Transcanal Endoscopic Approach to the Sinus Tympani: A Clinical Report

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Objectives: To investigate the anatomic limitations of the endoscopic transcanal approach to sinus tympani (ST), in particular, how this approach might allow a complete visualization of the ST recesses and to propose a morphologic classification of the ST using computed tomography and to examine if this could be useful for the surgeon in preoperative planning to decide the type of approach to the ST.

Study Design: Case series.

Patients and Methods: Forty patients affected by middle ear disease with ST involvement were included in our study. All patients underwent a preoperative computed tomographic scan of the temporal bone. All patients underwent tympanomastoid surgery with intraoperative use of the endoscope. We assessed the variation in depth of the ST area, analyzing the posterior and medial extension of the medial boundary of the ST, and performing a radiomorphologic classification of the ST.

Results: Of the 40 patients, it has been possible to describe the detailed morphology of the shape of the ST in 38. We classified the depth of the ST into 3 types based on radiologic findings: Type A (a limited ST), Type B (a deep ST), and Type C (a deep ST with a posterior extension). Of 35 ST of Types A and B, there was good exposure of the medial boundary of the sinus using a transcanal endoscopic approach in 33 (94.2%), whereas in 3 (60%) of 5 patients of Type C, it was not possible to explore the complete depth of the sinus, especially the ST portion under and posterior to the facial nerve.

Conclusion: The transcanal endoscopic approach to the ST is indicated in ST of Types A and B. In ST of Type C, it is not always possible to have good control of the ST; in these cases, a posterior retrofacial approach is suggested.

Key Words: Radiomorphology—Retrofacial approach—Sinus tympani—Transcanal endoscopic approach.

of the endoscopic approach such as bleeding, the dimensions of the external ear canal, and the depth of the ST.

MATERIALS AND METHODS

From November 2007 to June 2008, 40 patients affected by middle ear disease (31 cholesteatomas, 5 retraction pockets, 4 chronic otitis media) and with ST involvement were included in our study. All patients underwent a preoperative computed tomographic (CT) scan of the temporal bone. The axial projections were obtained with sequential 1.0 mm slices; scanning was performed from the arcuate eminence to the jugular fossa.

We assessed the variation in depth of the ST area, analyzing the posterior and medial extension of the medial boundary of the ST, and performing a radiomorphologic classification of the ST.

Radiomorphologic Evaluation of the Depth of the ST

On the preoperative CT scan of the temporal bone, the medial and posterior extension of the ST with respect to the third portion of the facial nerve was studied. From the analysis of the axial scan of the ST, we observed several morphologic variations of the depth of the ST. We classified the depth of the ST into 3 types based on radiologic findings as follows:

Type A patients presented a limited ST (the medial limit of the third portion of the facial nerve corresponded to the depth of the sinus). In these cases, the ST was small and did not present a medial and posterior extension with respect to the facial nerve (Fig. 1).

Type B patients presented a deep ST (the medial boundary of the ST lies medially with respect to the third portion of the facial nerve and did not present a posterior extension with respect to the facial nerve; Fig. 1).

Type C patients presented a deep ST with a posterior extension (the medial boundary of the ST lies medially and posteriorly with respect to the third portion of the facial nerve). In these cases, the ST is very large and deep. In all these patients, a well-developed mastoid is present (Fig. 1).

All patients underwent tympanomastoid surgery with intraoperative use of the endoscope. We focused our work on describing the variation in shape of the ST and the anatomic variation of the ponticulus area using the endoscopic view.

FIG. 1. Computed tomographic classification of the ST. Sinus tympani Type A, a limited ST without medial and posterior extension with respect to the third portion of facial nerve; ST Type B, ST with medial extension without posterior extension with respect to the third portion of facial nerve; ST Type C, ST with posterior extension with respect to the third portion of the facial nerve. Ch indicates cochlea; Fn, facial nerve; Pr, promontory; Sn, ST.
Instrumentation and Equipment

The optical equipment used consisted of 0-, and 45-degree rigid Hopkins rod telescopes with a 3-mm outside diameter (Karl Storz, Tuttlingen, Germany). A 3-chip high-resolution monitor and camera (Karl Storz) were used for all of the procedures. All of the surgical endoscopic procedures were recorded on a high-definition digital video disc. The morphology of the ST was studied during surgery and also at the end of surgery using the recorded digital video disc. Endoscopic ear surgery was performed with a set of suitable microendoscopic instruments (Karl Storz).

Surgical Approach

Intraoperative endoscopy-assisted surgery was performed on all 40 patients. The endoscopes with various angles (0–45 degrees) were introduced through the external meatal canal after traditional microscopic surgery and before middle ear reconstruction.

The position of the surgeon during the endoscopic approach to the ST was different with respect to traditional microscopic surgery; the surgeon stood on the opposite side with respect to the affected middle ear (Fig. 2A) to permit a better view of the anatomy of the ST area. In this way, introducing the endoscope into the external ear canal, it was possible to observe the medial boundary of the ST and also have a good visualization of the ponticulus area. The surgeon held the endoscope with the left hand and used different surgical instruments with the right hand. During the endoscopic approach, the surgical field was cleaning frequently. The pathology was removed from the ST using a suitably angled instrument (Fig. 2B, C).

RESULTS

A consecutive case series consisting of 40 patients affected by chronic middle ear disease with ST involvement underwent classic tympanomastoid surgery, followed by an endoscopic transcanal approach over a 1-year period. There were 22 men and 18 women with a median age of 40.3 years.

Based on our CT scan classification, we found that 14 (35%) of 40 patients showed a Type A ST, 21 (52.5%) of 40 showed Type B ST, and 5 (12.5%) of 40 showed a Type C ST.

Intraoperative Endoscopic Evaluation of the Shape of the ST

Of the 40 patients, it has been possible to describe the detailed morphology of the shape of the ST in 38, whereas it was not possible to obtain a good view of the ST area in 2 patients as a result of excessive bleeding.

The endoscopic approach allowed us to identify different morphologic types based on the shape of the ST. Of the 38 patients:

- 27 (71%) of 38 presented a classic shape; the ST was located between the ponticulus and subiculum lying medial to the facial nerve and to the pyramidal process (Fig. 3A);
- 4 (10.5%) of 38 presented a confluent shape; there was an incomplete ponticulus, and the ST was confluent to the posterior sinus (Fig. 3B);
- 4 (10.5%) of 38 presented a partitioned shape: there was a ridge of bone extending from the third portion of the facial nerve to the promontory area, separating the ST into 2 portions (superior and inferior; Fig. 3C);
- 3 (7.9%) of 38 presented a restricted shape; there was a high jugular bulb reducing the inferior extension of the ST (Fig. 3D).

Intraoperative Endoscopic Evaluation of the Ponticulus Area

Of the 40 patients, we could describe the ponticulus morphology in 38. We found 3 different morphologies of the ponticulus area:

- 32 (84.2%) of 38 patients presented a classic morphology of the ponticulus; in these patients, the ponticulus was completely formed, and it was like a ridge of bone extending from the pyramidal process to the promontory area; this structure represented the superior limit of the ST dividing the ST from the posterior sinus (Fig. 4A);
• 4 (10.5%) of 38 patients presented an incomplete ponticulus; in these cases, the ST and the posterior sinus were confluent (Fig. 4B);
• 2 (5.3%) of 38 patients presented a communicating ponticulus; in these subjects, the ponticulus was like a small bridge of bone, and under it was a communication from the ST to the posterior sinus (Fig. 4C).

Feasibility of the Endoscopic Transcanal Approach to the ST

Of the 40 patients, endoscopic transcanal approach allowed us to explore the complete ST area in 35 (87.5%), especially the medial boundary of the sinus. Comparing the endoscopic approach to our radiomorphologic classification, the results were as follows:

Of 35 ST of Types A and B, there was good exposure of the medial boundary of the sinus in 33 (94.2%). It was not possible to explore the medial boundary of the sinus in only 2 patients because of excessive bleeding during surgery.

Of 5 ST Type C, there was a good exposure of the deep ST (Type C) in 2 (40%), whereas in 3 patients (60%), it was not possible to explore the complete depth of the sinus, especially the ST portion under and posterior to the facial nerve. These patients presented a particularly posterior mastoid pneumatization.

Of 31 patients affected by cholesteatoma, it was possible to remove the pathology from the ST under endoscopic control in 29 (93.5%), whereas in 2 patients (1 with excessive bleeding and another with a deep ST Type C), it was not possible to remove the disease with the endoscope, and we had to change to a posterior approach using the microscope for the patient with excessive bleeding and to a retrofacial approach for the patient with ST Type C.

Of 5 patients affected by a retraction pocket, good exposure of the deep ST (Type C) was not possible in 2.

Of 4 patients affected by chronic otitis media, in 1 patient, it was not possible to describe the morphology of the sinus because of excessive bleeding during surgery.

We did not find any limitation of the endoscopic approach in any patient with respect to the dimensions of the external auditory canal. In our experience, the...
cholesteatoma has always been differentiated from surrounding tissues. In this series, there was no morbidity or complication secondary to the use of the 45-degree-angled endoscope.

**DISCUSSION**

The ST is located medially to the facial nerve and to the pyramidal eminence and lies lateral to the posterior semicircular canal. The anatomic space between the subiculum and the ponticulus is very limited (Fig. 5).

The sinus is subject to great variability in size and shape. Meckel (12) was the first to describe the ST but only considered the portion anterior to the pyramidal eminence.

Steinbrugge (13) then described the posterior extension of the ST medially to the pyramidal eminence and facial nerve. He observed the depth of the ST and also pointed out the consequences of the disease in this kind of ST.

In the 1970s, Donaldson et al. (5) studied the surgical anatomy of the ST of fetal, infant, and adult temporal bone sections. They described the variation in size and shape of the ST and observed that the sinus lay medially with respect to the facial nerve canal, and it could extend posteriorly to or beyond the posterior margin of the vertical portion of the facial nerve.

For this reason, when the ST is large, it cannot be cleaned adequately with any known instruments.

The ponticulus is a bony ridge extending from the pyramidal process to the promontory region, which separates the ST from the posterior sinus. This structure is very important because it represents the superior limit of the ST. In a study based on 50 temporal bones, Holt (14) examined the anatomy of the ponticulus. He described the ponticulus as a sort of bridge of bone extending from the pyramidal eminence to the promontory. In his work, he also described the anatomic variations of the ponticulus; in fact, with the 50 temporal bones, he found a complete formation of the ponticulus in 33 cases, a remnant of the ponticulus in 7, and a complete absence of it in 10.
In our study, the endoscopic approach to the ST with a 45-degree instrument allowed us to visualize the morphology of the ponticulus area in 38 of 40 cases. The intraoperative endoscopic evaluation of the ponticulus area has been very useful, particularly for 2 patients in which the ponticulus was like a small ridge of bone (Fig. 6), and under it, there was communication from the ST to the posterior sinus. In 1 of these patients, the cholesteatoma was also present under the ponticulus, and it was necessary to drill the ponticulus to remove the cholesteatoma with suitably angled instruments under endoscopic control.

The surgical management of ST cholesteatoma remains controversial. Residual cholesteatoma is among the major causes of failure in surgical treatment of cholesteatoma. It occurs as a consequence of growth of a fragment of the matrix inadvertently remaining in the middle ear at the time of cholesteatoma surgery. In our previous study (15), focused on the frequency of residual cholesteatoma detected with the intraoperative use of the endoscope after traditional microscopic surgery, we found that the ST was the most common site of residual cholesteatoma fragments. Other studies reported in literature have shown the same results (16,17).

The problem of residual cholesteatoma depends on the surgical approach; in fact, poor access cannot permit accurate cholesteatoma removal. For this reason, the particular anatomy of the ST requires maximum surgical exposure to permit a complete removal of the disease. Several surgical techniques have been described to approach the ST area.

Farrior (4) proposed a posterior tympanotomy exposing the facial recess and the bone overlying the following fallopian canal to remove the pyramidal eminence and anterior bone portion of the facial nerve. It has been claimed that this removal of the lateral wall of the ST provides a more direct view into the ST.

Recently, a posterior approach to the ST through the mastoid has been proposed by several authors (2,9,10). The retrofacial posterior approach was performed by dissecting the triangular bony area formed by the facial nerve, lateral semicircular canal, and posterior semicircular canal. This approach is very difficult and requires an expert otologic surgeon because the facial nerve, the...
posterior semicircular canal, and the lateral semicircular canal are all at risk of injury.

The development of endoscopy for the middle ear (9,18–24) has permitted exploration of hidden recesses such as the ST. Thomassin et al. (18) found that the quality of disease eradication had significantly improved with the intraoperative use of the endoscope, which allowed a consequent reduction of residual cholesteatoma. Using the endoscopic approach to the middle ear recess in cholesteatoma surgery, Badr-El-Dine (19) also found that the use of the endoscope did reduce the residual cholesteatoma rate. In their clinical report, El-Meselaty et al. (17) demonstrated that the endoscopic approach to the ST gave the surgeon better control over the pathology, thus achieving better eradication. A direct view of the ST could also be obtained by a transtubal endoscopic evaluation of the middle ear as described by Kimura et al. (25) and Edelstein et al. (26). This atraumatic approach is a suitable method for exploring the mesotympanic structures.

Recently, Baki et al. (9) studied the endoscopic anatomy of the ST on 30 cadaveric temporal bones. They found that the ST is bounded laterally by a constant ledge of bone anterior to the facial nerve, and in 6 specimens, when the ST was deep and extending posterior to the facial nerve, it was not possible to visualize this region clearly with the endoscope because the orifice plane was more or less perpendicular to the axis of the external auditory canal. They suggested a lateral lip of bone removal anteriorly to the facial nerve to allow a good exposure of the deep ST with an optical instrument.

In addition, in our experience, we discovered that when the ST posterior extension was particularly developed behind the facial nerve, it was not possible to visualize the ST portion under the third tract of the facial nerve. We found the presence of a constant ledge of bone anterior to the facial nerve very close to the pyramidal process forming the lateral wall of the ST. Under this area, the third portion of the facial nerve was also very close in deep sinus Type C.

![FIG. 8. Endoscopic view of ST during surgery. A, Restricted shape; B, partitioned shape. Asterisk indicates ridge of bone dividing the ST into 2 portions; Fn, facial nerve; In, incus; JB, jugular bulb; p, ponticulus; Pe, pyramidal process; Pr, promontory; PS, posterior sinus; rw, round window; s, stapedial tendon; st, stapes; ST, inferior portion of ST; STs, superior portion of ST.](image1)

![FIG. 9. Sinus tympani Type C: posterior extension of the ST respect the third portion of the facial nerve. Endoscopic view. Fn indicates facial nerve; Pe, pyramidal process.](image2)
In our work, we emphasized the importance of the position of the surgeon during the endoscopic approach, standing on the opposite side to the affected ear; this detail is very important in obtaining a good exposure of the medial boundary of the ST recess (Fig. 7).

This direct anterior approach also allows us to see the anatomic variation in the shape of the ST area (Fig. 8). Despite several other studies using the surgical approach to the ST performed on cadaveric temporal bones, we preferred to study the feasibility of the endoscopic transcanal approach using a clinical report; in fact, during tympanomastoid surgery, it has been possible to understand the limits of the endoscopic approach, for example, bleeding, the dimensions of the external ear canal, and the depth of the ST. In our experience, the endoscopic approach to the ST was limited by intraoperative bleeding in 2 of 40 patients, and the dimensions of the external ear was not a problem for this approach even in children. In addition, we found that the posterior extension of the ST in relation to the facial nerve is the most important anatomic landmark to assess if it is possible to gain surgical accessibility to the ST with an endoscope. This relationship is also very important in deciding the type of approach (anterior transcanal endoscopic approach or posterior retrofacial approach).

For this reason, we proposed a radiomorphologic classification of the depth of the ST. In our opinion, this classification could be very useful for the surgeon in preoperative planning to decide the type of approach to the ST. No previous studies have been published in literature regarding the indications of the endoscopic approach to the ST.

In our study, the transcanal endoscopic approach was very useful in patients with ST Types A and B; in fact, in 33 of 35 patients, it was possible to explore the depth of the ST, whereas in 3 of 5 patients with ST Type C, it was not possible to explore the entire depth of the sinus, especially the ST portion under and posterior to the facial nerve (Fig. 9). Given the rarity of ST Type C, further studies should be continued to validate our results. These studies should be particularly focused on this kind of deep ST.

CONCLUSION

The transcanal endoscopic approach to the ST is indicated in ST of Types A and B. When the surgical field is bleeding extensively, it is often necessary to clean the optical instruments, and in some cases, we had to change our approach. In ST of Type C, especially associated with a well-developed mastoid cell, it is not always possible to have good control of the ST; in these cases, a posterior retrofacial approach is suggested.

REFERENCES