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Original Article

Cost-effectiveness analysis of endoscopic tympanoplasty versus microscopic tympanoplasty for chronic otitis media in Taiwan

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Abstract

Background: Health care systems and physicians need to conform to budgets and streamline resources to provide cost-effective quality care. Although endoscopic tympanoplasty (ET) has been performed for decades, no studies on the cost-effectiveness of ET and microscopic tympanoplasty (MT) for treating chronic otitis media have been published. The present study aimed to compare the cost-effectiveness of ET and MT for treating chronic otitis media.

Methods: This study was performed using a Cohort-style Markov decision-tree economic model with a 30-year time horizon. The economic perspective was that of a third-party payer (Taiwan National Health Insurance System). Two treatment strategies were compared, namely ET and MT. The primary outcome was the incremental cost per quality-adjusted life year (QALY). Probabilities were obtained from meta-analyses. Costs were obtained from the published literature and Taiwan National Health Insurance System database. Multiple sensitivity analyses were performed to account for data uncertainty.

Results: The reference case revealed that the total cost of ET was $NT 20,901 for 17.08 QALY per patient. By contrast, the total cost of MT was $NT 21,171 for 17.15 QALY per patient. The incremental cost effectiveness ratio for ET versus that of MT was $NT 3703 per QALY. The cost-effectiveness acceptability curve indicated that ET was comparable to MT at a willingness-to-pay threshold of larger than $NT 35,000 per QALY.

Conclusion: This cost-effectiveness analysis indicates that ET is comparable to MT for treating chronic otitis media in Taiwan. This result provides the latest information for physicians, the government, and third-party payers to select proper clinical practice.

Keywords: Chronic otitis media; Cost effectiveness; Endoscopy; Microscopy; Tympanoplasty

1. Introduction

Since the 1950s, microscopic tympanoplasty (MT), which can be performed through postauricular, endaural, and transcanal approaches, has been the standard surgery for repairing perforated tympanic membranes.[1–5] Postauricular incision enhances the visibility of the operative site, whereas the transcanal approach is reserved for patients with small tympanic perforations and wide ear canals.[3] Therefore, MT through the postauricular approach is preferred globally.[3–5] Despite having a high graft take rate (>90%), this technique frequently necessitates shaving, deep postauricular incision, and general anesthesia.[3–6]

Endoscopic tympanoplasty (ET) has been increasingly practiced since the late 1990s.[7–14] The major difference between MT and ET is the surgical view. The view during microscopic surgery is defined and limited by the narrowest segment of the ear canal, whereas transcanal endoscopy bypasses the narrowest ear canal

Conflicts of interest: The authors declare that they have no conflicts of interest related to the subject matter or materials discussed in this article.

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and provides a wider view, even when a 0-degree endoscope is used.[8,9] Therefore, ET does not require canalplasty, postauricular incision, and general anesthesia; thus, it is less invasive than MT.[7–14]

In recent years, health care systems need to conform to budgets and streamline resources to provide cost-effective quality care. Because of this budgetary limitation, physicians must understand the underlying expense associated with their medical service and select the most cost-effective treatments. Hence, a decision-analytic model that incorporates costs and outcomes can be used to analyze this medical question from a socioeconomic perspective.[15]

Although ET has been performed for decades, no studies on the cost-effectiveness of ET and MT have been published. Therefore, this study evaluated the cost-effectiveness of ET and MT for treating chronic otitis media. The results of this study provide objective evidence that enable decision makers to judiciously allocate medical resources.

2. Methods

2.1. Economic model

The economic perspective of this evaluation was that of the Taiwan National Health Insurance (NHI) System. The primary outcomes were incremental cost-effectiveness ratios (ICERs). The ICER is commonly used in equations in health economics to provide vital information for decision makers to allocate resources. It is the ratio of the change in costs to the change in effectiveness between the two strategies: (cost of strategy A − cost of strategy B/effectiveness of strategy A − effectiveness of strategy B). Therefore, the ICER provides the additional cost associated with the additional benefit of the new intervention being evaluated.[15] We followed the guidelines of the Consolidated Health Economic Reporting Standards (CHEERS) statement established in 2013.[16,17]

This study contained only data from the published literature, and no patient data were used; therefore, institutional review board and ethics committee approval was not required.

2.2. Patient population

We assumed a hypothetical cohort of 1000 patients undergoing operations for treating simple chronic otitis media in hospitals in Taiwan in 2016. The definition of simple chronic otitis media was tympanic perforations without ossicular chain disease and cholesteatoma.

In this model (Fig. 1), patients with simple chronic otitis media received two comparative treatments, either ET or MT. Based on our previous study, ET was performed through a transcanal approach and under local anesthesia and intravenous sedation.[14] MT was performed using a postauricular approach and under general anesthesia, according to a study by Wang et al.[18–20] If the operations (ET or MT) were successful, the patients would achieve the status of patients with cured chronic otitis media. If the operations failed, the patients would either undergo reoperation or continue to have the status of patients with chronic otitis media. For patients receiving reoperations, if the reoperations were successful, the patients would achieve the status of patients with cured chronic otitis media. If the reoperations failed, the patients would continue to have the status of patients with chronic otitis media.

After completing the decision tree, the data of the patients was entered into the Markov model. The cycle duration was defined as 1 year. Based on Taiwan life expectancy statistics and assuming an average age of 50 years for patients with chronic otitis media, this Markov model was run for 30 cycles to reach an average age of 80 years.[14,21] We assumed that

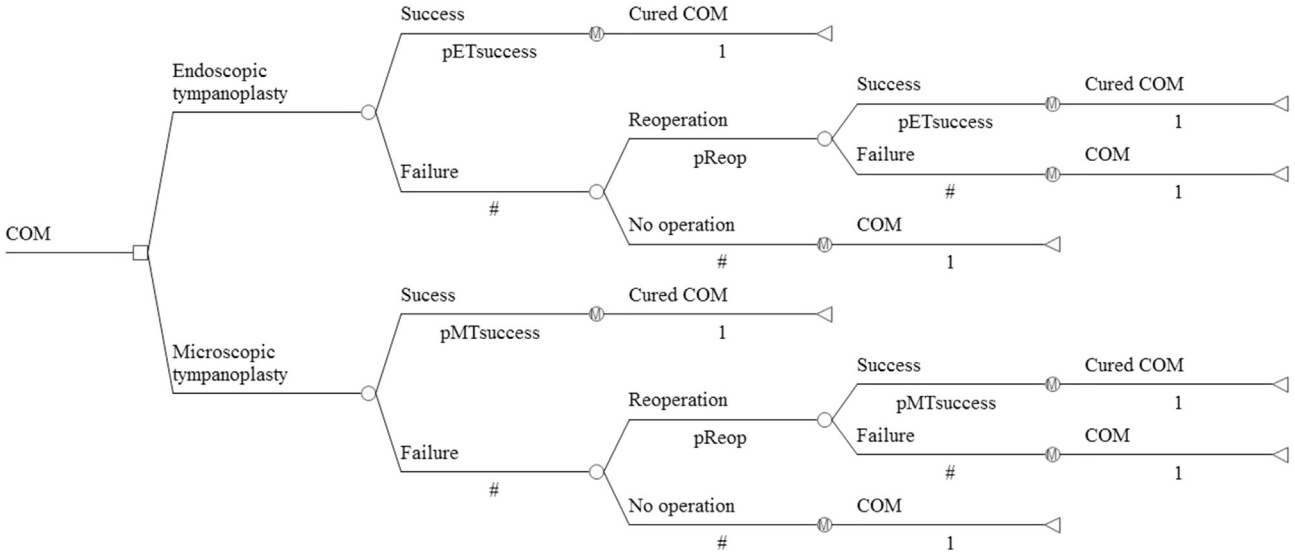

Fig. 1. Decision tree and Markov cycle for patients with simple chronic otitis media undergoing endoscopic tympanoplasty or microscopic tympanoplasty (COM: chronic otitis media).

"with cured chronic otitis media" and "with chronic otitis media" were stable conditions. Therefore, patients with chronic otitis media and patients with cured chronic otitis media would remain in the same status for the next Markov cycle, respectively.

2.3. Probabilities

Model probabilities were acquired from the highest quality evidence (systematic reviews and meta-analyses) or relevant studies for comparing ET and MT. Based on a systematic review and meta-analysis, the mean success rates of ET and MT were 85.1% (3.1%) [mean (standard error, SE)] and 86.4% (SE, 3.0%), respectively (Table 1).[22] We assumed that the probability of reoperation was 33% (SE, 3.0%) (Table 1), according to the study by Wang et al.[18–20]

2.4. Effectiveness: utility values

The primary effectiveness outcome was the quality adjusted life year (QALY). QALYs were derived by multiplying the life expectancy by the utility.

The health state utility for this economic evaluation was obtained from the study by Wang et al. The authors estimated the health state utility using the validated Chinese version of the Chronic Ear Survey.[18] The Chronic Ear Survey is a statistically validated chronic ear-specific outcome measurement method, developed by the Massachusetts Eye and Ear Infirmary.[23] This is a 13-item Likert scale survey that uses three subscales. The activity restriction subscale examines the effect of chronic otitis media on a patient's daily life. The symptom subscale examines the presence of symptoms such as hearing impairment and drainage. The medical resource utilization subscale reviews the use of medications and office visits. According to previous studies, the average utility score for patients with chronic otitis media was 0.522 (SE, 0.178) and that for patients with cured chronic otitis media was 0.885 (SE, 0.20) (Table 1).[19,20]

2.5. Costs

In the decision tree, we calculated the primary costs of ET and MT for 1 year. The monetary unit was New Taiwan (NT) dollars; the average exchange rate with United State dollars was approximately 31.1 in 2016. Only direct costs were considered. The cost of ET included the following: admission operation cost, postoperative 1-year outpatient service cost, and reoperation cost. The frequency of postoperative office visits and duration of medication were retrospectively obtained from our medical records and previous studies (Table 2).[14] The cost of MT included admission operation cost, postoperative 1-year outpatient service costs, and readmission cost (Table 2).[20] In the Markov cycles, we calculated the cumulative cost of follow-up visits (ET and MT) for 30 years.

2.6. Sensitivity analysis

Multiple forms of sensitivity analysis were performed to account for inherent data uncertainty, including two probabilistic sensitivity analyses.

2.7. Probabilistic sensitivity analyses

Two probabilistic sensitivity analyses using a Monte Carlo simulation with 1000 scenarios were performed. These results were presented as a cost-effective acceptability curve (CEAC) and ICER scatterplot.[15,24,25] The CEAC is used to graphically represent the uncertainty in an economic evaluation.[24,25] It is a crucial outcome for decision makers because it provides the degree of certainty in an economic conclusion at several willingness-to-pay (WTP) thresholds.

The ICER scatterplot is a technique used to visually represent the cost-effectiveness of all the different ICERs generated from the iterations of the probabilistic sensitivity analysis.[15,25] The ICERs are plotted on the cost-effective plane, which is divided into four quadrants.[15,25] The ICERs in quadrant II are both cheaper and more effective; thus, they represent the most dominant intervention. By contrast, the ICERs in quadrant IV are more expensive and less effective; thus, they are considered "dominated" and are typically rejected. Decisions to accept the alternative interventions in quadrants I and III depend on the maximum ICER that decision makers are willing to accept.[15,25]

2.8. Discounting

The discount rate was 3% per year for both cost and effectiveness.

Table 1
Input probabilities used in the decision tree model.

Variable	Description	Mean	Standard error	Reference
pETsuccess	Probability of success of endoscopic tympanoplasty	85.1%	3.1%	Tseng et al.[14]
pMTsuccess	Probability of success of microscopic tympanoplasty	86.4%	3.0%	Tseng et al.[14]
pETcost	Probability of primary cost for endoscopic tympanoplasty	16052	4087	Medical records, NHI
pMTcost	Probability of primary cost for microscopic tympanoplasty	16462	4087	Wang et al.,[20] NHI
pETreopcost	Probability of cost for reoperation of endoscopic tympanoplasty	32104	5780	Medical records, NHI
pMTreopcost	Probability of cost for reoperation of microscopic tympanoplasty	32924	5780	Wang et al[20] NHI
pReop	Probability of reoperation	33%	3%	Wang et al.[20]
pUcuredCOM	Probability of utility for patients with cured chronic otitis media	0.885	0.200	Wang et al.[20]
pUCOM	Probability of utility for patients with chronic otitis media	0.522	0.178	Wang et al.[20]

ET, endoscopic tympanoplasty; MT, microscopic tympanoplasty; NHI, Taiwan National Health Insurance.

Table 2
Average cost per procedure and total cost.

	Average cost per procedure ($NT)	Number of procedures (SE)	Total cost per patient ($NT)
Cost of endoscopic tympanoplasty			
Admission operation fee	12,320	4087	12,320
Outpatient antibiotics	50/week	2.40 (1.63)	120
Outpatient ear drop	150/bottle	1.80 (1.32)	270
Outpatient physician fee	213/visit	6.92 (2.31)	1474
Outpatient registration fee	150/visit	6.92 (2.31)	1038
Outpatient local treatment fee	120/visit	6.92 (2.31)	830
Postoperative audiometry	984	3	2952
Primary cost of endoscopic tympanoplasty	16,052	4087	16,052
Cost of endoscopic tympanoplasty for reoperation	32,104	5780	32,104
Cost of microscopic tympanoplasty			
Admission operation fee	12,320	4087	12,320
Outpatient antibiotics	50/week	3.50 (1.98)	175
Outpatient ear drop	150/bottle	1.20 (1.24)	180
Outpatient physician fee	213/visit	7.84 (3.28)	1670
Outpatient registration fee	150/visit	7.84 (3.28)	1176
Outpatient local treatment fee	120/visit	7.84 (3.28)	941
Postoperative audiometry	984	3	2952
Primary cost of microscopic tympanoplasty	16,462	4087	16,462
Cost of microscopic tympanoplasty for reoperation	32,924	5780	32,924
Cost of follow-up visits			
Annuanl cost of patients with cured chronic otitis media	483	10	4830
Annuanl cost of patients with chronic otitis media	633	30	18,990

$ NT, New Taiwan dollar; SE, standard error.

2.9. Statistics

The cost-effectiveness analysis was performed using the TreeAge Pro Healthcare Module 2016 software (TreeAge Software, Inc., Williamstown, MA).

3. Results

3.1. Reference case

With a time horizon of 30 years, the total cost of ET was $NT 20,901 for 17.08 QALY per patient. By contrast, the total cost of MT was $NT 21,171 for 17.15 QALY per patient. The ICER for ET to MT was $NT 3,703 per QALY (Table 3). The cost-effectiveness plane is depicted (Fig. 2). Both the cost and effectiveness of ET were less than those of MT.

3.2. Probabilistic sensitivity analysis

The CEAC is depicted (Fig. 3). ET was comparable to MT at a WTP threshold of larger than $NT 35,000 per QALY. The probability of ET being cost-effective was 43.8% at a WTP threshold of $NT 35,000 per QALY. By contrast, the probability of MT being cost-effective was 56.2% at a WTP threshold of $NT 35,000 per QALY.

The scatterplot indicated variability in the distribution of the 1000 ICEs generated from the probabilistic sensitivity analysis. The ICER scatterplot depicted that over 44% of individual ICER outcomes were below the $NT 35,000 per QALY threshold (Fig. 4).

Results from the reference case and probabilistic sensitivity analyses suggest that ET is comparable to MT for treating patients with simple chronic otitis media.

4. Discussion

Chronic otitis media is a highly prevalent disease of the tympanic cavity. This disease often reduces patient's quality of life, causes a significant financial burden on health care systems, and is associated with substantial productivity costs. MT has been performed for over 50 years, whereas ET has been practiced for only 5–10 years. Compared with MT, ET is less

Table 3
Incremental cost effectiveness ratio.

	Total Cost ($NT)	Incremental cost ($NT)	Total effectiveness (QALYs)	Incremental effectiveness (QALYs)	ICER (ET versus MT) ($NT/QALY)	C/E ($NT/QALY)
ET	20,901	–	17.08	–	–	1224
MT	21,171	270	17.15	0.07	3703	1234

C/E, cost effectiveness ratio; ET, endoscopic tympanoplasty; ICER, Incremental cost effectiveness ratio; MT, microscopic tympanoplasty, $NT: New Taiwan dollar; QALY, quality adjusted life year.

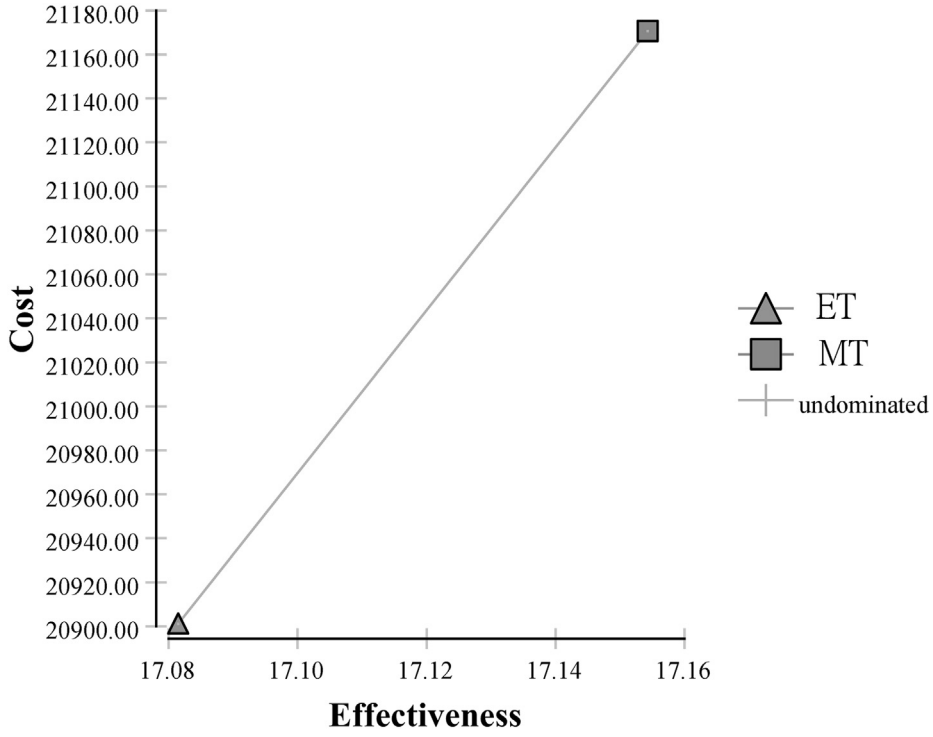

Fig. 2. Cost-effectiveness plane of ET versus MT (ET: endoscopic tympanoplasty; MT: microscopic tympanoplasty).

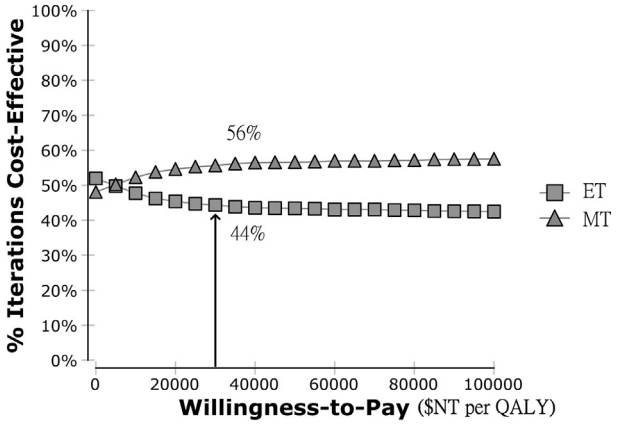

Fig. 3. Cost-effective acceptability curve depict that the probability of ET and MT being cost-effective is 44% and 56% at willingness-to-pay thresholds of $NT 35,000 per QALY, respectively. (ET: endoscopic tympanoplasty; MT: microscopic tympanoplasty; $NT: National Taiwan dollar; QALY: quality adjusted life year).

invasive because it does not require postauricular incision and canalplasty. A cost-effectiveness analysis of ET and MT has not been conducted. Our study is the first to suggest that ET is comparable with MT for treating chronic otitis media in the Taiwan NHI system. This result provides the latest information for physicians, the government, and third-party payers to select proper clinical practice.

For the reference case (Table 3), MT provided a small increase in both utility (0.07 QALY) and cost ($NT 270), and the value of ICER was also small ($NT 3703 per QALY). These results indicate that the difference between ET and MT is minimal with respect to cost-effectiveness. In the CEAC (Fig. 3), the probability of ET and MT being cost-effective stabilized after a WTP threshold of $NT 35,000 per QALY (44% vs. 56%). The scatterplot shows 1000 individual ICERs on the cost-effectiveness plane. Of all ICERs, 95% were almost equally distributed in the four quadrants. Nearly half (44%) of individual ICERs were below a WTP threshold of $NT 35,000 per QALY. On the basis of these findings, we conclude that ET is comparable to MT for treating chronic otitis media in the Taiwan NHI system.

In this study, several input variables merit clarification. First, in a systemic review and meta-analysis by Tseng et al.,[22] the author identified four studies that compared the efficacies of ET and MT. The pooled tympanic membrane closure rates were comparable (85.1% vs. 86.4%). This result was the highest quality of evidence yielded by a literature search; thus, we adapted this data in this study. Second, the admission operation cost for treating chronic otitis media was approximately $NT 12,320 (SD = 4087). This payment was unchanged whether the surgical techniques (ET vs. MT) or anesthesia procedures (intubation general anesthesia or intravenous anesthesia) were used based on the Taiwan NHI system. The difference between the cost for ET and MT was primarily a result of the fee for postoperative follow-up visits. ET is less invasive than MT (involving no postauricular incision and canalplasty); thus, the follow-up visits of ET were fewer than those of MT.

The present study has four advantages. First, data on the costs and utility of ET were relevant to those of MT. The costs of ET and MT were both calculated from Taiwan NHI. The utility of ET and MT were based on the validated Chinese

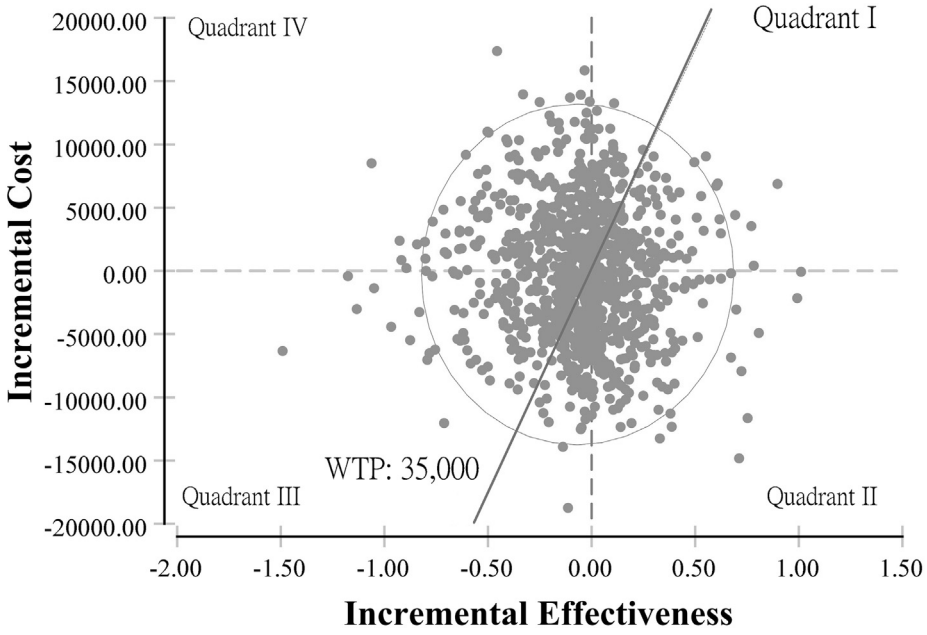

Fig. 4. Incremental cost effectiveness ratios scatterplot demonstrate that over 44% of individual ICER outcomes are below the $NT 35,000 per QALY threshold. (ICER: incremental cost effectiveness ratio; QALY: quality adjusted life year; WTP: willingness-to-pay).

version questionnaire. Second, we estimated the variables on the basis of the highest quality evidence (systematic review and meta-analysis). Third, we performed multiple forms of sensitivity analyses to account for data uncertainty, including two probabilistic sensitivity analyses. Fourth, our model is the first to provide a framework for evaluating the cost-effectiveness of ET and MT using evidence-based parameter values.

This study has four limitations. First, institutional differences in performing ET and MT affect the overall cost and surgical outcomes. Each institution should consider site-specific costs and surgical outcomes for ET and MT and evaluate its own results. Second, because the literature regarding the utility of patients receiving ET is unclear, we assumed that patients receiving ET and MT had identical utility. Third, the indirect costs associated with ET and MT were not defined; therefore, we did not evaluate the costs from a societal perspective. Fourth, our study included only simple chronic otitis media and excluded chronic otitis media with ossicular chain disease and cholesteatoma. Therefore, over-generalization of these results should be avoided.

Because of these limitations, future studies should include ET-specific utility, indirect cost, and operations for ossiculoplasty and cholesteatoma in their cost-effectiveness analyses for comparing ET and MT.

In conclusion, chronic otitis media is a common ear problem that has significant deleterious effects on patients and creates a substantial burden on the health care system. This decision tree-model compared the cost-effectiveness of ET with that of MT for treating simple chronic otitis media. This cost-effectiveness analysis suggests that ET is comparable to MT for treating simple chronic otitis media in Taiwan. This result provides the latest information for physicians, the government, and third-party payers to select proper clinical practice.

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