auditory meatus (EAM) (Fig.2), through which its control must be done, is impossible to clean and aerate correctly, unless its access is wider and its size reduced, and this is what makes the meatoplasty, and the use of muscular pedicles as necessary. Fig.3

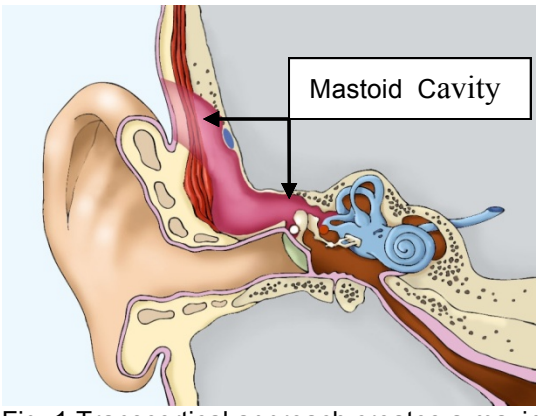

Fig. 1 Transcortical approach creates a maximum Mastoid Cavity.CWU

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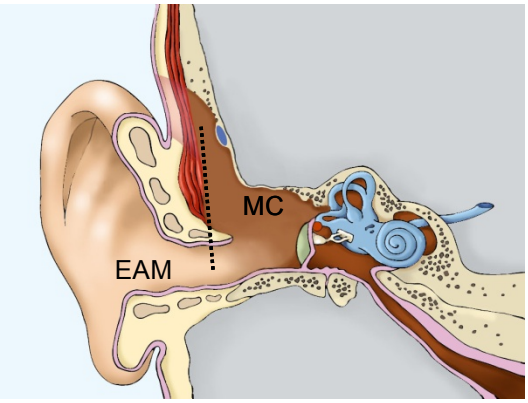

Fig. 2 The dot line indicates the Mastoid Cavity external limit, located at the same level as the External Auditory Meatus.CWD

But this is not necessary, when access to the mastoid is made within the auditory meatus, respecting it, preserving the cortical mastoid bone as external wall, and starting the drilling in the anterior tympanosquamous suture, which will significantly reduce the size of the cavity, one of the main factors to integrate the mastoid cavity. Fig.6

E-Cavity integration

Understanding by integrated mastoid cavity, the one that does not cause discomfort to the patient, does not require the care of the surgeon, and does not need to be reconstructed. This approach requires achieving the integration of the cavity, preserving the cortical bone, to thus obtain a cavity with a preserved bone perimeter, and with its aeration ensured trough the communication with the EAC, which is reached by approaching the mastoid anteriorly, through the tympanic bone. Three factors must be considered to integrate the mastoid cavity:

a-Size

The cholesteatoma is an invasive pathology that ends as far as its extension reaches.

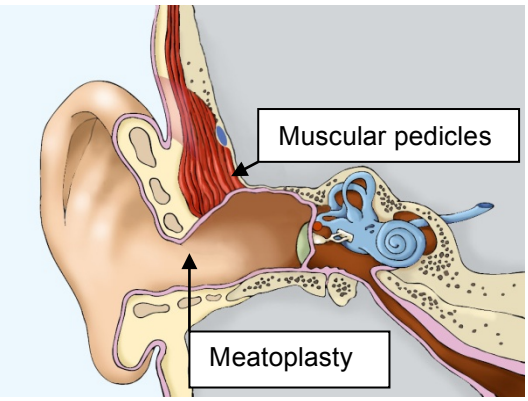

Fig.3 Meatoplasty and muscular pedicles are necessary for a wide access and reduced size of Mastoid Cavity

It is not necessary to remove the smallest and farthest cells, because the mucosa heals in them spontaneously, as long as a good aeration is maintained (1). The removal of healthy mastoid cells does not insure recurrence.The MACS(Mastoid Air Cell System) contributes to auto-regulation of temperature and gas pressure into the middle ear,(6,7,14) so any surgical technique must be respectful as far as possible,with this anatomical structure.The MACS is not in the cholesteatoma origin,it only suffers the growth of it.There is no need to destroy the MACS as long as atelectasis is avoided.Once the cortical bone is destroyed,there is

no chance to preserve even partially the MACS,because the uncontrolled cells that remains under the soft tissues or in farthest anatomical place, becomes a potential aspect of recurrent cholesteatoma or chronic middle ear efussion,and that is why these mastoid cells must be radically eliminated. This fact is a consequence of the transcortical approach.
The subcortical approach(EMA) preserves the MACS,according with the cholesteatoma involvement,and entails an orderly development and regeneration of the mastoid,(13) with a properly aeration,trying to prevent atelectasis (ventilation-aeration).
Acquired cholesteatoma is not a mastoid pathology in its origin, so there is no need to remove healthy bone tissue unnecessarily beyond the cholesteatoma itself, which would limit mastoid drilling, and would significantly reduce the size of the mastoid cavity and the extension of this condition. This main factor is what will permit cavity-integration, as long as a proper aeration is kept.Epitympanotomy includes epitympanic contents,mainly malleus/incus joint.Epitympanic-mastoidectomy takes place,when the all lateral wall and ossicles are removed and supratubal recess is exposed.

b-Ventilation and Aeration

This technique puts into practice a concept of ventilation-aeration in two independent cavities. One, a tympanic cavity ventilation trough the Eustachian tube in order to preserve the middle ear pressure, and physiological function. Two, the mastoid cavity aeration through a natural tube, which is what the EAC becomes when the cavity access and the approach pathway are made to match. Ventilation involves directly the Eustachian tube, but aeration does not. Pretending that an ear with Eustachian tube dysfunction could ventilate the tympanic cavity, and besides, the surgically widened mastoid cavity, are the pathophysiogenic causes of failure in closed techniques. Fig. 4
The ear will express through fibrosis, adhesive processes, effusion, and in the worst of cases, recurrence of cholesteatoma.
This technique prevents the functional enlargement of the Eustachian tube, which is the origin of atelectasis, (8) and its consequences. Fig. 5.

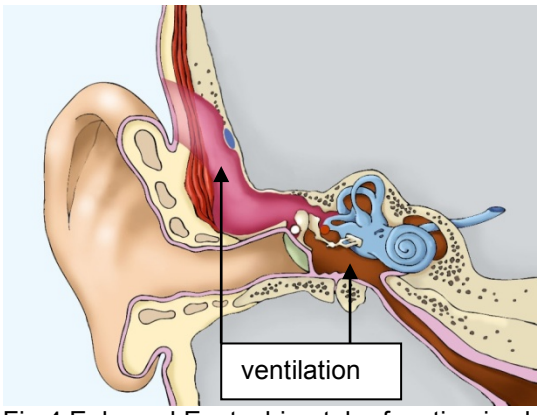

Fig.4 Enlarged Eustachian tube function in closed technique.CWU

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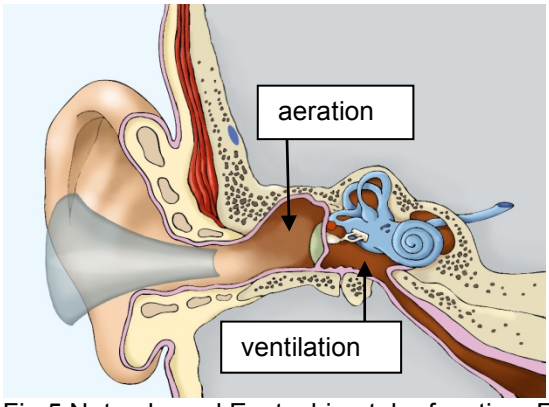

Fig.5 Not enlarged Eustachian tube function. EMA semi-open technique

c-Epithelization

The last integrated factor is a correct epithelization, and this will depend on the management given to the soft tissues. The EMA does not apply external incisions, or discharge incisions, and is characterized by a total respect for soft tissues that correspond to the auricular insertion, avoiding the use of mastoid retractors and the use of muscular pedicles that would compromise the vascular irrigation of these tissues, causing an ischemia at precisely the moment when vascular input is most needed, i.e. the immediate post-operatory period.

Any tissue will be better integrated if vascular irrigation is made by preserved vessels, than by the newly formed ones.

Moreover, advantages must be taken of the characteristics of this skin, which is different from the rest, because it does not grow from the depth to the surface, but instead, does it by a medial development of 0.05 mm per day, which favors epithelization, as long as the vascular pedicles that nourish it are respected, and that the cavity is not excessively enlarged. A very large cavity will demand more aeration and epithelization, that will hardly permit integration.

These three factors: size, aeration and epithelization, have to go together and supplement each other, to be successful in the integration, and for these three factors to act in agreement, it is necessary: Fig. 6

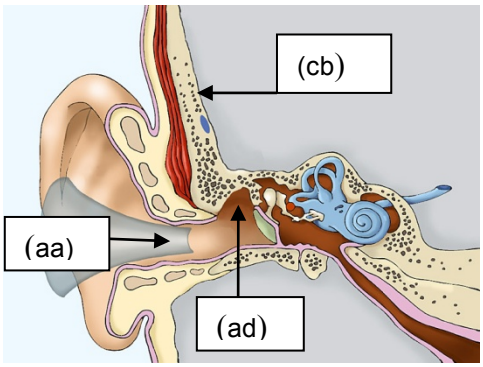

Fig.6 EMA Cavity-Integration factors:
start attical dissection (ad), preserve cortical bone (cb), match access with approach (aa)

- to start the dissection at the origin of the cholesteatoma, to control its extension;
- To preserve the mastoid cortical bone, with a subcortical approach to achieve a uniform plane of epithelization;
- To match the access with the approach, to ensure a direct aeration.

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F-Repair and reconstruct

The term repair is used, when the mastoid cortical bone is preserved, and the term reconstruction is used when it is not, because damages are more extensive.
This is a technique that lowers the EAC posterior wall only as needed, so as to avoid leaving inaccessible anatomical spaces, in the post-operative period.
An open technique with well performed cavity does not require reconstruction. (2)
EMA does not apply any kind of reconstruction, or obliteration, or extrusion, nor any other surgical technique that does not allow the cavity visual control in the post-operative period. The best reconstruction is that one that is never needed.
The visual control in a well performed endomeatal mastoid cavity enables watching and controlling the ear response. Otherwise, complications may arise.

G-Cavity protection

The EMA mastoid cavity has a double protection. Internal: by attically closing the tympanic cavity, thus preventing effusions in the middle ear compromising the mastoid cells.
External: by preserving the protective role of the external auditory meatus. Fig.8

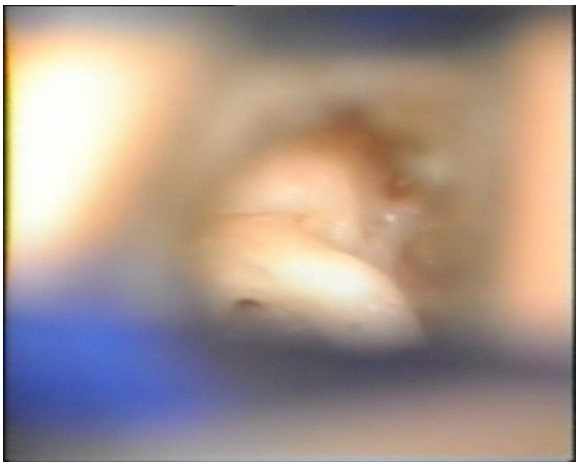

Fig. 8 EMA semi-open technique.Left ear.Post-operative **open** Epytimpanic-Mastoid Cavity without meatoplasty.

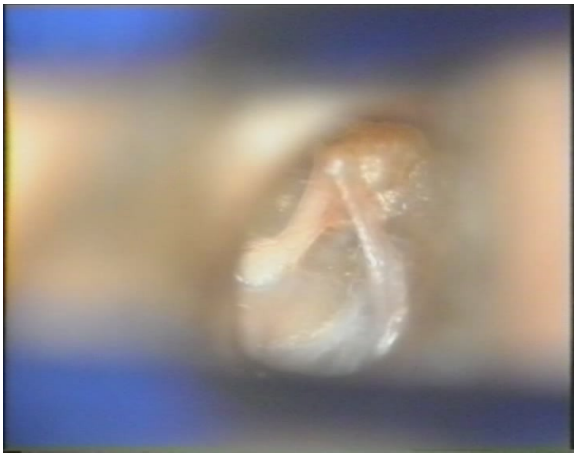

Fig.9 EMA semi-open technique.Left ear.Post operative atticaly **closed** Tympanic Cavity without meatoplasty.

H-Characterisitics of the tympanic cavity

It will depend on the type of tympanoplasty to be conducted, which in turn will depend on the mucosa condition, the residual ossicular chain, tubal dysfunction, etc.
Mostly, acquired cholesteatoma is an epitympanic pathology (5),(9) in its origin and growing, and respects the mesotympanum due to Proctor's tympanic isthmus. Depending on an earlier diagnosis, often times there is nothing to do in the mesotympanum, except to preserve the undamaged structures; but if it is necessary to act due to an osteitis of the whole atticus, with ossicular and cavity involvement, the tympanic cavity is closed at the level of the Fallopian canal, when there is no lateral attical wall left. Fig.9
Although a flatter cavity is obtained, the atticus is under control (specifically the supratubal recess), (3) and the final tympanoplasty result is usually appropriate.

Surgical steps

All the surgery is aided and carried out, through a two-valve autostatic ear speculum (mod. Dr. Prades), it is a two-hand surgery with usual surgical instruments (Fig.7), under local anesthesia in combination with intravenous sedation,if it is necessary,otherwise pre-operatory prescription(diazepam-metamizol)is enough.

Fig.7 EMA surgical instrumental set

Surgical position:
The head patient is not secured and rests in the head-holder operating table, lower than the patient's shoulders. Neck extension facilitates the procedure, while head rotation to the opposite side determines the patient surgical position, which must be free of any fixation, to allow the speculum to be placed in the optimal position. It should also be repositioned as needed throughout the procedure, since inadequate visibility, is probably the primary objection to the EMA.

Soft tissues:
The technique consists of practicing a high tympanotomy, with a U skin incision, from approximately 6 to 12, from the tympanic annulus to the end of the bony portion of the EAC, in its junction to the cartilaginous portion. All the skin from the posterior wall is freed, except in those cases of small cholesteatomas,or wide EAC, were a tympanomeatal flap is confectioned, depending on skin condition.

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Hard tissues:
The drilling starts, taking as reference the tympanosquamous suture and the anterior tympanic spine, to continue the dissection to the mastoid antrum and exteriorizing it,enlarging the atticotomy upward and backward in the direction of the tegmen, and later lowering it to the tip of the mastoid, as much as necessary.

Cholesteatoma size:
EMA recognizes three types,depending on the involvement.Attical for small cholesteatoma;attical-antral for medium cholesteatoma and attical-antral-mastoidal for large cholesteatoma.
In small cholesteatoma,only with attical involvement,there is no need to totally remove the attical lateral wall.Partial demolition up to the involved anatomical point is enough,taking care that the lateral wall is a critical point for residual cholesteatoma. To explore the anterior atticus and supratubal recess, the cog must be removed, but does not imply sacrificing the ossicular chain if it is not compromised, due to the appropriate EMA visibility.
When the eardrum is preserved and also the ossicular chain,the skin of the posterior wall is free or taking part of the tympanomeatal flap,once it is replaced covering the minimal cavity, a spontaneous repair of the posterior wall,with a connective bridge protecting the cavity can be observed as a final surgical result.

In medium cholesteatoma,once the antrum is exteriorized is easily to find the limit of the cholesteatoma extension,but to continue or not it also depends on the cholesteatoma condition,if it is encapsulate there is no need to advance,but if is not,antrostomy must be enlarged until normal mucosa is finded.

Small and medium cholesteatomas are a major indication for the EMA,since is capable to maintain the correspondence with the pathology.Limited approach to limited pathology.

In large cholesteatoma, the posterior and attical lateral wall are completely lowered, following the Fallopian canal up to the stylo mastoidean foramen, what it is termed as a “round mastoidectomy”, because the wider EAC is virtually confused with the mastoid cavity..

Functional step:
Conducting a tympanoplasty without the attical lateral wall and with preserved eardrum or graft, over the Fallopian canal,resuts in a flat tympanic cavity with a type lll solution(columellar tympanoplasty-myringostapediopexy).In cholesteatoma surgery ,the stapes can be not involved and if it is ,the EMA allows to gently clean the oval window and expose properly the stapes,similar as an endomeatal stapedectomy procedure.For those cases where the tympanic cavity is deeper,ossicular transposition with the patient incus is the answer to maintain the contact in between the stapes and the eardrum.Meanwhile the stapes is available,functional results can have a good chance,as surgeons already know.The technique try to avoid the use of artificial prosthesis, using ossicles,cartilage and perichondrium from of the patient.
If it is not possible a functional step,due to severe lesions(chronic effusion, absence of ossicular chain,fixed footplate,mucosa involvement,tubal dysfunction,etc.)the tympanic-mastoid cavity must remains open as a radical surgery treatment,trying to achieve a dry ear. One-stage surgery is practiced whenever is possible.

Dressing:
The EAC and the cavity is packing with Gelfoam,and external cotton and a gauze ends the dressing. Perioperative antibiotics are not usual.

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Pitfalls

Facial nerve

The EMA is a safe surgical technique,because all the anatomical structures are under visual control,including the facial nerve that can be perfectly identified in its tympanic segment,which is the only visible portion of the Fallopian canal.Coming from behind the EAC posterior wall,the anatomical landmarks may disappear (e.g. the lateral semicircular canal and mastoid antrum in atelectatic ear),with the risk of facial nerve injury.Coming in front the posterior wall and through the EAC the facial nerve is always identified with no need to drill.That is one of the main advantages of EMA,taking care that at this place is very common to find a dehiscence.Mostly lesions of the facial nerve,takes place in the second genu and the third segment,due to the poor visibility of the retro auricular approach.

Perilymphatic fistula.Only ear

Another consideration in cholesteatoma surgery is the presence of a perilymphatic fistula,most of the times around the lateral semicircular canal, overall if it is a only hearing ear.In those cases EMA allows to explore the ear, and evaluate the risk of totally remotion, in order to live a residual cholesteatoma and control it through the EAC access,without living a large mastoid cavity.

Anatomical recesses

Residual cholesteatoma in the anatomical recesses,can be better eliminated also coming in front the posterior wall of the EAC,that coming from behind, specifically the supratubal recess and sinus tympani, that are involved in the cholesteatoma origin(3)(5). In all cases the supratubal recess must be explored and exposed,and depending on the cholesteatoma size the surgical result can be just an epytimpanic cavity or epytimpanic-mastoid cavity.

Tympanoplasty

Cartilage is not used to perform a tympanoplasty, due to its poor visibility and elasticity. One of the main principles of cholesteatoma surgery with the EMA, is the capability to notice the recurrence in an earlier stage that enables to act accurately at the right moment, before definitive lesions can take place.Cartilage is an excellent tissue to repair the bone defect, especially in tympanic pocket retraction with limited atticotomy of the posterior wall,it helps perfectly to keep in place the restored tympanomeatal flap.

Pearls of wisdom

Even there is no need to use the otoendoscopes,surgeons with no experience in this approach,but also, in those cases of anatomical variability, the otoendoscope might be useful controlling and solving the lack of visibility, that direct microscopic visualization makes difficult, and thus enables infiltration control of the cholesteatoma and act accurately, according to what the cholesteatoma requires,with limited drilling.

During surgery,patient´s head and the autostatic ear speculum,need to be repositioned depending on the cholesteatoma anatomical area involved.At that point, surgeon also need to modify his surgical position,it does not imply a big movement,but it must be enough space around him,and not to be tighten by assistants or surgical instruments.

Procedure

Advantages

The endomeatal approach is a procedure that allows several advantages:

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Allows a direct access to the cholesteatoma, because it is a technique that does not seek for the cholesteatoma, but finds it at its anatomical origin. The dissection starts in the cholesteatomatous atticitis.
Allows controlling the extension of the approach and not going beyond the size of the cholesteatoma; practicing a limited drilling, and a correspondence surgery with cholesteatoma size not creating further additional surgical space,respecting to a maximum healthy tissues and for instance the MACS.
Allows a better identification of the anatomical structures, since by acting endomeatally, there is no need to drill to find the tympanic segment of the facial nerve and is unnecessary to skeletonize the lateral sinus and the whole dura as well.
Allows better control of the sinus timpany, stape cruras, anterior atticus, supratubal recess, and the Eustachian tube orifice,(4) that condition the residual cholesteatoma and functional result.
Allows to explore and control the only hearing ear and evaluate the surgical risk,without leaving a large mastoidectomy.
Allows minimal incisions, since they are only limited to the skin of the posterior wall of the EAC, in order not to compromise vascular irrigation and to favor an appropriate epithelization.
Allows not having to practice meatoplasty and preserving the external auditory meatus.
Allows an internal and external protection of the mastoid cavity.
Allows a ventilation of the meso-tympanic cavity and aeration of the epytimpanic-mastoid cavity, in order to prevent enlargement of the Eustachian tube function.
Allows integrating the cavity resulting from surgery.
Allows preserving the auditory function and restoring it if necessary, in one-stage surgery.
Allows reducing the surgical time with local anesthesia or and intravenous sedation with an outpatient plan surgery, and intervening those patients with severe associated pathology, that do not admit general anesthesia or geriatric patients.
Allows controlling recurrence and cleaning the epytimpanic-mastoid cavity in office control, avoiding secondary surgical look.
Allows obtaining enough grafts; in this case, the tragal perichondrium; while with others approaches sometimes it is not sufficient, because approach injuries are more extensive.
Allows the daily hygiene of the patient and water risk,due to the characteristics of the EAC, the integrated mastoid cavity, and the protective function of the preserved external meatus.
Allows a hearing aid, because preserving the meatus stabilizes the prosthesis and facilitates its adjustment.

Drawback

The technique drawback is that it is a deep and narrow surgical space, and any surgery must be performed trough the ear speculum, which should not be a drawback for ENT surgeons, who are used to work in these spaces because our specialty is focused on cavities, just as it happens with endonasal or endolaryngeal surgery.
Otoendoscopes,can be usefull to explore anatomical recesses and assist microscopic surgery (M.A.S.) in order to drill,sometimes,the exact amount of bone according with cholesteatoma extension.

Discussion

More than 30 years of experience with the EMA, (12) show a surgical technique that meets all the conditions of an optimal approach.
Compared with other surgical alternatives, EMA does not leave any unexplored anatomical recess as it could occur through the posterior tympanotomy mastoidectomy (e.g. sinus timpany and supratubal recess) (3) mostly the reason for failure, with an uncontrolled post-operative mastoid cavity, of the canal wall-up procedure.
EMA does not practice meatoplasty and transcortical demolition, leaving a single anatomical sequel: the integrated mastoid cavity.It prioritizes function over reconstruction in comparison with canal wall-down mastoidectomy and reconstructive techniques.
It is a third choice surgical alternative, neither open nor closed, but a semi-open technique. (11)

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Results

Our last surgical series,carried out in 156 patients and controlled in a five years period, show 92% of good results, understanding as such, the presence of a dry cavity, appropriately epithelized. Hearing results (preserved/improved hearing) were correct in 97% of the cases, taking as reference pre-operatory audiogram.

Complications displayed: Recurrence of cholesteatoma: 3.9% ,attending those cases within small cholestetoma and only epitimpanotomy was practiced,in order to preserve the ossicular chian.Wet ear: 2.9%, due to tubal involvement. Deficient epithelization: 0.7%, that affected the mastoid tip. Neurosensorial Involvement: 3%, affecting mainly high frequencies.

Cholesteatoma recurrence it´s only a matter of correct exposure and control of the epitimpanyc-mastoid cavity

Potential complications and how to avoid them

Facial nerve

EMA is most of the time,a local anesthesia procedure and a transitory facial palsy can arise in the immediately post operatory period,due to the over anesthetic dose,even it recovers in few hours,the way to avoid it is to stop the anesthetic infiltration under microscope control,up to the moment when the inner skin portion of the EAC,begin the detachment from the bone,and also changes its colour.

Otorrhea and recurrence

Cronic otorrhea and recurrent cholesteatoma is another hugely complication in the post operative period,that can be avoided during surgery,lowering the posterior wall as much as needed, until a good access to the mastoid cavity and the supratubal recess is achieved.There must be always the outcome to clean the epytimpanic-mastoid cavity easily and with a good aeration,otherwise otorrhea and recurrence, will not be solved.

Fistula C.F.L

Cerebrospinal fluid leakage is not an important complication with the EMA,due to it is not an anatomical landmark and dura exposition is limited to the cholesteatoma size.Tegmen dehiscence can be a surgical find and depending on the size ,usually there is nothing to do but if a small tear appears as a consequence of cholesteatoma removal, patient must rest with an upper head position, and in few days leakage will usually stop spontaneously.

Post operative management

The EMA allows a simpler post-operative period, due to the absence of external incisions, suturing and compression dressings.

The EAC dressing must remains in place during one month,and if it becomes wet, or extruded, then smoothly suction and antibiotic drops must be prescribed.Over that period of time,ephitelization must be controlled in office,just to avoid small granulomas that are easily solved with gently suction,and helps to guide the epithelial regeneration.Control must be taken each two or three weeks.

Long term results,encourage the control to one or twice a year as much,depending on the new skin aspect and size of the integrated cavity.

Present and future of otological approaches

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Specialties connected to otology have already evolved into this type of approach:**endo**. Rhinology with endo-nasal surgery, and laryngology with endo-laryngeal surgery. It is only logical that it is so.
Current clinical and radiological exploration (10), allows making an increasingly earlier stage diagnosis of cholesteatoma, and therefore, with a smaller size. This will lead to less aggressive approaches, so as to prevent a lag between the cholesteatoma injuries, and the surgical performance. The endomeatal approach, suggest a different systematization than conventional surgery, in order to obtain another surgical and functional concept.
Cholesteatoma is not a retro-auricular pathology, it has epytimpanic and anterior-auricular in origin, and can be approached in that order.

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