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Surgical Anatomy of Transcanal Endoscopic Approach to the Tympanic Facial Nerve

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Objectives/Hypothesis: Until recently, tympanic facial nerve surgery had been performed using microscopic approaches, but in recent years, exclusive endoscopic approaches to the middle ear have increasingly been used, particularly in cholesteatoma surgery. The aim of this report was to illustrate the surgical anatomy of the facial nerve during an exclusive endoscopic transcanal approach.

Study Design: Retrospective video review of cadaveric dissections and operations on living patients in a tertiary university referral center.

Methods: Between November 2008 and July 2010, a total of 12 endoscopic cadaveric dissections were performed by an exclusive endoscopic transcanal approach. All dissections were recorded and stored in a database. In July 2010, video recordings from those dissections were reviewed, and the anatomic variations and accessibility of the tympanic facial nerve were studied and noted. Two further video recordings from living patients affected by middle ear chronic disease were also included in our study.

Results: In all 14 subjects, the transcanal endoscopic approach guaranteed direct access to the entire tympanic segment of the facial nerve after ossicular chain removal, allowing decompression of the nerve from the geniculate ganglion and the greater petrosal nerve to the second genu of the facial nerve. As in microscopic techniques, the cochleariform process and transverse crest (cog) may represent useful landmarks.

Conclusions: The tympanic facial nerve can be thoroughly visualized by an exclusive endoscopic transcanal approach, even in poorly accessible regions such as the second genu and geniculate ganglion. Further clinically based reports may strengthen our preliminary results.

Key Words: Facial nerve anatomy, facial nerve decompression, ear surgery, endoscopic approach, transcanal approach.
Level of Evidence: 4.

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INTRODUCTION

The microscopic surgical approach to the tympanic segment of the facial nerve is traditionally performed transcanally, although for the most anterior portion of the nerve, a transmastoid approach with a posterior atticotomy is required; this is because of its reduced accessibility from the external ear canal, in particular, in the region lying anterior to the cochleariform process, namely the region in close proximity to the geniculate ganglion, the anterior epitympanum and the supratubal recess. In addition, the second genu of the nerve cannot be easily approached transcanally, and a transmastoid approach is often required. Endoscopic instrumentation, techniques, and knowledge have greatly improved in the last few years, and we believe that endoscopic surgical techniques will gain increasing importance in otologic surgery. In fact, from our 6-year experience in endoscopic ear surgery, we believe that most of the spaces considered to have difficult accessibility with the microscopic technique could be easily visualized by endoscope-assisted surgery, and we believe that new anatomic concepts should be introduced for this purpose.[1,2]

During several cadaveric dissections performed in recent years by our team, we noticed that the tympanic facial nerve could be quite easily visualized transcanally by endoscopic techniques, even in the most anterior or posterior extensions, so we decided to perform a descriptive study on a retrospective case series that could be useful in improving our understanding of the anatomy of the tympanic facial nerve from an original perspective (endoscopic). The aim of our study was to analyze the morphology and the surgical and anatomic findings and variations of the tympanic facial nerve and surrounding middle ear structures by using an exclusive transcanal endoscopic approach. We believe that this preliminary experience, mainly based on cadaveric dissections, may possibly be extensively applied in the future in surgery with living patients, with some consequential benefits on mastoid tissue sparing and improved accessibility to the tympanic facial nerve.

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MATERIALS AND METHODS

Between November 2008 and July 2010, a total of 12 endoscopic cadaveric dissections were performed with an exclusive endoscopic transcanal approach. All dissections were recorded and stored in a database. In July 2010, video recordings from those dissections were reviewed, and the anatomic variations and accessibility of the tympanic facial nerve were studied. Two more videos from patients affected by middle ear chronic disease were also included in our study. In 2009, both patients had undergone a transcanal endoscopic approach to the tympanic cavity with decompression of the tympanic segment of the facial nerve. The equipment used during surgery were 0° and 45° rigid endoscopes (Karl Storz, Tuttlingen, Germany) 15 cm in length and 3 mm in diameter. A three-chip high-resolution monitor and camera (Aida; Karl Storz, Tuttlingen, Germany) were used for all of the procedures. Cadaveric dissections were performed with identical instrumentation as was used in our operating theater.

During video reviews of the operations or dissections, accurate descriptions of the tympanic segment of the facial nerve were obtained and noted, particularly the morphology of the facial nerve and geniculate ganglion, and their relationships to the cochleariform process, anterior epitympanic space, transverse crest, semicanal of tensor tendon of the malleus, and pyramidal eminence were examined.

Surgical Technique for Cadavers

A posterior tympanomeatal flap was created with a round knife using the 0° endoscopic view; then the tympanomeatal flap was elevated and transposed inferiorly.

Direct access to the most superior and the most anterior portions of the tympanic segment of the facial nerve and atticotomy were achieved by removing the lateral bony wall of the attic until the incudomalleolar joint and the anterior epitympanic space were visible endoscopically (Fig. 1A). To obtain a direct exposure of the second genu of the facial nerve, the posterior bony wall of the lateral attic was drilled until an endoscopic view of the pyramidal eminence was obtained. The dissection was continued by disarticulating the incudostapedial joint.

The incus was removed (Fig. 1B) and the head of the malleus was cut (Fig. 1C). After this surgical step, it was possible to observe the entire tympanic segment of the facial nerve (Fig. 1C and 1D), analyzing its course from the geniculate ganglion up to the retrotympanum, at the level of the pyramidal eminence.

Our attention was focused on the following points (Fig. 2A and 2B):

- the position of the tympanic segment of the facial nerve and its relationship to the pyramidal eminence and the oval window niche;

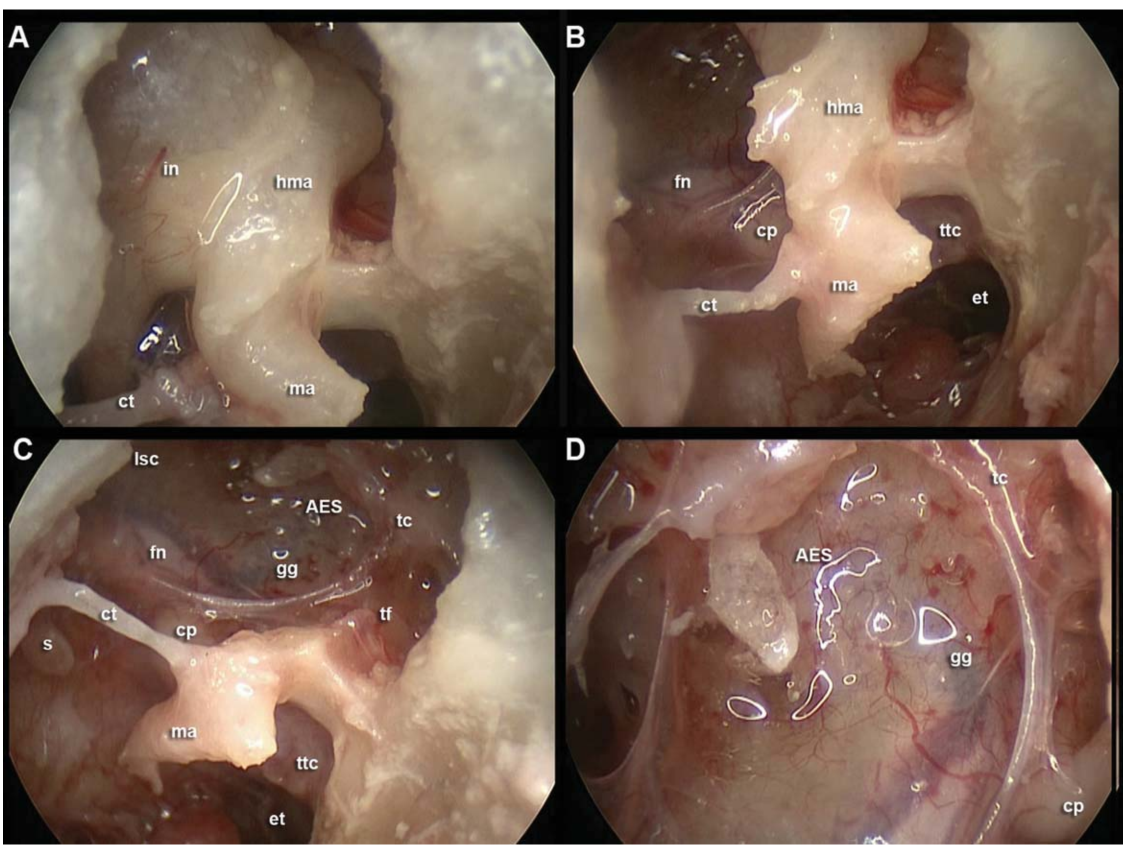

Fig. 1. Endoscopic surgical approach to the tympanic facial nerve. (A) Removal of the lateral boney wall of the attic until the incudomalleolar joint and anterior epitympanic space are visualized. (B) Incus removal. (C) Removal of the head of the malleus. (D) Closer view of the anterior epitympanic space and exposure of the geniculate ganglion area. in = incus; hma = head of malleus; ma = malleus; ct = corda tympani; fn = facial nerve; cp = cochleariform process; ttc = tensor tympani canal; et = eustachian tube; lsc = lateral semicircular canal; AES = anterior epitympanic space; gg = geniculate ganglion; tc = transverse crest; tf = tensor fold; s = stapes. [Color figure can be viewed in the online issue, which is available at wileyonlinelibrary.com.]

- visualization of the ganglion and its relationship to the anterior epitympanic space and cochleariform process;
- visualization of the greater petrosal nerve;
- orientation of the semicanal of the tensor tendon of the malleus with respect to the nerve;
- and detection of the transverse crest and its relationship to the facial nerve. In some cases, the bone of the anterior epitympanic space around the ganglion was removed, drilling close to the facial nerve and identifying the position of the greater petrosal nerve.

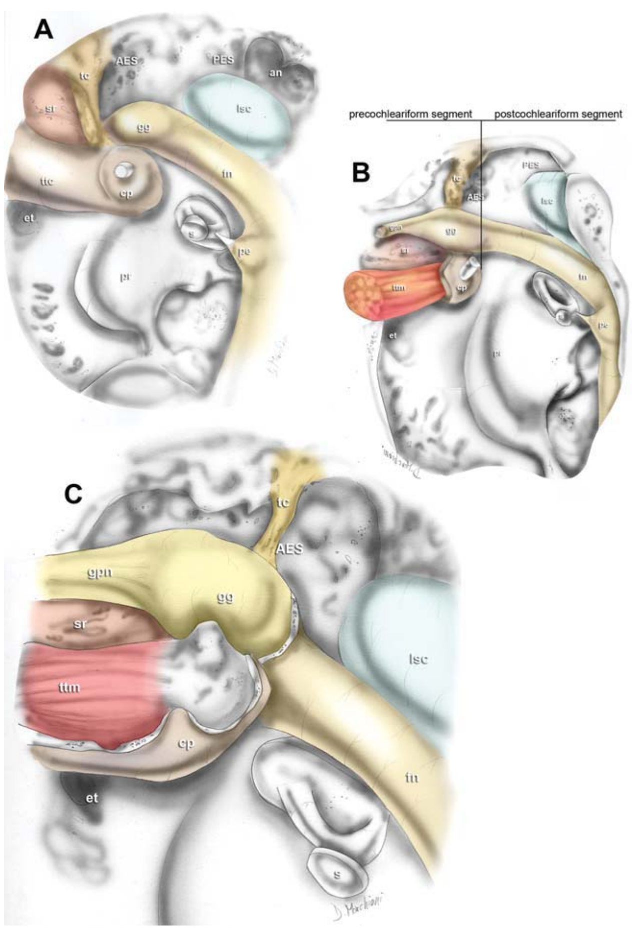

Fig. 2. Schematic drawing of the endoscopic view of the tympanic facial nerve. (A) Course of the tympanic segment of the facial nerve and its anatomic relationships, in particular with the anterior epitympanic space, the cochleariform process and the lateral semicircular canal; (B) Anatomic relationships of the tympanic facial nerve with the cochleariform process: division of the tympanic facial nerve into the precochleariform segment and postcochleariform segment. The relationships with the transverse crest are shown; (C) Geniculate ganglion area and exposure of the greater petrosal nerve after drilling the bone of the anterior epitympanic space around the ganglion. et = eustachian tube; ttc = tensor tympani canal; sr = supratubal recess; tc = transverse crest; AES = anterior epitympanic space; gg = geniculate ganglion; cp = cochleariform process; pr = promontorium; PES = posterior epitympanic space; an = antrum cell; lsc = lateral semicircular canal; fn = facial nerve, pe = pyramidal eminence; s = stapes; ttm = tensor tympani muscle; gpn = greater petrosal nerve. [Color figure can be viewed in the online issue, which is available at wileyonlinelibrary.com.]

Clinical Cases

As mentioned, the video recordings of two patients affected by middle ear chronic disease were also retrospectively analyzed. In those patients, a transcanal endoscopic decompression of the tympanic segment of the facial nerve had been performed. They were both male, aged 47 and 17 years, and had presented to our department with a clinical history of chronic otorrhea. A computed tomography scan showed pathologic tissue involving the tympanic facial nerve, and a cholesteatoma was suspected in both. One of these subjects also presented with a facial nerve palsy, grade 4 on the House-Brackmann scale.

RESULTS

In all 14 video reviews, the endoscopic approach allowed us to understand the anatomic characteristics of the tympanic segment of the facial nerve from the geniculate ganglion to the second genu of the facial nerve, observing the course in the tympanic cavity with respect to the epitympanic spaces and middle ear structures.

Cochleariform Process

Observing the location of the tympanic segment of the facial nerve with respect to the cochleariform process from an endoscopic point of view, it was possible to

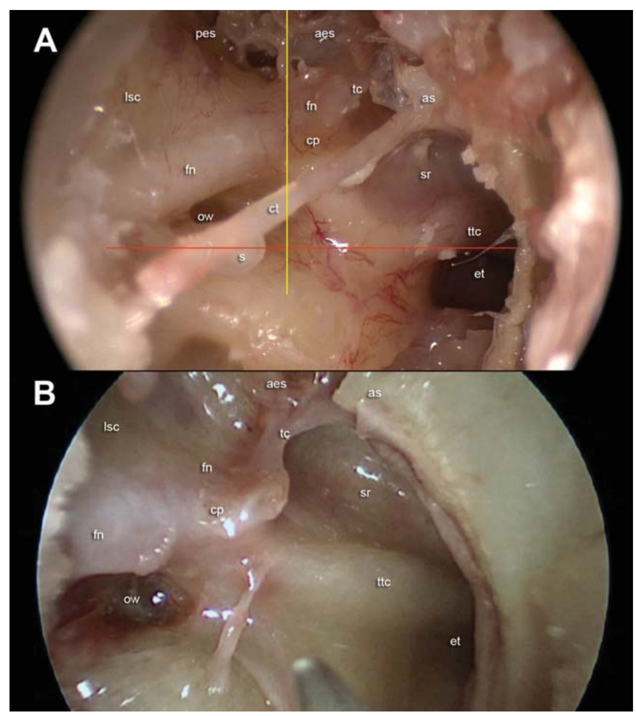

Fig. 3. The orientation of the facial nerve with the cochleariform process. (A) In nine of 12 subjects, the postcochleariform segment had an oblique orientation with respect to the semicanal of the tensor tendon of the malleus. (B) In three of 12 subjects, the postcochleariform segment had a parallel orientation with respect to the semicanal of the tensor tendon. lsc = lateral semicircular canal; s = stapes; ow = oval window; fn = facial nerve; PES = posterior epitympanic space; ct = corda tympani; cp = cochleariform process; AES = anterior epitympanic space; tc = transverse crest; as = anterior spine; sr = supratubal recess; ttc = tensor tympani canal; et = eustachian tube. [Color figure can be viewed in the online issue, which is available at wileyonlinelibrary.com.]

consider two portions of this nerve segment with different orientations. We named these two portions as follows:

Precochleariform segment (Fig. 2C and Fig. 3) refers to the portion of the tympanic facial nerve lying superiorly and anteriorly to the posterior bony limit of the cochleariform process.

Postcochleariform segment (Fig. 2C and Fig. 3) refers to the portion of the tympanic facial nerve lying posteriorly to the posterior bony limit of the cochleariform process.

Precochleariform segment of the tympanic facial nerve. In all subjects, the position of the geniculate ganglion was in the floor of the anterior epitympanic space lying just medially and just superiorly to the cochleariform process (Fig. 2B and 2C), having a horizontal orientation parallel to the semicanal of the tensor tendon of the malleus. In all subjects, the head of the malleus and the incus had to be removed to gain direct access to the entire tympanic segment of the facial nerve; in particular, malleus removal can give good access to the precochleariform segment and the geniculate ganglion area (Fig. 4A and 4B). In all 12 subjects, the cochleariform process represented the landmark to identify the geniculate ganglion. In eight of 12 subjects, the geniculate ganglion was covered by the bone of the anterior epitympanic space cells, and by drilling the cellularity of the anterior epitympanic space just anteriorly and superiorly to the cochleariform process, the geniculate ganglion could be completely visualized (Fig. 5). On the other hand, in four of 12 subjects, the geniculate ganglion was detected by curetting without any drill after ossicular chain removal because a partial dehiscence of the ganglion in the anterior epitympanic space cells was noted. Access to the greater petrosal nerve was obtained by removing the head of the malleus to gain good access to the anterior bony wall of the anterior epitympanic space. In all subjects, it was necessary to drill anteriorly to the geniculate ganglion, removing the transverse crest and the supratubal recess (when present) to uncover the greater petrosal nerve, following the anterior orientation of the facial nerve (Fig. 5).

Postcochleariform segment of the tympanic facial nerve. After removal of the incus and the head of the malleus, the transcanal endoscopic method allowed a direct approach to the postcochleariform segment of the facial nerve, allowing a lateral exposure of this anatomic

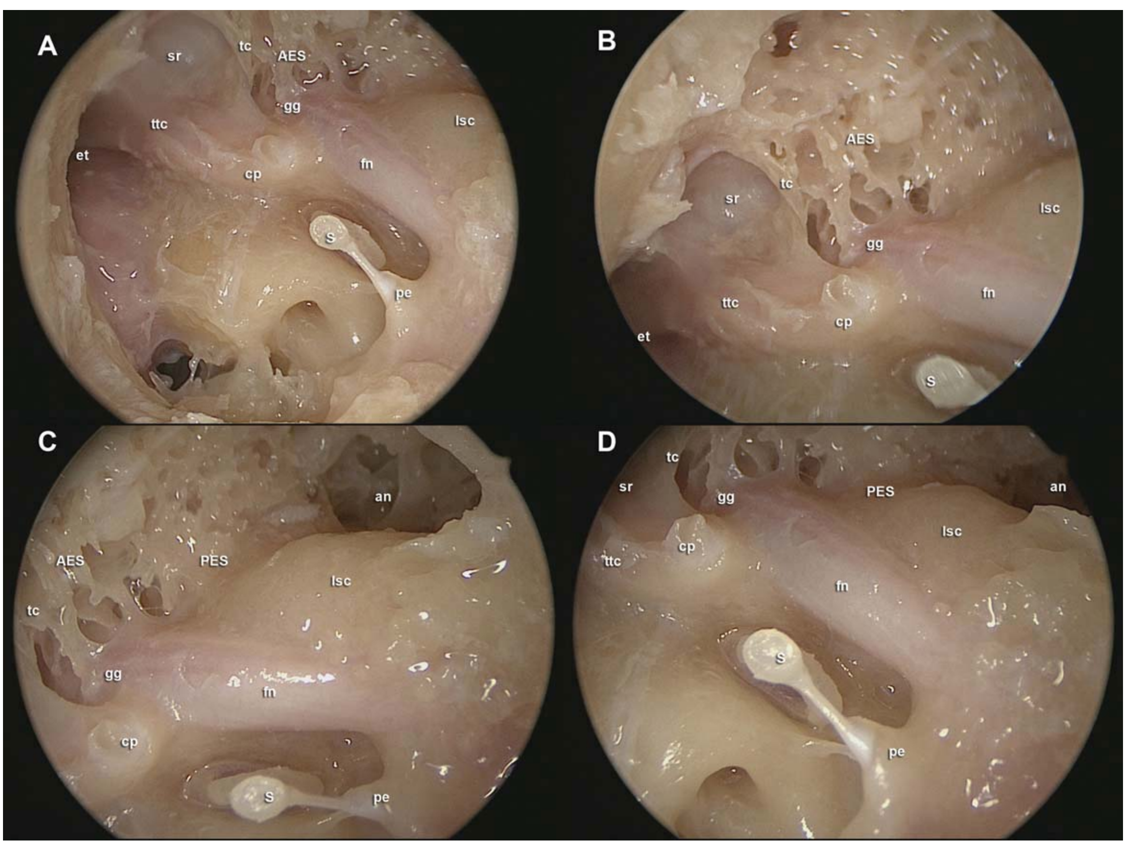

Fig. 4. The entire visualization of the tympanic facial nerve with the endoscopic approach. (A) Endoscopic view of the pre-postcochleariform segment and the geniculate ganglion area after malleus and incus removal. (B) Closer view of the geniculate ganglion area and its relationship with the cochleariform process. (C) Endoscopic view of the course of the postcochleariform segment of facial nerve parallel to the lateral semicircular canal. (D) A more posterior endoscopic view of the postcochleariform segment of the facial nerve and its anatomic relationships. et = eustachian tube; ttc = tensor tympani canal; sr = supratubal recess; tc = transverse crest; AES = anterior epitympanic space; gg = geniculate ganglion; cp = cochleariform process; fn = facial nerve; s = stapes; pe = pyramidal eminence; lsc = lateral semicircular canal; PES = posterior epitympanic space; an = antrum cell. [Color figure can be viewed in the online issue, which is available at wileyonlinelibrary.com.]

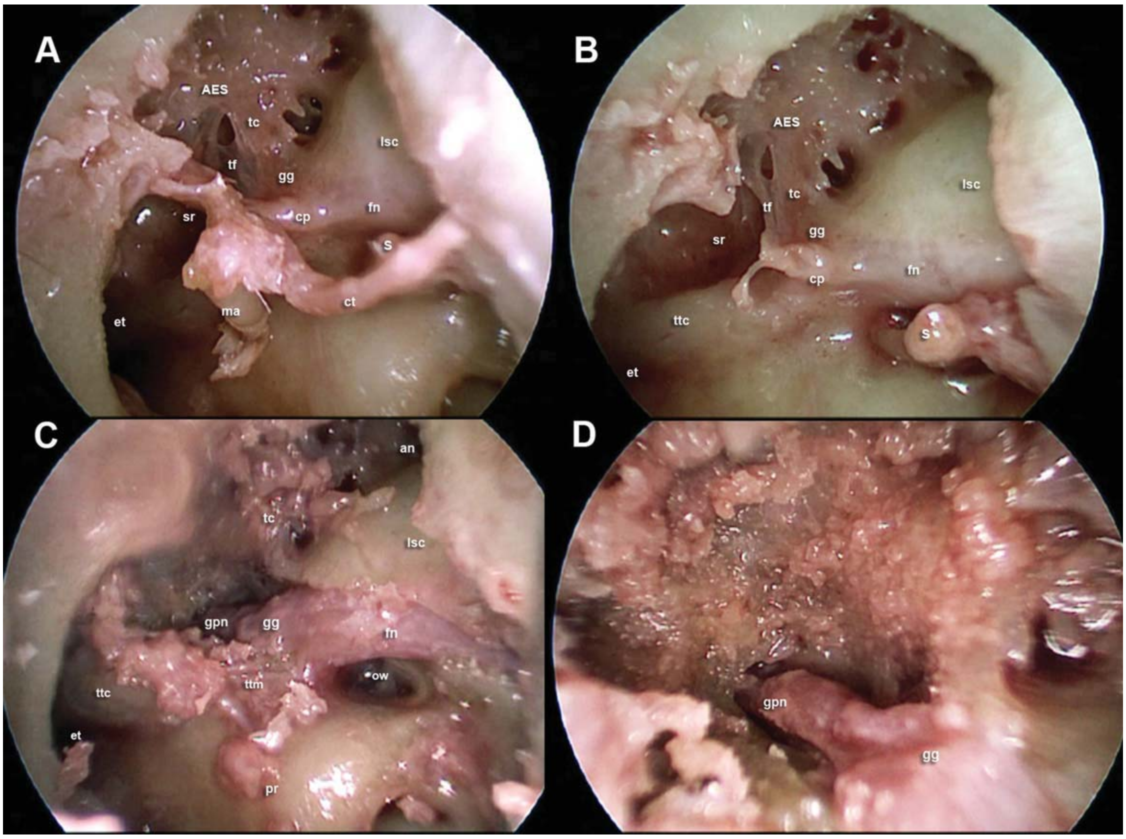

Fig. 5. The endoscopic approach to the geniculate ganglion area. (A) Endoscopic view of the geniculate ganglion area and relationship with the cochleariform process. (B) Endoscopic view after removal of the malleus. (C) Complete visualization of the geniculate ganglion after drilling the cellularity of the anterior epitympanic space just anteriorly and superiorly to the cochleariform process. (D) Closer endoscopic view of the greater petrosal nerve after the removal of the transverse crest and the supratubal recess. et = eustachian tube; sr = supratubal recess; tf = tensor fold; AES = anterior epitympanum space; tc = transverse crest; gg = geniculate ganglion; ma = malles; cp = cochleariform process; ct = corda tympani; s = stapes; fn = facial nerve; lsc = lateral semicircular canal; ttc = tensor tympani canal; ttm = tensor tympani muscle; gpn = greater petrosal nerve; ow = oval window; pr = promontory; an = antrum. [Color figure can be viewed in the online issue, which is available at wileyonlinelibrary.com.]

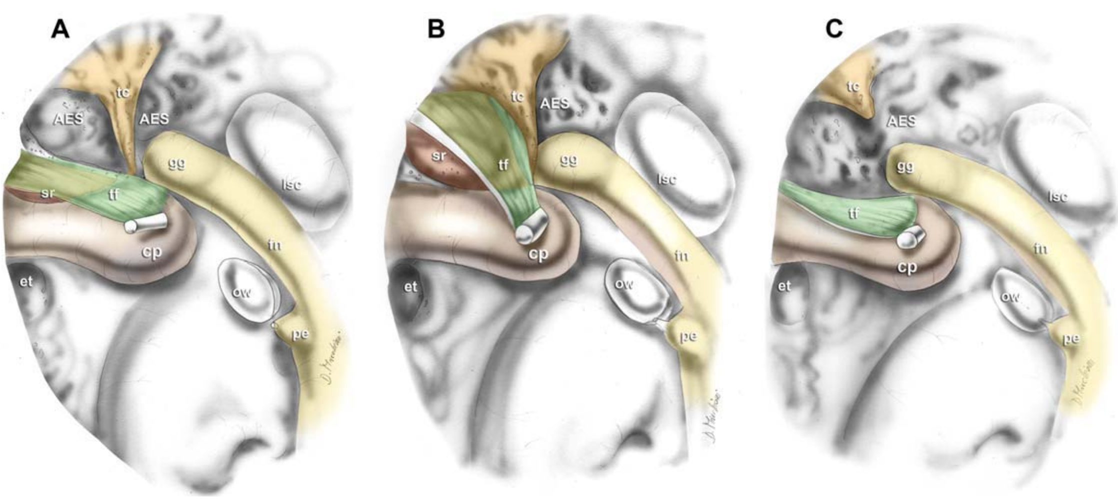

Fig. 6. Schematic drawing showing different conformations of the transverse crest. (A) Complete transverse crest without a direct relationship to the tensor fold and which has a horizontal orientation attaching to the tegmen tubae and to the semicanal of the tensor tendon; in this way, the anterior epitympanic space is divided into two portions. (B) Vertical orientation of the tensor fold attaching to a complete transverse crest; in this way, this crest represented the limit between the anterior epitympanic space and the supratubal recess. (C) Incomplete transverse crest. et = eustachian tube; sr = supratubal recess; tf = tensor fold; AES = anterior epitympanum space; tc = transverse crest; gg = geniculate ganglion; cp = cochleariform process; fn = facial nerve; lsc = lateral semicircular canal; ow = oval window; pe = pyramidal eminence. [Color figure can be viewed in the online issue, which is available at wileyonlinelibrary.com.]

area lying directly in front of the surgeon. The only region of the facial nerve that was accessed without chain removal appeared to be the most posterior, in close relationship with the second genu and the pyramidal eminence. In all 12 specimens examined, this segment represented the floor of the posterior epitympanic space. In nine of 12 subjects, this segment had a slightly oblique orientation with respect to the semicanal of the tensor tendon of the malleus, descending above the oval window and the stapes from the cochleariform process anteriorly to the pyramidal eminence posteriorly where the second genu was present (Fig. 3A). In three of 12 subjects, this segment had a parallel orientation to the semicanal of the tensor tendon of the malleus (Fig. 3B). The postcochleariform segment was parallel to the lateral semicircular canal in all 12 subjects, the latter representing an important landmark to reach the aditus ad antrum with an endoscopic technique (Fig. 4C and 4D).

Semicanal of Tensor Tendon of the Malleus

Observing the location of the tympanic segment of the facial nerve compared to the semicanal of the tensor tympani muscle, we noted a constant parallel orientation of this semicanal in all subjects, lying inferiorly with respect to the precochleariform tract of the facial nerve. Moreover, in seven of 12 subjects, this structure represented the floor of the supratubal recess (Fig. 3A and 3B), but in five of 12 subjects, no supratubal recess was found, so this structure represented the floor of the anterior epitympanic space.

Transverse Crest

The transverse crest can be considered as a ridge of bone extending inferiorly from the tegmen tympani of the anterior epitympanic space, just anterior to the cochleariform process. It is also commonly known as the "cog."[3,4] The transverse crest was detected in all 12 subjects, and this anatomic structure showed different conformations and relationships to the surrounding structures (geniculate ganglion, tensor fold, and supratubal recess) (Fig. 6). The transverse crest was complete in seven of 12 subjects, having a transverse inclination attaching anteriorly and superiorly to the most anterior portion of the tegmen tympani and "indicating" posteriorly and inferiorly the cochleariform process. In five subjects with a complete transverse crest, the tensor fold had a vertical orientation attaching to the transverse crest, and this bony crest represented the limit between the anterior epitympanic space and the supratubal recess (Fig. 6B and 7A). In two subjects with a complete transverse crest, the tensor fold had a horizontal orientation attaching to the tegmen tubae and to the semicanal of the tensor tendon of the malleus, so the transverse crest did not have a direct relationship with the tensor fold and divided the anterior epitympanic space into two portions, one posterior and a smaller one anterior (Fig. 6A and 7B). In five of 12 subjects, an incomplete or rudimental transverse crest was found, in close relationship to the tegmen of the anterior epitympanic space (Fig. 6C and 7C), and in one of these subjects, the crest presented a little fold descending toward the anterior limit of the cochleariform process.

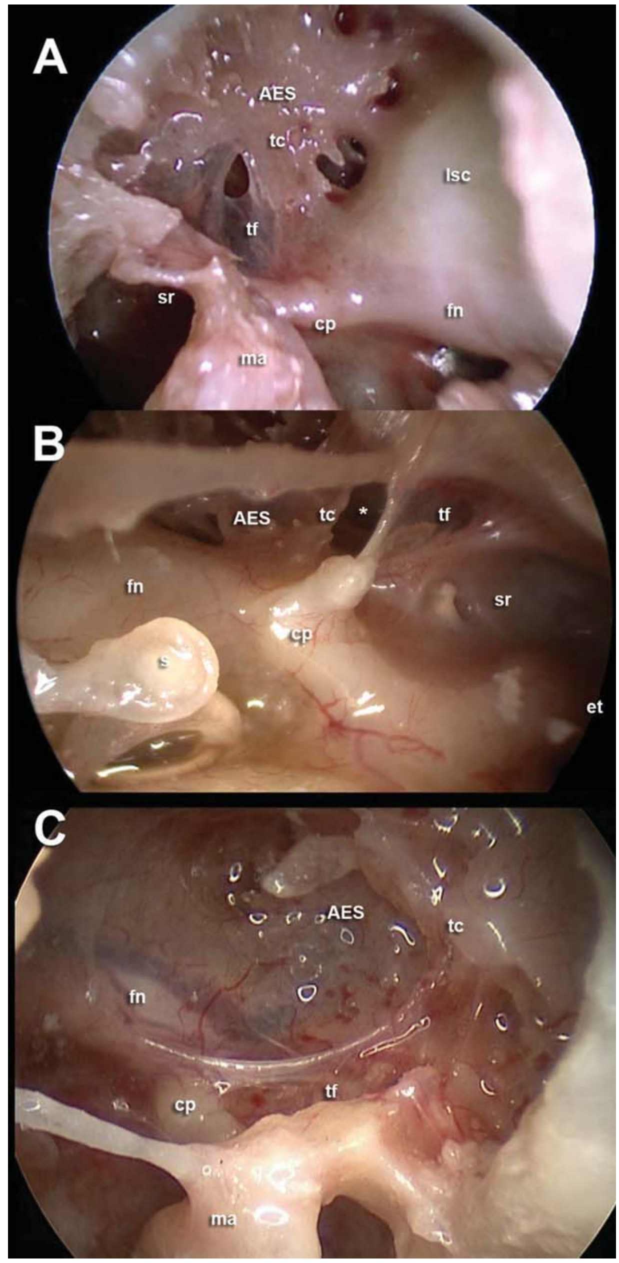

Fig. 7. Endoscopic view of the different conformations of the transverse crest. (A) Tensor fold has a vertical orientation attaching to the transverse crest, and this boney crest represents the limit between the anterior epitympanic space and the supratubal recess. (B) Horizontal orientation of the tensor fold attaching to the tegmen tubae and to the semicanal of the tensor tendon, so the transverse crest divides the interior epitympanic space into two portions. (C) Incomplete transverse crest. sr = supratubal recess; tf = tensor fold; AES = anterior epitympanum space; tc = transverse crest; ma = malleus; cp = cochleariform process; fn = facial nerve; lsc = lateral semicircular canal; s = stapes; et = eustachian tube. [Color figure can be viewed in the online issue, which is available at wileyonlinelibrary.com.]

Observing the anatomic relationship between the facial nerve and the transverse crest during our dissections, we noted that this crest, when complete, was a

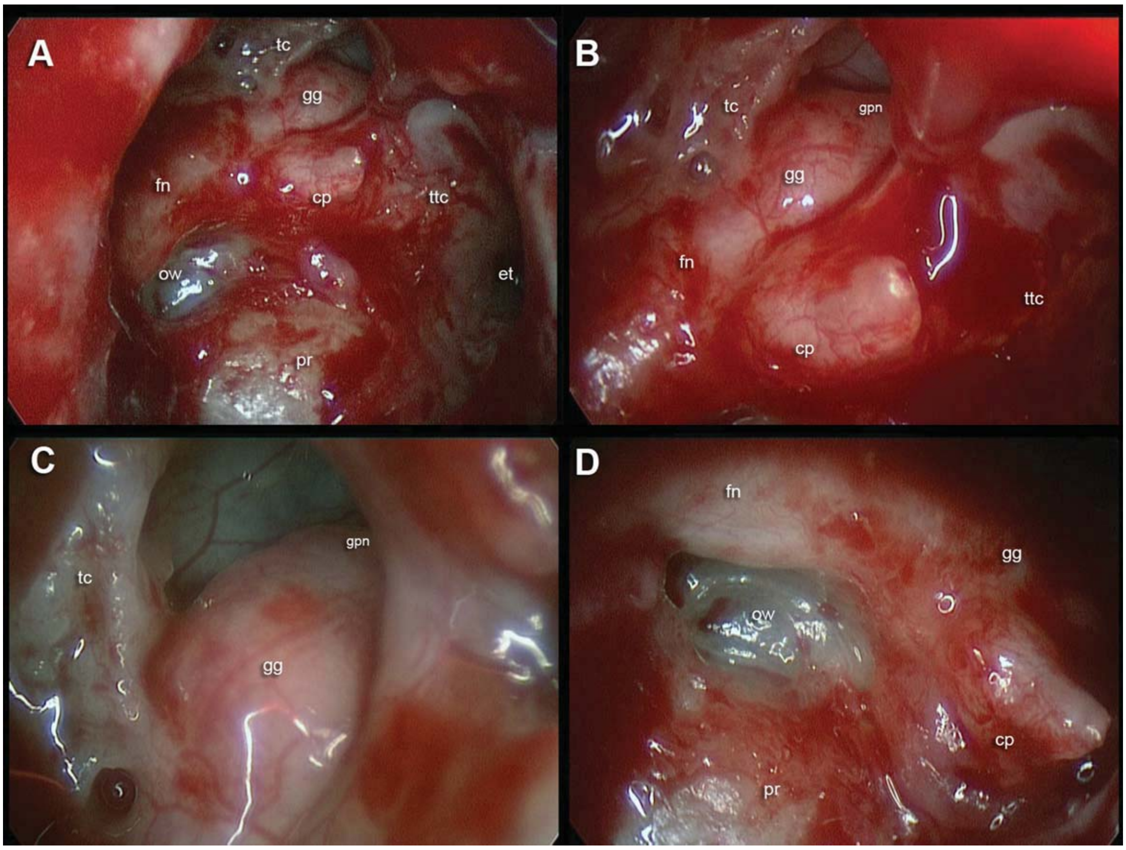

Fig. 8. Clinical case. (A) Endoscopic view after removal of the incus and malleus and after removal of cholesteatoma involving the anterior epitympanic space. (B) Closer view of the geniculate ganglion area. (C) Geniculate ganglion area after removal of epidermization over the ganglion. (D) Closer view of the anatomic relationship between the facial nerve and oval window. fn = facial nerve; ow = oval window; tc = transverse crest; gg = geniculate ganglion; cp = cochleariform process; pr = promontory; ttc = tensor tympani canal; et = eustachian tube; gpn = greater petrosal nerve. [Color figure can be viewed in the online issue, which is available at wileyonlinelibrary.com.]

consistent landmark for the geniculate ganglion during the endoscopic approach. In fact, in seven of 12 subjects, the transverse crest descended from the tegmen to the cochleariform process indicating the location of the geniculate ganglion (Fig. 5).

When incomplete or rudimental, the transverse crest could not be considered a true landmark for the geniculate ganglion, either because it did not clearly indicate the ganglion (3 subjects), or because it lay significantly anteriorly and laterally to the nerve (2 subjects).

Further Findings of Clinical Cases

In the two patients who underwent the transcanal endoscopic approach to the tympanic segment of the facial nerve, it was possible to remove the pathologic tissues from the tympanic cavity and obtain an endoscopic exposure of the entire tympanic segment of the facial nerve allowing decompression of the nerve. In one subject, we found a cholesteatoma involving the anterior epitympanic space and the facial nerve ganglion; we had to remove the incus and the malleus to obtain a direct exposure of the precochleariform segment of the nerve. After these surgical steps, we were able to detect the geniculate ganglion removing the epimerization from the anterior epitympanic space over the ganglion (Fig 8).

In the other patient, we found granulation tissue involving and compressing the postcochleariform segment of the tympanic facial nerve where we found Fallopian canal dehiscence. After removal of the incus and the head of the malleus, we were able to remove the pathologic tissues from the tympanic facial nerve allowing decompression of the nerve.

In the follow-up after surgery, the patients showed normal functions of the facial nerve.

DISCUSSION

Although middle ear endoscopic surgery is still in its infancy, its adoption is gradually spreading through the otology community. Endoscopes with various degrees of angulation (0°, 30°, 45°, 70°) allow the surgeon to “see around corners” to visualize hidden spaces, provide a magnification effect when close to objects, and use a three-chip high-resolution monitor and camera. They allow detailed visualization and description of the middle ear anatomic structures, even the smallest and least accessible, including hidden areas (such as the retrotympanum or anterior epitympanum). In the first

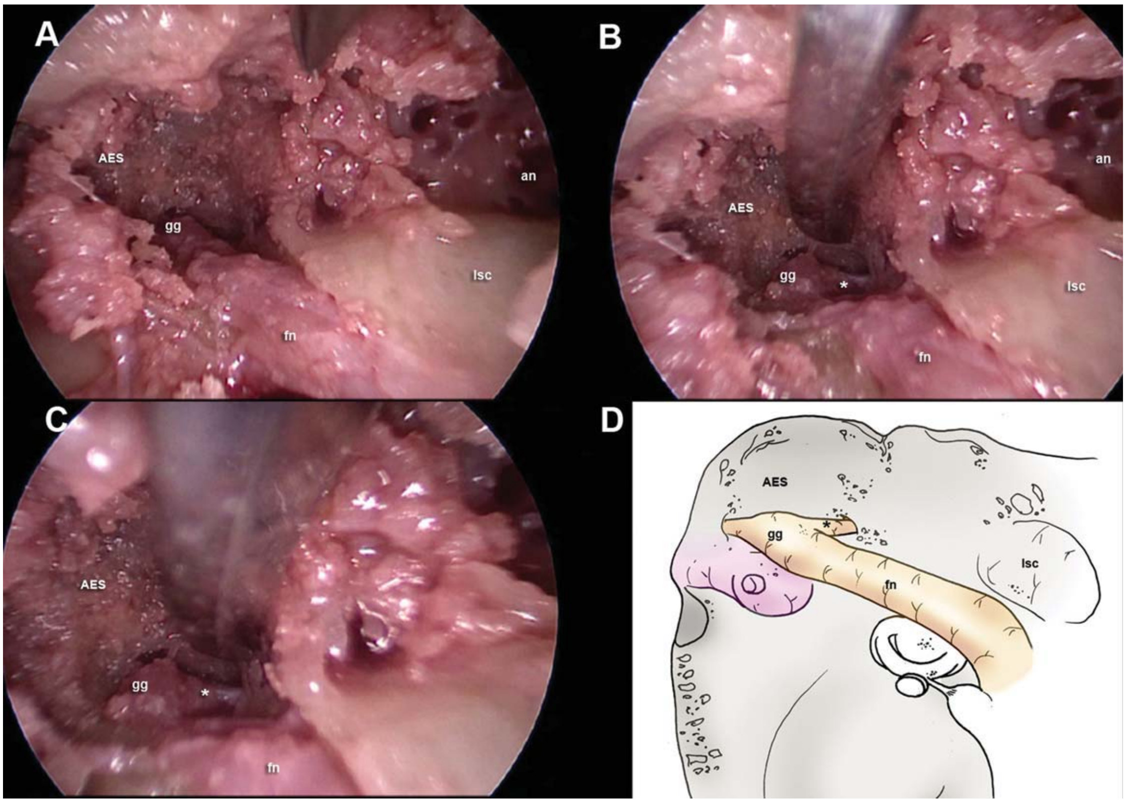

Fig. 9. The transcanal endoscopic exposure of the labyrinthine segment of the facial nerve. (A) The complete course of the tympanic facial nerve from the second genu to the geniculate ganglion; (B) Exposure of labyrinthine facial nerve after drilling of the cellularity close to the geniculate ganglion. (C) A closer endoscopic view of the labyrinthine facial nerve; (D) Complete course of the tympanic facial nerve to the second genu, to the geniculate ganglion, and to the most medial part of the labyrinthine tract. AES = anterior epitympanic space; gg = geniculate ganglion; fn = facial nerve; lsc = lateral semicircular canal; an = antrum. [Color figure can be viewed in the online issue, which is available at wileyonlinelibrary.com.]

attempts, the endoscope was used with an explorative aim, and operations were performed mainly with microscopic vision,[5–7] but its exclusive use in ear surgery is gradually diffusing.[8–11] However, use of the endoscope as the main tool instead of the microscope requires a complete change in surgical procedures that still must be codified. The advances in that field also introduced new anatomic[1,2] and physiologic concepts,[12] which are mandatory, in our opinion, to understand and support surgery.

As a result of our experience, understanding of the anatomy of the region in relation to the precochleariform tract of the facial nerve was also revised. We believed the decision to divide the tympanic nerve into two segments (pre- and postcochleariform) had a surgical consequence: In fact, it is in that extreme anterior segment of the tympanic facial nerve that endoscopy seems to guarantee true advantages compared to microscopy in terms of visualization and surgical maneuvering. Classic transcanal microscopic procedures are well known, and, after removal of the incus and head of the malleus, enable visualization of most of the tympanic segment of the facial nerve except for some regions such as that at the extreme anterior part of the nerve, the one extending toward the geniculate ganglion: In these cases, access to the anterior epitympanum should be made by a mastoidectomy and posterior atticotomy, and of course, removal of the incus and head of the malleus. Based on the results of the present study, although chain removal can be considered mandatory, the geniculate ganglion can be easily and quickly accessed transcanally by an exclusive endoscopic approach, hence sparing mastoid tissues and avoiding more extended approaches. This could have important clinical relevance; for example, the most common segment involved in posttraumatic facial nerve palsy is considered to be the perigeniculate region,[3] and in the case of a finding consistent with a fracture involving that region, traditional approaches to the geniculate ganglion would be by a middle cranial fossa approach, or, in the case of dead hearing after trauma, also by a translabyrinthine approach.[3]

So based on the preliminary results of this report, in expert hands, an exclusive endoscopic approach can be used in the above-mentioned cases. Usually (8 of 12 subjects) the geniculate ganglion is covered by the bone of the anterior epitympanic space cells, and it can be located by drilling the cellularity of the anterior epitympanic space just anteriorly and superiorly to the cochleariform process. Less frequently, the geniculate ganglion is directly visualized, without drilling any cellularity, but only removing the boney sheath of the Fallopian canal. As shown previously, an exclusive transcanal endoscopic approach is even able to dissect transcanally the greater petrosal nerve and the most lateral portion of the labyrinthine tract of the facial nerve: in fact, although not planned in advance, in one patient in our case series, a dissection of the most lateral portion of the labyrinthine facial nerve was easily performed by only removing some cellularity close to the geniculate ganglion (Fig. 9). Similarly, in the most posterior portion, toward the second genu of the nerve, close to the retrotympanum in the transition zone between the tympanic and mastoid segment of the structure, the nerve becomes transcanally inaccessible by microscope, and mastoidectomy is required. Also in these cases, as shown in our images (Fig. 4A and 4B), the facial nerve could be easily visualized by an exclusive endoscopic approach, sparing mastoid tissues and wide external incisions.

A further concept that we tried to revise in this report was the anatomy of the transverse crest (namely the cog), which is not always clearly described in the literature, probably because of different nomenclature, difficulties in visualization, and lack of clear images or drawings that indicate the anatomy of this structure. Frequent variability of this structure was noted, and its variability also influenced the relationship with the supratubal recess and anterior epitympanic space. It is also worth underlining that the cog represents a landmark for the facial nerve only when complete (7 cases out of 12). When rudimental, it could even be misleading for the real position of the nerve. As mentioned, in five subjects with a complete transverse crest, the tensor fold had a vertical orientation attaching to the transverse crest, and this boney crest represented the limit between the anterior epitympanic space and the supratubal recess (Fig. 6B and 7A). On the other hand, in two subjects with a complete transverse crest, the tensor fold had a horizontal orientation attaching to the tegmen tubae and to the semicanal of the tensor tendon of the malleus, so the transverse crest did not have a direct relationship with the tensor fold and divided the anterior epitympanic space into two portions, one posterior and a smaller one anterior (Fig. 6A and 7B).

Of course, the transcanal endoscopic approach may have some limitations. First of all, adequate dimensions of the external ear canal are mandatory in performing the complex endoscopic surgical maneuver. In fact, all the procedures are performed by only one hand, and this could be difficult for an inexperienced surgeon. In particular, one should be careful of the stapes during procedures around the postcochleariform segment of facial nerve, and the use of small burrs may represent a good option for this. Moreover, as is also true in all the middle ear endoscopic procedures, excessive intraoperative bleeding may force the surgeon to switch to a microscopic approach, so that it is possible to hold with the second hand a suction device during the operation. The use of endoscopic approaches requires, for complete visualization of the facial nerve, incus disarticulation and removal, so in these cases the endoscope does not give advantages in terms of ossicular chain preservation compared to microscopic techniques: anyway the incus can be replaced at the end of the operation or an ossiculoplasty can be performed instead.

CONCLUSION

The tympanic facial nerve can be thoroughly visualized using an exclusive endoscopic transcanal approach, even in poorly accessible regions such as the second genu and geniculate ganglion, avoiding mastoidectomy and external incisions. This may possibly have clinical significance, for example, in posttraumatic facial nerve decompressions, but clinically based reports will be needed to strengthen our preliminary results. As in microscopic techniques, the cochleariform process and transverse crest (cog) often represent useful landmarks in an exclusive endoscopic transcanal approach.

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