COMPARISON OF THE DIAGNOSTIC ACCURACIES OF FOUR MAIN OTOSCOPIC EXAMINATION METHODS

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ABSTRACT

Objective: Otoscopic examination can be carried out by using four primary methods. These include otoscopic examinations made with head mirror, auriscope, otomicroscope and video-endoscope. We aimed to compare four otoscopic examination methods with respect to their accuracies in the identification of pathologies and normal structures in the external ear canal and tympanic membrane. **Methods:** Our study involved 99 patients and their 151 ears. According to the gold standard parameters, we calculated sensitivity, specificity, positive predictive value, negative predictive value and accuracy of the otoscopic examination methods in determining otoscopic diagnostic parameters. **Results:** in determining 16 main and 77 sub-parameters which were in otoscopic examination form with four different methods, although head mirror method was insufficient in 43.8%, handle otoscopy in 25%, otomicroscopy was in 12.5% of 16 main parameters, otoscopic examination with video-endoscopy was determined all of 16 main parameters. **Conclusion** Our results indicate that otoscopy with video-endoscope is superior to the other three examination modalities on the identification of external ear canal, tympanic membrane and normal or pathologic structures in these locations. Otomicroscopy seems to be the most accurate method after video-endoscopy. Even though auriscope is a better diagnostic tool than a head mirror, it is not enough for recognition of many anatomic structures.

KEYWORDS examination; diagnosis; endoscopy; microscopy; otoscopy

Introduction

Otoscopic examination is one of the core diagnostic measures used in otorhinolaryngology practice. A careful otoscopy can allow the physician to establish the diagnosis accurately in many ear diseases. A thorough otoscopic examination is mandatory for the diagnosis of common ear diseases such as acute otitis media, serous otitis media, and chronic otitis media [1]. The otoscopic examination can be carried out by using four primary methods. These include otoscopic examinations made with head mirror, auriscope, otomicroscope and video-endoscope. Head mirror and auriscope are more frequently used than otomicroscope and video-endoscope in routine daily practice [2,3].

This study aimed to compare these four otoscopic examination methods on their accuracies in the identification of pathologies and normal structures in the external ear canal and tympanic membrane. Unfortunately, all of these examination modalities cannot be administered in every patient suffering from an ear complaint. We hope to demonstrate the advantages and superiorities of each examination method and to guide the selection of the appropriate examination method for various conditions for establishing the diagnosis accurately.

Materils and methods

This study was performed on a total of 151 ears of 99 patients (60 females, 39 males). Both ears of 52 cases were included, whereas only one ear could be taken into account in 47 patients due to

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the impacted cerumen in the contralateral ear. Both normal or pathological findings were encountered in otoscopy. The study was approved by the ethics committee of the institution. Written informed consent was obtained from each patient.

Cases were evaluated in our University Faculty of Medicine Department of Otorhinolaryngology, where training of residents takes five years. Physical examination of patients was performed randomly by eight residents with an experience of 2-4 years in otorhinolaryngology practice. Physicians were informed in detail about the steps to be fulfilled during the examination. The ears were assessed by the same physician using a head mirror, otoscope, otomicroscope and video-endoscope, respectively. Initially, the examination started with head mirror and otoscope since these methods necessitated the least number of equipment. Afterwards, otomicroscope and video-endoscope were used for the same purpose. Therefore, we reduced the risk effect of following examination method. At the end of each examination step, "otoscopic examination assessment questionnaire" was filled in by the physician. Hence, four questionnaires have been filled for every patient, and each survey consisted of 16 main parameters together with 77 subsidiary parameters.

Firstly, the resident doctor made an otoscopic examination to the patient with head mirror (Aesculap AC 421, Tuttlingen, Germany). It was chosen the biggest appropriate ear speculum for this examination. The light source was on the right side of the patient, the left side of a physician. The level of height from floor to ear of the patient and the level of height from floor to eyes of the physician were the same. The head mirror that was placed in the centre of the head of the physician was 30 cm far from the ear of the patient.

After otoscopic examination had been made to the patient with head mirror, the same patient was made an otoscopic examination with handle otoscope (Riester, Tuttlingen, Germany) by the same doctor. The size of the speculum of handle otoscope was adjustable, and physician chose the biggest appropriate speculum. While otoscopic examination, the image was made larger through the rotatable magnifying glass that was in front of the handle otoscope.

Then, the otoscopic examination was made with otomicroscopy (Carl Zeiss S 30 U/G 100-200 V 50/60 Hz, Weimar, Germany) to the same patient using a biggest appropriate speculum to the external ear canal. Otomicroscopy had 5 level enlargement feature, and the third level was usually used for this because of decreasing the image definition while using a bigger level.

There was video camera (Karl Storz telecam-C 20212034 Pal 30 mm, Tuttlingen, Germany), a rigid endoscope (Karl Storz Hopkins 7200 A 4 mm, Tuttlingen, Germany), cold light source, image screen and a computer that could transfer and record images on the left side of the patient. The 0-degree rigid endoscope was inserted without touching the surround of the external ear canal.

Otoscopic examination views and videoendoscopic records were taken during the study were evaluated by a professor experienced in otology, and this interpretation was accepted as gold standard. Data derived form questionnaires and gold standards were compared regarding sensitivity, specificity, negative and positive predictive values and overall accuracy rates. The diagnostic accuracy of a method becomes more precise as sensitivity, specificity, negative and positive predictive value and overall accuracy rate becomes closer to 1 [4]. The lower limit of sensitivity, specificity, negative and positive predictive value was set at 0.70; while it was 0.90 for overall accuracy rate [5,6].

Findings derived from otoscopy were grouped as basic (n:14) and detailed (n:12) parameters. Basic parameters consisted of findings frequently seen in routine daily practice that necessitate less experience, whereas specific parameters were those that required a more substantial experience (Table1).

Statistical analysis was performed using STATISTICA AXA 7.1 for Windows (StatSoft Inc., Tulsa, OK, USA). Chi-square test, McNemar test and Kappa analysis were utilised for assessment of parameters under investigation. The level of statistical significance was $p<0.05$ for 2X2 tables, while for 3X3 or 4X4 tables, Kappa value >0.70 in conjunction with a p-value <0.05 were required for statistical significance.

Results

In our study it was seen in otoscopic examination that 57 of 151 ears (37.7%) had perforation in tympanic membrane (Figure 1), 7 of them (4.6%) granulation, 44 of them (29.1%) myringa sclerosis, 8 of them (5.3%) air fluid level behind tympanic membrane, 26 of them (17.2%) erosion of external ear canal wall, 28 of them (18.5%) secretion. It was stated that 5 of the ears (17.8%) in which this secretion was seen had serous, 1 of them (3.6%) had mucous, 22 of them (78.6%) had purulent (Figure 2). It was stated that 72 of 151 (47.7%) the colour of tympanic membrane was normal, 13 of them (8.6%) was pink, 7 of them (4.6%) was hyperemic and 59 of them (39.1%) was matt (Figure 3). In 92 of 151 ears (60.9%), there was no triangle of Politzer in the tympanic membrane. In 47 of them (31.1%) there was a triangle of Politzer in it. It was irregular in 12 of them (7.9%). 86 of 151 ears (56.9%) there was retraction pocket in the tympanic membrane. 13 of 151 ears (8.6%) there was cholesteatoma in the tympanic membrane (Figure 4). 11 of the 13 ears in which cholesteatoma was found were in the attic region, 1 of them (7.7%) was in sinus tympani, 1 of them (7.7%) was in pars tensa (Figure 5). In 14 of 151 ears (9.3%) chorda tympani, 144 of them (95.4%) annulus tympanicus, 147 of them (97.4%) manubrium, 63 of them (41.7%) incus, 38 of them (25.2%) stapes, 10 of them (6.6%) stapedial tendon, 38 of them (25.2%) orifice of Eustachian tube, 72 of them (47.7%) promontorium tympani, 4 of them (2.6%) oval window, 26 of them (17.2%) round window, 5 of them (3.3%) posterior crus of stapes as anatomical structures were seen in otoscopic examination (Figure 6). Comparison of primary and subsidiary parameters to the gold standard is shown in Table 2. The rate of insufficiency of otoscopic examination methods for diagnosis of main parameters accurately is provided in figure 7. The rate of insufficiency of otoscopic examination methods for diagnosis of subsidiary parameters correctly is provided in figure 8.

FIGURES

Comparison of four examination methods to the gold standard on their accuracy in diagnosing particular parameters is shown in Table 3.

Examination with head mirror yielded different results with the gold standard in 8/12 parameters (66.7%) while examination with auriscope displayed the difference in 7/12 parameters (58.3%). Otomicroscopy revealed a difference in 5 parameters (41.7%), whereas video-endoscopy was different from the gold standard in only one parameter (determination of incus) (8.3%). Comparison of 4 examination methods to the gold standard on their accuracy in diagnosing detailed parameters is shown in Table 4.

Table 1 Findings derived from otoscopy were grouped as basic (n:14) and detailed (n:12) parameters.

Basic parameters (n:14)		**Detailed parameters (n:12)**	
perforation	cerumen	middle ear mucosa	granulation
secretion	type of secretion	retraction pocket	myringa sclerosis
the colour of the tympanic membrane	Politzer triangle	chorda tympani	incus
cholesteatoma	air-fluid level	stapes	stapes tendon
bulging of the tympanic membrane	promontorium	posterior crus of stapes	Eustachian tube
Valsalva maneuver	Toynbee maneuver	tympanic orifice	oval and round windows
manubrium	annulus		

Table 2 Comparison of main and subsidiary parameters to the gold standard.

	Number and percent of undiagnosed main parameters		**Number and percent of undiagnosed subsidiary parameters**
	np*	**np****	**np***
Head mirror	7(43.8%)	7(43.8%)	20(25.9%)
Auriscope	4(25%)	5(31.3%)	13(17%)
Otomicroscope	2(12.5%)	0 (0%)	9(11.6%)
Video-endoscope	0 (0%)	0 (0%)	1(1.3%)
*: Chi-square test, number of parameters that yield p<0.05 when compared to the gold standard			
**: Number of patients with an overall accuracy rate <0.90			

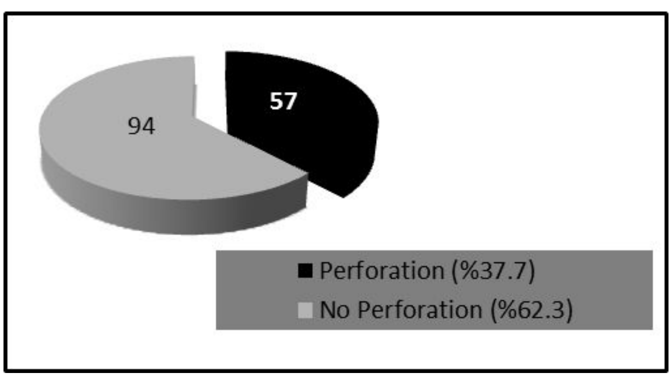

Figure 1: Statement of perforation in tympanic membrane n=151

Discussion:

Otoscopic examination constitutes one of the most important steps in the diagnosis of ear diseases. A meticulous otoscopy may be sufficient for recognition and diagnosis of many ear diseases. However, narrow anatomic structure, microanatomy and challenges in the examination of cavities may mandate illumination and magnification of external ear and middle ear structures (tympanic membrane, middle ear structures in case of tympanic membrane perforation). Otoscopic examination is one of the main components of otorhinolaryngologic examination and it can be carried out by four methods [1]. In the present study, ears were evaluated via the head mirror, auriscope, otomicroscope and video-endoscope, respectively. Therefore, we had started our examination with the most simple method and ended up with the most sophisticated measure. We hope that this sequential design will not cause a problem for interpretation of our results.

To the best of our knowledge, there is no similar study that compares four otoscopic examination methods in the medical literature (Medline, Web of Science). Hence, the current study may be the first trial carried out on this topic. Due to the uniqueness of this study, we did not have a chance to compare our results to that of another trial. In general otorhinolaryngologic examination, head mirror or auriscope may be as sufficient as otomicroscope or video-endoscope for identification of a healthy ear. Our results have shown that video-endoscopy is superior

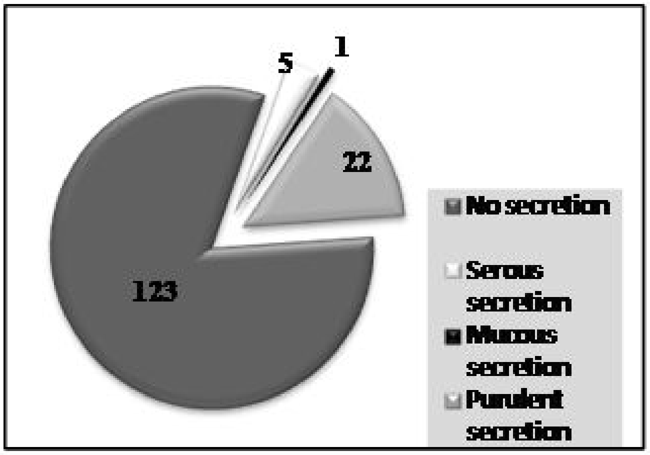

Figure 2: Statement of secretion in otoscopic examination n=151

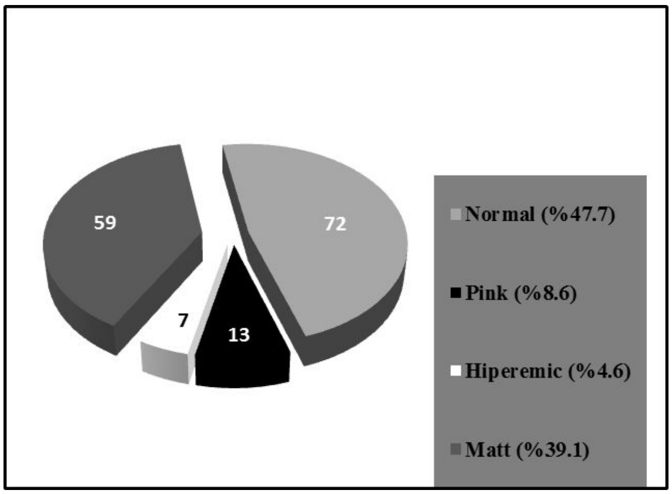

Figure 3: The colour of tympanic membrane n=151

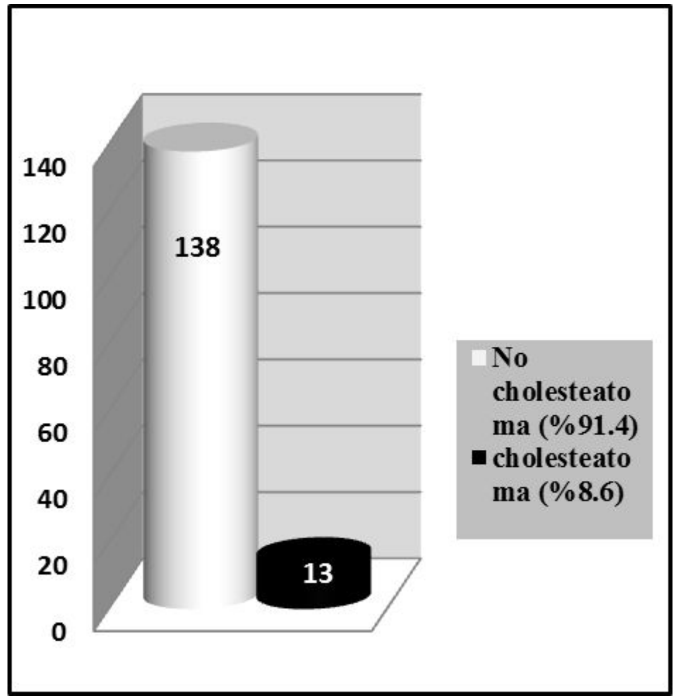

Figure 4: Statement of cholesteatoma n=151

to other examination methods, but it must be noted that these examination methods are complementary to each other. This hypothesis is supported by the high specificities of 4 examination methods detected in our study. Interestingly, video-endoscopy had a high positive predictive value close to gold standard for determination of pathologic findings that constitute the majority of main parameters. In spite of having a lower accuracy, otomiscroscopy was also able to determine many parameters. Nevertheless, it may fail to identify especially deeper structures and retraction pockets. Recent advances have provided development of otologic microscopes that enable a deeper and sharper vision. If we had a facility to use such microscopes, limitations for determination of some parameters might be probably eliminated. Remarkably, the vision may be restricted by the speculum and width of the external ear and video-endoscopy is devoid of such a restriction.

Even though head mirror and auriscope are commonly used otoscopic examination methods, they may fail to demonstrate details and may, therefore, lead to misdiagnosis in some circumstances. Illumination and magnification of external and middle ear may be compulsory owing to the narrow anatomic structure, microanatomy and challenges in the examination of the cavity. Advances in video optic technology have produced video-endoscope, and otoscopic assessment of tympanic membrane with video-endoscope have improved the diagnostic accuracy[2].

Otoscopy with video-endoscope is useful for documentation of anatomy and pathology in the external ear canal and tympanic membrane as well as facilitation of learning and improvement of skills[1,3]. Visual records obtained with otomicrsocope only include certain zones due to the limitation by the size of the speculum. Since ear speculum may not pass from the most narrow portion of the external ear canal and there may be a long distance between the lens of the microscope and ear speculum, tympanic membrane may not be visualised entirely. This problem becomes more obvious in children attributed to their narrower ear canal and difficulty of cooperation. The primary advantage offered by video-endoscope is a visualisation of the tympanic membrane completely including the whole annular ligament [1]. Moreover, video-endoscope permits the demonstration of the tympanic membrane to the patients and accompanying people. Thereby, the treatment plan can be explained more clearly, and documentation of pathology can be made for medicolegal issues. Also, otoscopy with video-endoscopy can be used to evaluate the assessment of mastoidectomy cavity both preoperatively and postoperatively[1].

Recent studies have documented some missing points in paediatrics residency and otorhinolaryngology practice [7-9]. Traditionally, otoscopic skills improve with repetitive practice under the supervision of experienced staff [10]. New educational researchers have developed new modalities that rely on integrated video records or images of tympanic membrane [11-14]. Learning otoscopic examination depends on multiple practices, and this can be made in conjunction with observation of otologic images in textbooks. Unfortunately, this approach has provided a limited improvement in diagnostic skills. Viewing the tympanic membrane by placing the endoscope into the ear canal may permit assessment of these images by experienced otologists during or after the examination [11].

Most important aspect in the treatment of cholesteatoma is

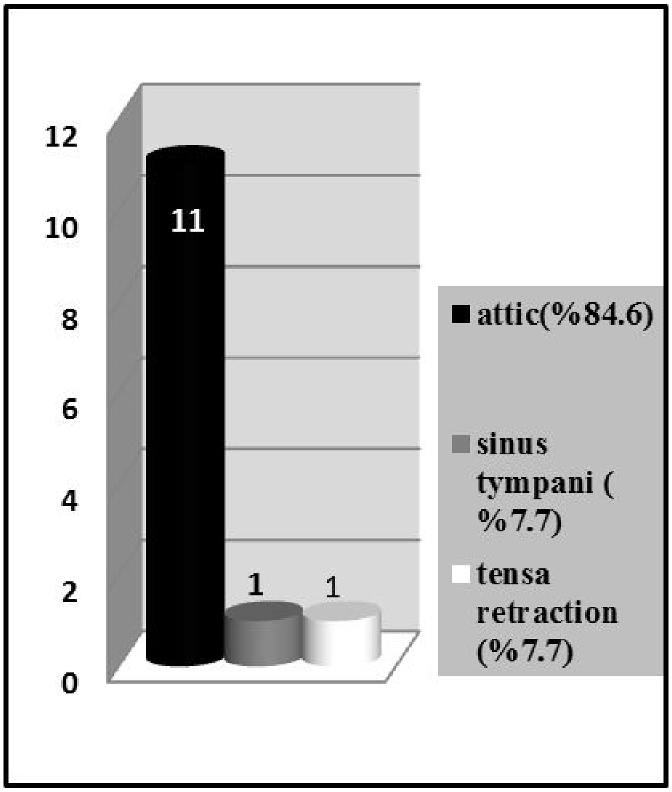

Figure 5: Region of cholesteatoma n=13

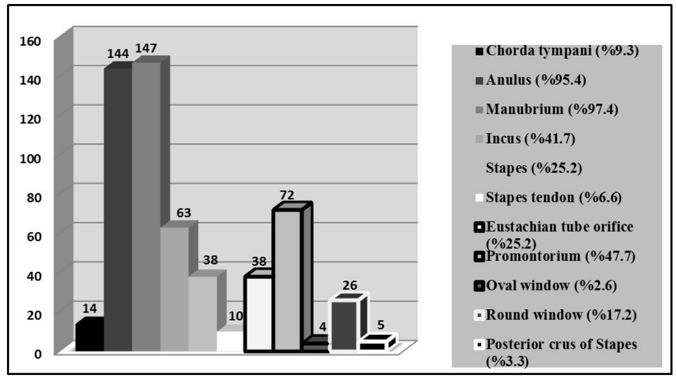

Figure 6: Anatomical structures were seen in otoscopic examination n=151

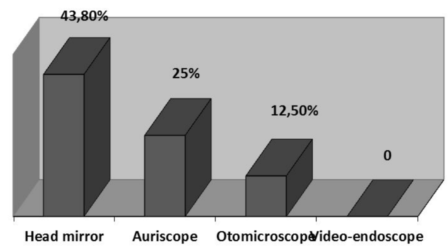

Figure 7: Rate of insufficiency of otoscopic examination methods for diagnosis of main parameters accurately p<0.05

protection. Early recognition of retraction pockets that may lead to cholesteatoma due to disturbance of epithelial migration is crucial. Head mirror and auriscope may not be enough for diagnosing retraction pockets. The otomicroscopic examination may have limitations attributed to the visual angle, quality of microscope and experience of a physician [15]. In contrast, otoscopic examination with video-endoscope allows early detection of deep retraction pockets and pre-cholesteatoma.

Chronic otitis media is a condition that should be diagnosed both by general practitioners or otologists [11]. Tympanic membrane undergoes many pathological alterations such as retraction, atelectasis, tympano sclerosis and fibrosis [15-18]. Head mirror was found to be insufficient for detection of cholesteatoma, while the other three methods were capable of ruling in cholesteatoma. Out of 13 cholesteatoma cases, only 23% could be diagnosed with head mirror, and 46.1% could be detected with auriscope. In contrary, 100% of cholesteatomas have been determined by otomicroscope and video-endoscope.

Otomicroscope and video-endoscope have substantially facilitated middle ear surgery. Without these instruments, a safe middle ear surgery cannot be carried out. Usually, middle ear surgery is performed with otomicroscope, and preoperative controls are made with video-endoscope especially in cholesteatoma surgery [19]. Crusts or cerumen in the external ear canal may interfere with the otoscopic examination. In such circumstances, the otomicroscopic examination is superior to other modes of investigation since cleaning and interventions on the external ear canal can be performed safely. For instance, an attic cholesteatoma located behind a cerumen or crust may remain undiagnosed especially if it is asymptomatic. Even though it constitutes a minor portion of the tympanic membrane, pars flaccida must be evaluated completely and carefully [15].

The video-assisted endoscopy is a useful method that increases diagnostic accuracy in otoscopy [3]. Three ways can record images of tympanic membrane: camera linked otomicroscope, oto-endoscopic system and videoendoscopic system [20]. Otoscopic examination with video-endoscope can be used by otorhinolaryngologists, audiologists, otitis researchers and veterinarians [2,21,22]. Video-endoscope linked otoscopy system allows demonstration of video images of the tympanic membrane to patients, their families, physicians, and students [23].

Video-endoscopy possesses some disadvantages. The tip of the endoscope can be foggy during the examination, and this problem can be eliminated by application of an anti-fog solution or alcohol to the tip of the endoscope. Cleaning the cerumen or crusts may be required, and undesired head movements of the patient may result in external ear canal injury by the endoscope. Selection of an appropriate probe for ear canal and setting a good communication with the patient may aid in overcoming this problem. Focussing the view of the endoscope may be difficult especially when the endoscope is in the external ear canal. Automatic focus adjustment with a suitable attachment can be used for facilitation of focusing. Otoscopy with an endoscope may be difficult in patients with narrow external ear canals. In these patients, fine tip endoscopes may be used to get rid of this problem [1]. In the current study, we experienced some of these problems as well, but it must be noted that some simple precautions could be taken for avoidance. We used an anti-fog solution for obtaining a clear view and patients were instructed not to move their heads suddenly and to inform the physician in case of pain during the examination. We made the adjustment for focussing before placement of the endoscope in the ear canal. Therefore, we did not come across any problem in focusing. Analyses were carried out by relatively experienced residents. However, it might be more efficient if all examinations could be executed by the otorhinolaryngology staff [24].

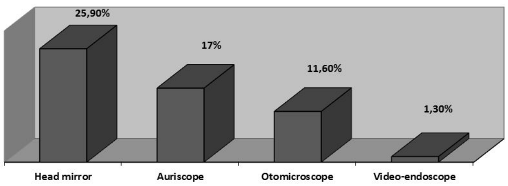

Figure 8: Rate of insufficiency of otoscopic examination methods for diagnosis of subsidiary parameters accurately p<0.05

Table 3 Comparison of diagnostic accuracies of four otoscopic examination methods to the gold standard regarding basic parameters (n=14).

n=14	p*	D	S	PPV	NPV	OAR
Head mirror	10	8	0	3	5	8
Auriscope	6	6	0	1	3	5
Otomicroscope	4	0	0	0	1	1
Video-endoscope	0	0	0	0	0	0

*: Chi-square test, p<0.05, D: sensitivity <0.70;
S: Specificity <0.70,
PPV: Positive predictive value, <0.70,
NPV: Negative predictive value,<0.70;
OAR: Overall accuracy rate, <0.90.

Although we accept our weakness that the data are from 8 years ago, and the technical and electronic progress in video (from analogue to digital, from 1-chip camera to 3-chip, better software, powerful computers) and the many new brands in this field, there is not any written study like this in the literature.

Conclusion

Our results indicate that otoscopy with video-endoscope is superior to the other three examination modalities on the identification of external ear canal, tympanic membrane and normal or pathologic structures in these locations. Otomicroscopy seems to be the most accurate method after video-endoscopy. Even though auriscope is a better diagnostic tool than a head mirror, it is not enough for recognition of many anatomic structures. The least capable diagnostic measure is head mirror method. Otomicroscopy and otoendoscopic examination must be performed for confirming the diagnoses of cholesteatoma and retraction pockets by colleagues that use the head mirror in routine practice.

Informed Consent:

Written informed consent was obtained from the patient who participated in this study.

Conflict of Interest:

The authors declared no conflict of interest.

Financial Disclosure:

The authors declared that this study has received no financial support.

Table 4 Comparison of 4 examination methods to the gold standard on their accuracy in diagnosing detailed parameters (n=12).

n=12	p*	D	S	PPV	NPV	OAR
Head mirror	8	10	0	7	3	8
Auriscope	7	9	0	5	2	8
Otomicroscope	5	4	0	1	0	8
Video-endoscope	1	0	0	0	0	0

*: Chi-square test, p<0.05, D: sensitivity <0.70;
S: Specificity <0.70,
PPV: Positive predictive value, <0.70,
NPV: Negative predictive value,<0.70;
OAR: Overall accuracy rate, <0.90.

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