16 Office Examination in Otitis Media

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Office Examination in Otitis Media

- How to collect and store high-quality images and data
- The challenge of examining the tympanic membrane: advantages and disadvantages of the otoscopes, microscopes, and endoscopes.
- Telemedicine otoscopy: Is it possible to make remote diagnostics?

Introduction

Otorhinolaryngology is a specialty that examines regions with difficult access. Evaluating structures such as the larynx, paranasal sinus, and ear has always been challenging since adequate angulation and lighting are simultaneously necessary. The technological improvements that occurred in the last decade brought a series of advances in the diagnosis process in otorhinolaryngology. Such progress led to a series of benefits, such as a greater understanding of the pathogenesis of diseases and the development of new therapeutic possibilities.

In otology, more specifically, it was not different. In the twentieth century, the otolaryngologist relied mainly on the otoscope, which has some limitations, such as limited amplification, angulation, and poor lighting. Although the otoscope has received several improvements over the years, such as the evolution of the halogen lamp to the LED lamp, today, it is just one more instrument among the many available in the office.

The microscopes, previously present only in operating rooms as large and heavy volumes, have evolved into much more compact and lightweight structures. In addition, there was a reduction in the cost of microscopes, a product of the dissemination of manufacturing techniques. As a result of these factors, today, the microscope can already be found in the office of most otologists.

The microscope is of foremost importance in manipulating the external and middle ear, allowing the removal of discharges, crusts, and granulations. It makes it possible to perform procedures with greater efficiency and less discomfort for the patient. Its significant difference is that it provides a three-dimensional and enlarged view, which allows better observation of the tympanic membrane and its relationship with structures of the external auditory canal and the middle ear. These features allow, for example, better identification and grading of tympanic retractions and better detailing of other aspects of the tympanic membrane and the external auditory canal.

Otoendoscopy, performed with the aid of 0°, 30°, and 45° rigid optics, emerged in the 1980s and was popularized in the twenty-first century. For otological examination in the office, perhaps the most evident benefit is the possibility of visualizing the anterior tympanic borders in patients whose external auditory canals are more tortuous. With the arrival of this technology, the tympanic membrane perforations previously classified as marginal can often be reclassified as central since the edges, hidden by the tortuosity of the external acoustic meatus, now become visible.

Otoendoscopy allows greater angulation in the external auditory canal, more efficient image amplification, and the possibility of more proximity with the tympanic membrane (often almost in direct contact). Also, it allows for the recording of the otoscopy, qualifying for reanalysis as often as required. New perspectives for studying chronic otitis media (COM) [1] emerged with the aid of those technologies.

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Our research group has used otoendoscopy since 2002. Based on the serial analysis of cases of COM, we have already proposed a new classification for middle ear cholesteatomas [2], with the description of new growth patterns until then not observed. Furthermore, considering the tympanic membrane perforations, as previously mentioned, many were reclassified when we could see the tympanic borders with the otoendoscopy. Also, we were able to recognize essential factors related to perforation's pathogenesis. An example is the description of signs [3] that suggest tympanic membrane retraction before tympanic perforation, an association not previously portrayed in the literature, namely:

1. Medialization of the malleus handle,
2. Tympanic remnants in touch over the promontory,
3. Tympanic remnants in touch with the ossicular chain (incus and stapes),
4. Erosion of the ossicular chain.

These signs, analyzed adequately from the pathogenesis perspective, culminated in the proposal of a new classification for tympanic membranes.

This chapter aims to help the reader assemble their equipment for assistance or research purposes. It is important to emphasize that, at present, the availability of equipment on the market is endless, making it impossible to determine which system would be the best. The message to be conveyed in the chapter refers to the general lines of assembling a video otoscopy system, as well as some tricks and techniques that we have learned in the last 20 years of experience in our group. The reader should adapt the system to their possibilities and needs.

How to Collect and Store High-Quality Images and Data

The studies mentioned above, like countless others that aim to increase knowledge about pathogenesis and improve the treatment of COM, are possible only through proper compilation and storage of data. Therefore, routine use and the combination of good visualization with storage systems are essential for research. In addition, it ensures the replicability and reliability of data from many patients and different data from the same patient at different moments, which allows for a perspective on the progression of chronic disease.

Technology has added unanimous benefits to the daily care of patients in the otolaryngologist's clinic. High-resolution otoendoscopy and storage systems used initially for research purposes rapidly migrated to our clinics. Today, we can easily and quickly manipulate the middle ear with a microscope and, later, visualize and record the otoendoscopy. In addition, such storage allows for further reanalysis and case discussion with colleagues, which leads to overall improved care.

Table 16.1 Example of the information on the protocol used at the Chronic Otitis Media Outpatient Clinic at Hospital de Clínicas de Porto Alegre

Identification information	Individual record number Patient information (age, race, sex)
Subjective information	Subjective information about the case (chief complaint, chronology, associated symptoms) Standardized scoring tests for hearing loss and tinnitus Medical history (comorbidities, risk factors, past procedures, family history)
Objective information	Physical exam annotations Audiometry test results Detailed description of the tympanic membrane and middle ear

Therefore, in the following pages, we will present the protocol developed in our research group over the last 20 years. We remind you that it is necessary to obtain the Informed Consent Form from the patient (or their guardian) to store and use data from the anamnesis and physical examination.

Anamnesis Protocol

Mainly used for research purposes [1], we will show our group's anamnesis and otoscopy description protocols. Table 16.1 shows the protocol in its current version. In order to avoid mistakes in data transposition, our anamnesis and description protocols have been the same for the last 20 years. We strongly suggest avoiding frequent changes in protocols.

In recent years, the same protocol has been computerized and is currently applied through the RedCap tool. It is a secure web application for building and managing online surveys and databases.

Preparation of the Ears

The first step in recording an adequate otoscopy is, without a doubt, the proper preparation of the ears. The external auditory canal must be thoroughly cleaned, removing accumulated discharge, debris, epithelial desquamation, or any other obstacles to the tympanic membrane. Any crusts adhered to the tympanic membrane or in the attic region must be removed, as they may hide underlying retractions or cholesteatomas. Granulation tissue should also be treated with focal cauterization, antibiotics, and topical corticosteroids, whether it comes from the external auditory canal or the middle ear. Often, proper registration may not be performed on the patient's first visit to the clinic. Sometimes, it is only after proper otological care that a proper diagnosis can be made. Figure 16.1 shows the same ear at three different times.

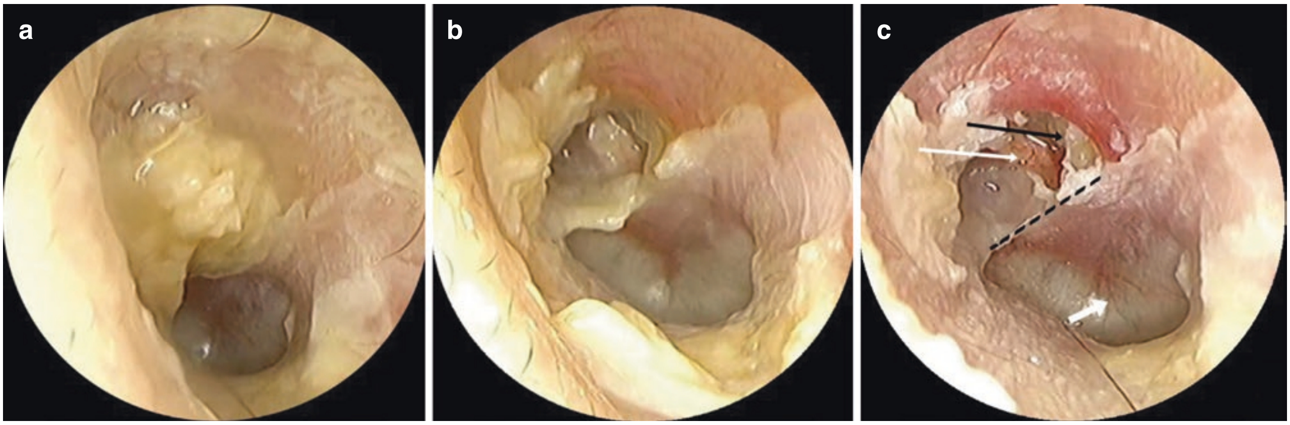

Fig. 16.1 Same ear at different moments. (**a**) At the patient's first visit, otorrhea, and epithelial debris make the diagnosis impossible. (**b**) After proper cleaning, reveal the infected attic cholesteatoma. (**c**) After the use of topical antibiotics and corticosteroids, with improvement in the infection and better definition of the attic cholesteatoma, with blockage of the tympanic diaphragm (dotted line), erosion of the malleus head (long white arrow), epithelial accumulation toward the aditus (long black arrow), and radial hypervascularization suggesting effusion in the mesotympanum (short white arrow)

Fig. 16.2 Examination room with otomicroscopy and otoendoscopy with a recording system. (**a**) View of the dental chair, with a microscope at the top and chairs with backrests on both sides. (**b**) Detail of the aspiration system (black arrow) with pedal actuation on both sides (white arrows) and instruments for otological manipulation also available on both sides

These cleaning and preparative procedures should preferably be performed with a microscope. It is more comfortable for the patient because it allows for better control of instruments since binocular vision provides three-dimensional visualization of the ear. In these cases, an ENT chair or dental chair can be used.

Aspiration must be potent, and the room must allow the physician to perform the procedures with the proper posture without causing discomfort during a whole day of appointments. Figure 16.2 shows the ideal setting idealized by this chapter's authors.

Videoendoscopy System

Image-capturing systems are constantly improving with the technological innovations that are in unceasing development. Therefore, we reiterate that we will present the principles for different video endoscopy systems so that each professional can assemble their own complete system according to their reality, availability, and needs.

The systems are composed of three parts: image acquisition, recording, and storage/editing. A system overview is shown in Fig. 16.3.

The image acquisition components consist of an endoscope, which can be rigid (telescope) or flexible (fiber optic), a camera, a light source, and a monitor. While flexible fiber optics are used more in other areas of otolaryngology, telescopes are the choice for video otoscopy. In our routine, we have three telescope options:

- 0°, 4 mm, and 18 cm are preferred for use as they have a larger image area.
- 0°, 2.7 mm, and 11 cm are preferable for children or patients with a narrow external auditory canal.
- 30°, 2.7 mm, and 11 cm are used in specific situations, such as the analysis of attic retractions or others that require more angulation.

Cameras, previously found only with traditional suppliers and at very high costs, are now popularized and can even be found on traditional shopping websites (eBay and Amazon, among others). Therefore, we strongly recommend at least a full HD resolution. Nevertheless, 4K-resolution systems are more easily found nowadays and provide a great-quality image. Also, we believe that 3D visualization will be available soon at a feasible price for use at medical clinics.

Light sources have also gone through several stages of evolution. Initially, halogen lamps associated with fiber optics granted much better visualization than battery-powered otoscopes or Garcia's mirror with a light source. The evolution of light developed xenon lamps, which were more powerful and had less energy consumption, and LED is currently the preferred technology. The adaptation of LED lamps to medical equipment made much more powerful lighting possible and reduced the light sources' size. Alternatively, we can also find LED sources integrated with micro-camera devices in a single volume. In Fig. 16.4, we demonstrate an example of each of these devices.

The monitor can be specifically built for this purpose, or a regular television monitor with Full HD resolution can be used with good performance. The monitor can also be connected to the physician's computer to demonstrate endoscopy images or procedures.

We must remember that there is no "free lunch." In other words, we should remember that despite the wide variety of camera systems and LED sources, quality may vary a lot between them. The technical specifications provided can often lead us to misassessments in the assembly of the video

Fig. 16.3 Components of a complete video otoendoscopy system

Fig. 16.4 Camera system with integrated LED source in the same volume (black arrow). LED light source (white arrow), with very reduced dimensions compared to those previously built with a halogen or xenon lamp

system. Just as an example, a camera with Full HD resolution (1920 × 1080 pixels) can provide an image with less quality than an HD (1280 × 720 pixels), which has a better-planned construction and higher-quality materials (lenses, conductors). At this point, it should be noted that traditional (and more expensive) brands tend to perform better than emerging brands and have surprisingly lower values, even if the technical specifications are the same. The professional should test the products whenever possible before making their final purchase.

Recording systems consist of image-capturing and recording devices. They are essential for teaching and research purposes but are optional for assistance. A video capture card and recording software are the items needed. The recording card must be compatible with the camera's output format (HDMI standard is the most modern and preferred standard nowadays). The HDMI interface is fully digital and capable of transmitting uncompressed audio and video data, representing an improved alternative to analog. It is still possible to use analogic technology (coax cable, S-Video, and composite video, among others), but these are in disuse and will probably disappear in a few years. The computer interface should preferably be USB to maximize compatibility and avoid data loss or delay.

As for the software used for capture, the options are extensive and very varied. The choice should be made according to the professional's choice and the sophistication required. Our clinic uses very simple and intuitive freeware, reducing the chances of wrong recordings or unintentional data loss.

Once the images are acquired and can be recorded, editing and storage systems are needed for future use of the images. Editing can be done with freeware too, which is usually very simple and intuitive. Most of the time, the physician is alone to record the otoendoscopy, generating unnecessary seconds of recording at the beginning and end of each video. Therefore, editing the video to cut the first and last seconds is necessary. Furthermore, it is also possible to perform cuts and add frames with structure names, captions, and other improvements that are currently available in programs for these purposes. Storage can be performed on physical media (computers, external hard drives, DVDs) or in clouds, the current preferred form. The best options are Google Drive, Dropbox, and YouTube.

Our Ideal System

The ideal system comprises all the requirements above and is shown in Fig. 16.5. A computer used exclusively to aid in video otoscopy seems perfect (regardless of whether it is a notebook, desktop, or all-in-one). Hardware used exclusively for this purpose has a lower chance of delays and crashes.

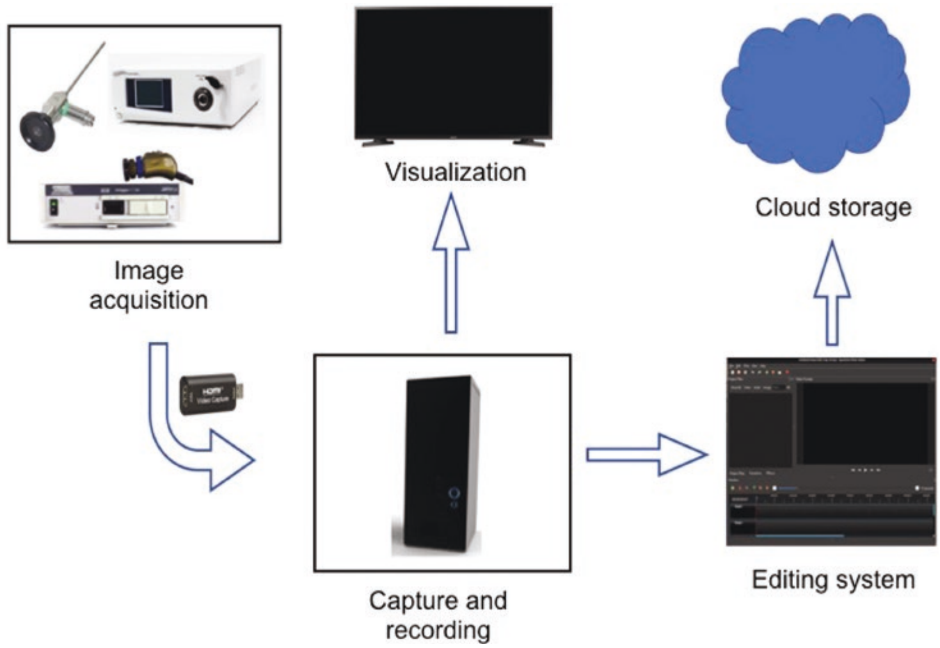

Fig. 16.5 Ideal video system composed of all previous requirements, with a computer used exclusively for this purpose. It consists of a camera for image acquisition, a video capture card, and a computer (with a monitor for visualization and software for editing) connected to cloud storage

Alternative System

Alternatively, the computer already used at the medical office can be the hardware for recording. Everything will depend on the positioning inside the room, and the possibility of using a wireless mouse and keyboard can help at the beginning and end of recordings. It is also possible to duplicate the image, favoring ergonomics in the service room. In this case, we suggest the use of image splitters so that the image does not suffer a delay with the capture before returning to the preview. The alternative system is shown in Fig. 16.6.

Software Tools for Analysis of the Tympanic Membrane

After recording and editing the video otoscopy, the assessment and quantification of tympanic membrane pathologies can either be performed manually by an expert or by specialized software.

Developed in 2006 in a partnership between the Federal Universities of Rio Grande do Sul and Santa Catarina and used for research at the Chronic Otitis Media Outpatient Clinic at Hospital de Clínicas de Porto Alegre, Cyclops Auris Wizard [4] (Fig. 16.7) is a tool used for quantitative analysis of the size and localization of tympanic membrane perforations. The software uses static frames from video otoscopy and provides accurate and reliable analysis using a semi-automated approach. The developers have published a validation study of the method using a subset of 39 cases randomly performed using images generated by experts [4]. Other researchers have used it to successfully correlate tympanic perforation characteristics to hearing loss patterns and to propose a new classification based on pathogenesis.

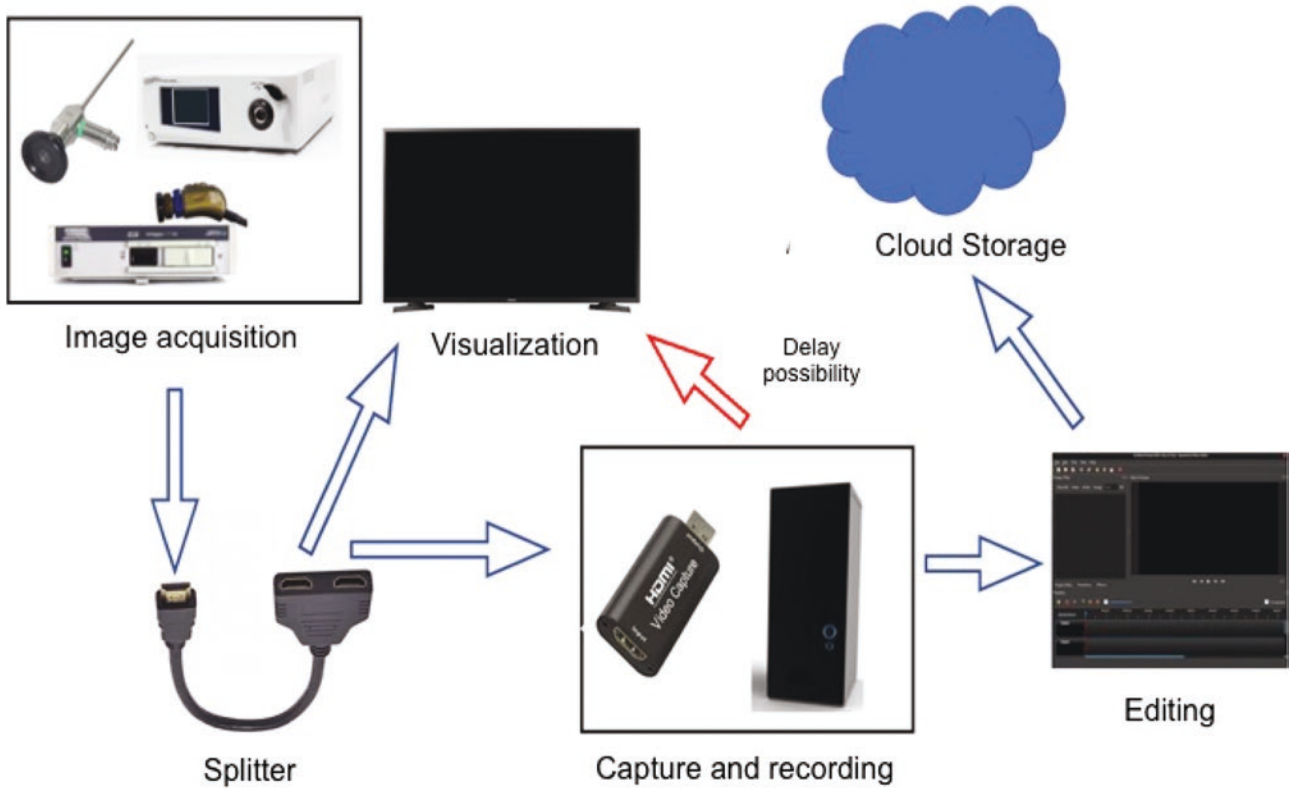

Fig. 16.6 Alternative video system

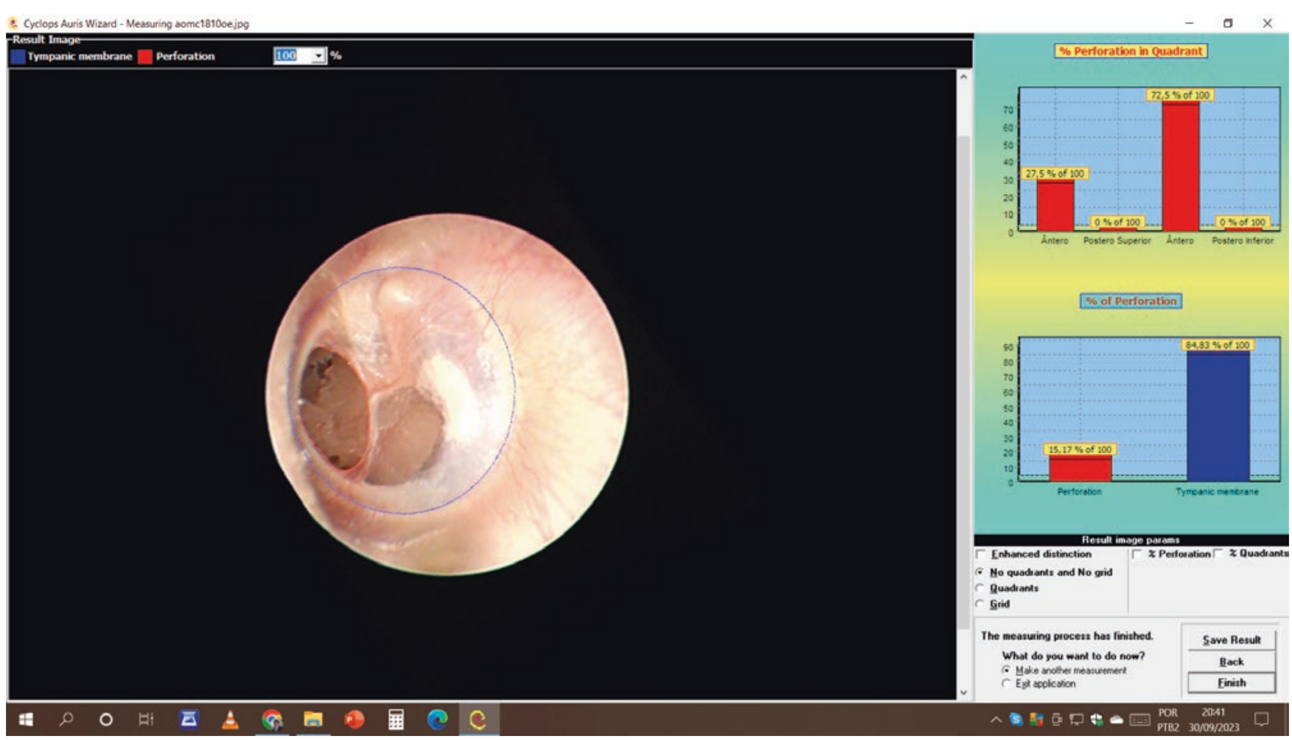

Fig. 16.7 Cyclops Auris Wizard interface

The Challenge of Examining the Tympanic Membrane: Advantages and Disadvantages of the Otoscopes, Microscopes, and Endoscopes

The instruments available today for examining the tympanic membrane are the otoscope, the microscope, and the endoscope. All three fulfill their objectives and should be available in the otologist's examining office. However, each one has particularities, which we will detail below.

The otoscope has evolved a lot in recent decades. Nowadays, long-lasting batteries and LED lamps are considerably improved compared to the first models that had halogen lamps powered by batteries, generating low-intensity lighting. However, perhaps, the main advantage today is its practicality and availability. In a case of less than 20 × 10 cm, we can take it anywhere and perform an excellent otoscopy.

The otoscope can be diagnostic, which only allows visualization, or operating, which also allows manipulation of the ear. It has undoubtedly been the most used instrument over the years. On the other hand, keeping one of the physician's hands occupied can reduce ergonomics and partially impair the ability to manipulate the ear. Also, luminosity is lower than in other devices, and angulation is limited. Finally, recording is impossible with most otoscopes, except for some clinical otoscopes that allow video equipment to be attached.

As described above, microscopes have suffered a significant reduction in size and cost in recent decades. That allowed many otolaryngologists to acquire this instrument for use in the office. Image magnification, with augmentation as much as 5, 10, 16, or 25 times, allows for a much more accurate diagnosis than the otoscope in many situations. Tympanic retractions, for example, can be identified and graded according to their severity with high precision since the binocular view allows for three-dimensional vision.

The microscope facilitates the manipulation of the external and middle ear since it allows amplified visualization of anatomical structures and enhances ergonomics, thus increasing the examiner's dexterity. In other words, in addition to better vision, it adds comfort to the physician and the patient. However, as a disadvantage, we can mention the same lack of angulation presented by the otoscope. When using the ear specula, the angulation is limited by the diameter of the external acoustic meatus and by the patient's discomfort at more accentuated angles. In addition, sometimes, it is impossible to overcome some tortuosity in the meatus (especially in the anterior wall).

Endoscopes are the most recent technology (compared to otoscopes and microscopes), but they have revolutionized ear examinations in the office and surgeries. The small diameter of telescopes (rigid optics) allows an examination of narrow ear canals and a closer vision of the tympanic membrane. This nearer visualization permitted many tympanic membrane perforations to be reclassified and allowed for new theories regarding the pathogenesis of different types of middle ear otitis (as previously discussed). An example can be found in Fig. 16.8.

However, as with any instrument, it also has its liabilities. As it occurs with the otoscope, it also provides two-dimensional vision, even if sometimes we can almost forget that given the quality of the image. Another disadvantage is the higher cost involved in having a complete set of endoscopic image acquisitions. As to manipulation, it has been argued by many experienced otologists that after some time of training, external and even middle ear procedures can be performed with good one-hand dexterity. Table 16.2 summarizes the advantages and disadvantages of each method.

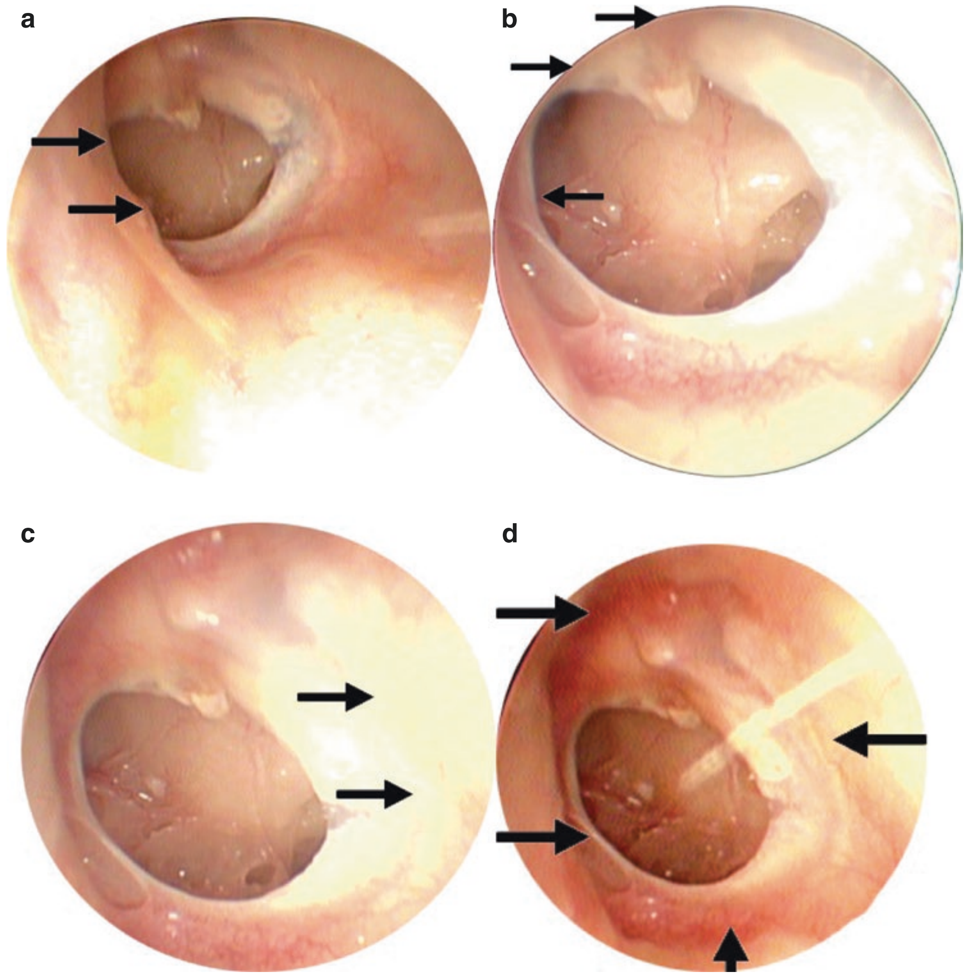

Fig. 16.8 Sequence of images from the same video otoscopy. (**a**) Tortuosity of the external auditory canal does not allow visualization of the anterior region (black arrows). (**b**) Proximity of the endoscope prevents visualization of the entire tympanic membrane on the same screen (black arrows). (**c**) Excessive light impairs the definition of the posterior edges (black arrows). (**d**) All criteria are met: visualization of the whole tympanic membrane and the perforation borders, good visualization of the attic, and adequate light power (black arrows)

Table 16.2 Advantages and disadvantages of each ear examining method

	Otoscope	Microscope	Endoscope
Advantages	• Availability • Quickness • Versatility	• Amplification • Three-dimensional vision • Ergonomics • Better manipulation	• Angulation • Ear canal tortuosity • Different diameters (for narrow ear canal)
Disadvantages	• Little amplification • Limited angulation • Allows for manipulation but with less precision	• More expensive • Limited angulation	• More expensive • Limited manipulation • Two-dimensional vision

Telemedicine Otoscopy: Is it Possible to Make the Diagnosis from a Distance?

Objectively answering the subtitle question: yes, it is possible. Currently, there is excellent availability and variability in image-recording devices, and the exchange of information between physicians is greatly facilitated. In addition to the devices and systems detailed previously in this chapter, we can also record ear examinations with smartphones using portable adapters.

Portable adapters can range from specific models for a particular smartphone to universal models. The adaptation and focus can be adjusted manually, and the device itself performs the recording, facilitating the sharing of images. We reiterate that the patient's consent is necessary for recording and storing the images.

We believe that, regardless of the technology used to acquire otoscopy images, it should be performed by physicians, preferably otolaryngologists, for two main reasons: first, the visualization of the tympanic membrane is not always easily accessible. Due to the presence of earwax, crusts, discharge, or even anatomical variations of the external auditory canal, access to the tympanic membrane can be arduous and require some experience. The second reason is that the manipulation of specific structures that may be present in the external auditory meatus may indicate injuries that should not be manipulated outside the surgical setting. An example is pulsatile aural polyps that can correspond to paragangliomas, highly vascularized lesions.

For now, we are unaware of portable devices that the patient can use to perform remote ENT appointments using telemedicine. Due to the singularities of the otorhinolaryngological examination, which requires specific instruments and adequate lighting, we believe that face-to-face consultations will still be essential in the short and medium term for adequate diagnoses.

However, teleconsultation is just one feature of telemedicine. The possibility of discussing cases among colleagues, remotely evaluating consultancies for other doctors, and even distance teaching has dramatically improved in recent years. All these possibilities for exchanging information and knowledge are of paramount importance for the evolution of otorhinolaryngology, especially because some diseases are more typical of specific populations. The possibility of exchanging knowledge with professionals from various parts of the world brings many benefits, especially for patients.

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