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Original article

Endoscopic classification of the external auditory canal for transcanal endoscopic ear surgery

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ABSTRACT

Objective: Evaluation of an endoscopic anatomic classification of the external auditory canal (EAC) for transcanal endoscopic ear surgery.
Materials and method: The EAC Canal Endoscopic Scale (CES) was initially defined according to total or partial EAC narrowing on 0° transcanal endoscopy. A retrospective study was then conducted between September 2013 and March 2015 in a series of consecutive patients fulfilling the study inclusion criteria.
Results: A total of 83% of 5000 patients (10000 ears) were classified as CES 0: i.e., total visualization of the tympanic membrane. Various kinds of EAC narrowing were described. Results were comparable between right and left ears.
Conclusions: 0° endoscopy provided total visualization of the tympanic membrane in most cases, thanks to its magnified lateral view. Preoperative CES classification allows use of angled endoscopes, curved instruments or drilling for canalplasty to be planned in the first step of transcanal endoscopic ear surgery.

1. Introduction

The transcanal approach is a recent development in endoscopic ear surgery. Surgical indications are continuously broadening, from external to inner ear, with endoscopic ear surgeons' experience [1–14].

Transcanal endoscopic ear surgery (TEES) is dependent on the anatomy of the external auditory canal (EAC). Total visualization of the tympanic membrane (TM) is usually provided by a 0° endoscope, possibly complemented by an angled endoscope or canalplasty.

The authors propose an EAC classification, the canal endoscopic scale (CES), assessed in a series of 5000 patients, with the aim of improving preoperative work-up for TEES.

2. Material and method

Inclusion criteria comprised:

- male or female patient over 6 years of age;
- with dry ears and healthy EAC skin;
- without history of ear surgery, congenital EAC deformity or congenital cartilaginous EAC narrowing.

The Canal Endoscopic Scale (CES) comprised:

- TM visualized on 0° 3 mm endoscopy:
  - CES 0: total visualization (Fig. 1),
  - CES 1: partial visualization:
- Anatomic part of TM hidden from endoscope (Figs. 2–6):
  - CES 1a (anterior): anterior part of TM (pars tensa), from anterior annulus to malleus handle,
  - CES 1a + beyond malleus handle,
  - CES 1p (posterior): posterior part of TM (pars tensa), from posterior annulus to malleus handle,
  - CES 1p+: beyond malleus handle,
  - CES 1s (superior): superior part of TM (pars flaccida),
  - CES 1i (inferior): inferior part of TM (pars tensa),
  - CES 1b (both, mixed): part of both pars tensa and pars flaccida,
  - CES 1c (circumferential): pars tensa and pars flaccida hidden by circumferential narrowing of EAC.

Results were reported according to CES, for right and left ears.

Statistical analysis used Student t test. The significance threshold was set at $P < 0.01$.

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Fig. 1. CES 0.

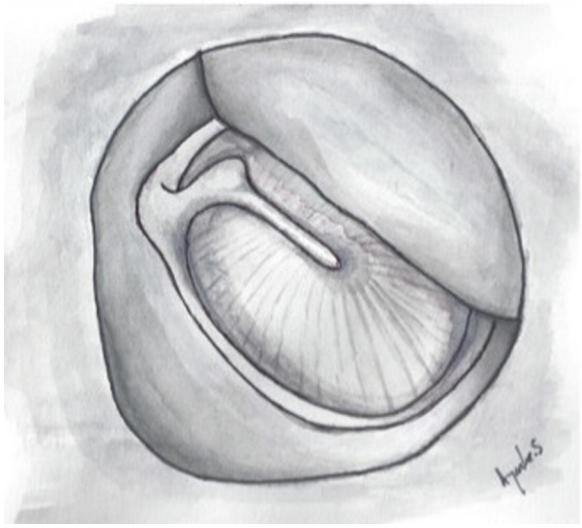

Fig. 2. CES 1a.

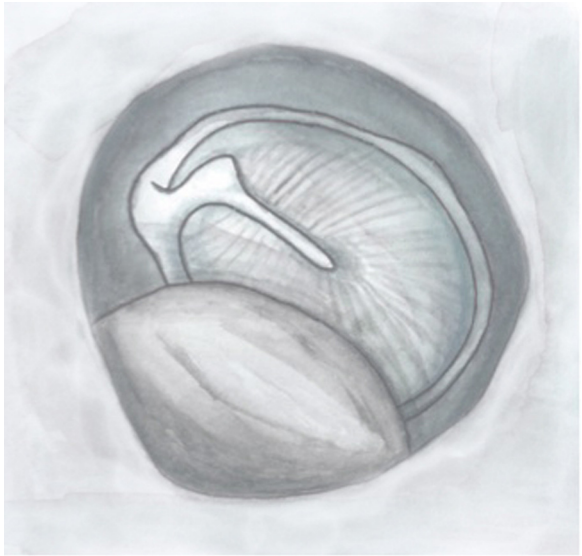

Fig. 3. CES 1p.

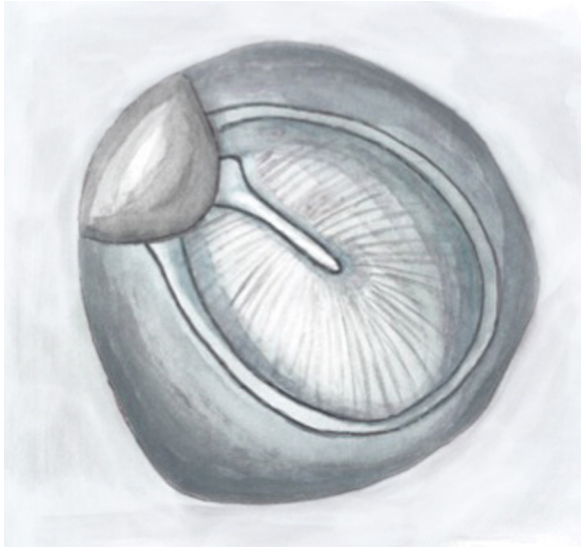

Fig. 4. CES 1s.

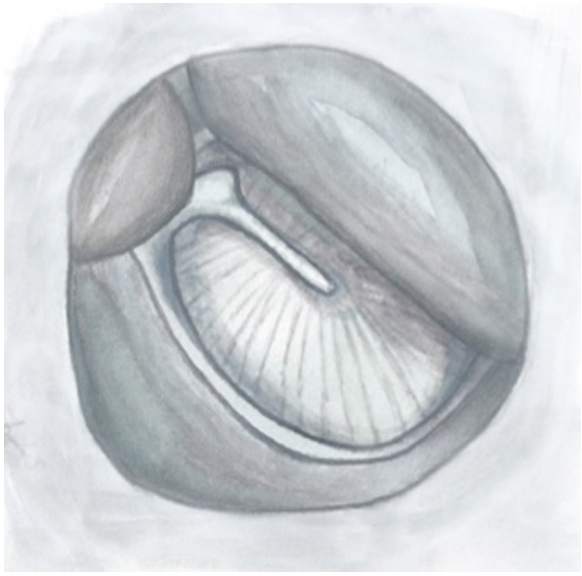

Fig. 5. CES 1b.

3. Results

3.1. Patients

The study was conducted on 5000 patients, on both ears.

A total of 2,400 were female (48%) and 2,600 male (52%). Mean age was 45 years (range, 6 to 86 years). 1,302 patients (26%) were children younger than 15 years and 3,698 (74%) were adults.

3.2. Total Visualization of TM (CES 0)

TM was totally visualized in 4,130 (83%) and 4,152 patients (83%) in right and left ears, respectively. Results were comparable between ears ($P < 0.01$).

*3.2.1. Right ears (*n *= 4,130)*

There was no EAC narrowing in 493 patients (12%).

In the other 3,637 patients (88%), narrowing was always located in the anterior EAC, and involved less than 50% of the anterior TM

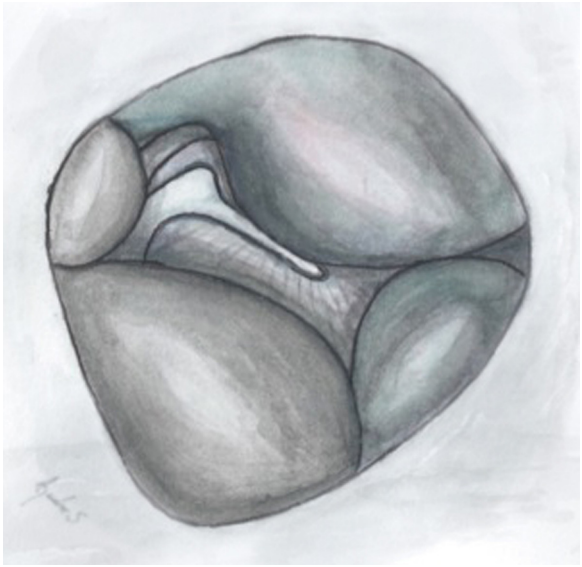

Fig. 6. CES 1c.

Table 1
Endoscopic classification of the external auditory canal for transcanal endoscopic ear surgery.

	Right ears		Left ears	
	n = 870	*N* = 5000	*n* = *848*	*N* = 5000
CES 1	870	17%	848	17%
CES 1a	609 (70%)	12%	619 (73%)	12%
CES 1a+	44 (5%)	0.9%	35 (4%)	0.7%
CES 1p	6 (0.7%)	1.2%	0 (0%)	0%
CES 1p+	0 (0%)	0 (0%)	0 (0%)	0%
CES s	50 (5.7%)	1%	25 (3%)	0.5%
CES i	85 (10%)	1.7%	106 (12.5%)	2.1%
CES b	70 (8%)	1.4%	59 (7%)	1.2%
CES c	6 (0.6%)	1.2%	4 (0.5%)	0.1%

a (anterior): anterior part of the TM (pars tensa), from the anterior annulus to the malleus handle. p (posterior): posterior part of the TM (pars tensa), from the posterior annulus to the malleus handle. a+ or p+: anterior or posterior part of the TM (pars tensa), beyond the malleus handle. s (superior): superior part of the TM (pars flaccida). i (inferior): inferior part of the TM (pars tensa). b (both): part of both the pars tensa and pars flaccida. c (circumferential): pars tensa and pars flaccida hidden by a circumferential stenosis of the EAC.

in 3,587 cases (86%). In 50 cases (2%), narrowing was caused by a bony hump located far from the annulus, allowing the tip of the endoscope to be introduced below the hump.

3.2.2. *Left ears* (n = *4,152*)

There was no EAC narrowing in 448 patients (11%).

In the other 3,704 patients (89%), narrowing was located in the anterior EAC, hiding up to 50% of the anterior TM in 3,640 cases (88%) and more than 50% in 39 cases (1%).

Narrowing was located in the posterior EAC in 5 patients (0.2%), and in the superior EAC, masking the pars flaccida, in 15 patients (0.4%).

3.3. *Partial Visualization of TM (CES 1)*

The majority of patients were classified as CES 1a (75% and 78% of right and left ears, respectively) ($P < 0.01$) (Table 1).

Tympanal overhang masked 50% of the anterior TM in 6% of right ears (303 patients) and 7.7% of left ears (387 patients).

The anterior TM was totally hidden when overhang reached the malleus handle, in 7% (350 patients) and 1% (53 patients) of right and left ears respectively.

When overhang extended beyond malleus handle (CES 1a+), endoscopy never provided total visualization of the anterior TM, in right or left ears.

EAC narrowing was is more frequent than superior or posterior narrowing (10% and 12.5% of right and left ears, respectively). This anatomic configuration prevented total visualization of the inferior TM, notably making the annulus difficult to elevate in this area.

In CES s, narrowing was caused by a bony hump masking the pars flaccida in all right ears (50 patients, 1%) and almost all left ears (36 out of 43 patients: 0.9%). Only very small bony humps allowed visualization of the pars flaccida, in 7 left ears.

In CES b, the pars flaccida was hidden by a bony hump in all cases. Anterior overhang prevented total visualization of the TM in 10 right ears and 14 left ears.

Circumferential narrowing (CES c) was rare in the present series. In 2 right and 2 left ears, narrowing prevented any introduction of the 3 mm endoscope in the EAC.

Likewise in case of posterior bony hump (8 patients), the endoscope provided partial visualization of the TM in 6 out of these 8 patients, with a posterior bony hump masking between 50% and 100% of the posterior TM.

Results were statistically comparable ($P < 0.01$) between both ears.

4. Discussion

4.1. *Principles of tees*

TEES provides a 'conical lateral' view from the tip of endoscope [15], improving visualization of the TM and access to TM pathologies: perforation, retraction pocket or cholesteatoma.

The endoscope exposes the TM and follows disease extensions in middle ear spaces, through ventilation pathways and the anatomic structures underlying strength and weakness of the ear. This functional approach is the basis of minimally invasive surgery.

On the other hand, the microscope provides a 'direct tunnel' view, limited by the bony anatomic structures of the middle ear [15], and requires removal of healthy bone and tissue to reach disease extensions.

4.2. *EAC and transcanal approach*

EAC anatomy is a key-point for TEES and transcanal microscopy.

If the surgeon is not able to visualize the entire TM, canalplasty is necessary, which can also be performed via a transcanal approach.

Anatomic features of EAC are rarely reported in preoperative medical records when microscopic or endoscopic ear surgery is planned.

The usual preoperative assessment for TEES involves otoscopy, audiometry, and temporal bone imaging on CT or MRI in case of retraction pocket or cholesteatoma.

The present study described a preoperative endoscopic classification for TEES: the Canal Endoscopic Scale (CES).

This classification fulfils the following necessary conditions:

- simple and quick: the result is reported after introduction of the 0° endoscope in the EAC;
- objective: total or partial visualization of the TM;
- reproducible: classification is determined on a single procedure and is available for all TEES cases.

4.3. *CES 0 patients*

Most patients were CES 0, with comparable results in right and left ears.

TEES can be performed in such cases, with a 0° endoscopic transcanal approach for any part of the TM. Tympanal drilling and/or antromastoidectomy are performed according to disease extension toward the anatomic spaces of the tympanic cavity or beyond external semi-circular canal.

Sub-classification as a, p, s, b, c is not appropriate for CES 0 patients. However, strictly straight EACs without any narrowing were rarely observed in the present series. Most narrowings were located in the anterior part of the bony EAC.

TM visualization depended on two parameters:

- the size of the bony hump or overhang. Most narrowings masked less than 50% of the anterior TM;
- the distance between the narrowing and the annulus: the further the narrowing from annulus (i.e., lateral in the EAC), the further the endoscope could be introduced, providing a 'conical lateral' view and total visualization of the anterior TM.

4.4. CES 1 patients

The main limit of 0° endoscope-assisted otoscopy concerned anterior overhang of the canal wall masking 50% to 100% of the anterior TM (CES 1a). Overhang beyond malleus handle (CES 1a+) was rare (1% in 5000 patients).

These anatomic situations can be encountered in surgery for anterior TM perforation.

These perforations are a surgical challenge. Reduced blood supply to the anterior TM increases the risk of graft necrosis [16,17]. The anatomy of the anterior canal wall can also prevent total visualization of the anterior edge of the perforation and can increase the risk of blunting. Angled 30° and 45° endoscopes coupled to curved instruments or endoscopic canalplasty can be used to reach the whole anterior TM.

The CES classification can predict these anatomic situations ahead of surgery. If canalplasty is planned, CES 1a patients are classified as CES 1aD (D meaning 'drilling of canal wall').

Patients with superior EAC narrowing masking the pars flaccida were classified as CES 1s, or CES 1b both the pars flaccida and pars tensa were masked. This anatomic situation can particularly occur in treatment of attic cholesteatoma, requiring canalplasty, as angled endoscopes providing only partial TM exposure.

Therefore, most of these patients were classified as CES 1sD or CES 1bD.

EAC anatomy is rarely considered as a critical point in preoperative assessment. Usually, the surgeon has to adapt the surgical approach and come to a decision about canalplasty intraoperatively.

Endoscopy provides accurate information about EAC anatomy.

Preoperative implementation of the CES allows the feasibility of 0° or angled endoscope-assisted TEES to be assessed, planning canalplasty from the outset and thus better informing the patient in advance of surgery.

The authors previously reported the value of endoscopy compared to microscopy fort TM visualization. Surgeons must be aware that the CES does not apply to microscopic procedures.

5. Conclusion

EAC anatomy is a critical parameter in transcanal endoscopic surgical procedures, but is often underestimated in the preoperative assessment for ear surgery.

The CES classification is an easy, quick, objective and reproducible classification.

In the light of the present results, the authors propose including this classification in the preoperative records of patients scheduled for TEES.

Disclosure of Interest

The authors declare that they have no competing interest.

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