Estimated Cost-effectiveness of Active Middle-Ear Implantation in Hearing-Impaired Patients With Severe External Otitis

Ad F. M. Snik, PhD; Noortje T. L. van Duijnhoven, MSc; Emmanuel A. M. Mylanus, MD, PhD; Cor W. R. J. Cremers, MD, PhD

**Objective**: To determine the cost-effectiveness of middle-ear implantations in hearing-impaired patients with severe external otitis in the Netherlands.

**Design**: Cost-effectiveness analysis, using single-subject repeated measures of quality of life and total cost determinations.

**Setting**: Hospital based.

**Patients**: Moderately to severely sensorineurally hearing-impaired patients (n=21) with severe chronic external otitis, eligible to receive a middle-ear implant.

**Main Outcome Measure**: Cost per quality-adjusted life-year (QALY), based on scores of the Medical Outcomes Study Short-Form Health Survey (SF-36) generic quality of life questionnaire. Only direct costs were included in cost calculation of middle-ear implantation.

**Results**: Mean health utility gain was 0.046 (0.012-0.079) (P=.01) measured at the mental component of the SF-36. With a mean profitable time of 19.4 years and an overall cost of €14 354, minimal cost-effectiveness of middle-ear implantation was €16 085/QALY.

**Conclusion**: Based on the cost per QALY, middle-ear implantation proved to be a cost-effective and justified health care intervention in the Netherlands.

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In patients with moderate to severe sensorineural hearing loss, conventional hearing aid fitting may be troublesome owing to chronic external otitis. Although some patients benefit from vented or silver- or gold-coated ear molds, others continue to experience pain or itching when the ear canal is occluded, which leads to nonuse of the hearing aid. In these patients, the electronic middle-ear implant may form a solution, because the device does not block the ear canal. At present, 2 types of middle-ear implants are commercially available: the Vibrant Soundbridge (Med-El, Innsbruck, Austria) and the Otologics MET device (Otologics LLC, Boulder, Colo).

Compared with conventional hearing aids, the application of the middle-ear implant involves surgery and higher financial cost, which has led to health care policy questions regarding treatment effectiveness and cost-benefit analyses. Cost-effectiveness of a treatment can be determined by combining the qualitative and quantitative health benefit with the cost of the treatment.
benefit in hearing-impaired subjects. It has been concluded that a major problem with generic HR-QOL questionnaires is their insensitivity to problems concerning audition and communication. Barton et al reported low benefit scores but marked differences between the outcomes of 3 different HR-QOL instruments, which indicates that cost-effectiveness depends on the questionnaire used. The BAHA system (bone-anchored hearing aid), a semi-implantable bone-conduction device, was not found to have any significant effect on QOL when generic instruments were used, whereas disability-specific questionnaires showed significant improvements. In contrast, significant changes in HR-QOL questionnaires were reported in postlingually deafened adults after cochlear implantation.

The relative insensitivity of existing HR-QOL questionnaires to audition and communication problems has led to the development of several new instruments to assess health benefit after hearing aid fitting. The Glasgow Benefit Inventory (GBI) is an HR-QOL questionnaire that was specially developed to measure outcomes of otorhinolaryngologic interventions. It examines how the health status of the patient has been affected by the intervention. The BAHA system (bone-anchored hearing aid), a semi-implantable bone-conduction device, was not found to have any significant effect on QOL when generic instruments were used, whereas disability-specific questionnaires showed significant improvements. In contrast, significant changes in HR-QOL questionnaires were reported in postlingually deafened adults after cochlear implantation.

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The Nijmegen Cochlear Implant Questionnaire (NCIQ) is an HR-QOL questionnaire that was specially developed to assess health status after cochlear implantation. It comprises questions in communicative, psychological, and social domains. Although the NCIQ has not yet been used widely, it has proven to be reliable and sensitive to clinical changes.

Up to now, none of the HR-QOL questionnaires has received a general recommendation. Therefore, it remains advisable to use several instruments in parallel to determine postintervention health status.

After the health utility gain has been determined, the number of quality-adjusted life-years (QALYs) can be calculated. A QALY is designed to aggregate the total health improvement in a group of individuals, while capturing improvements in QOL (health utility) and quantity of life. It is calculated by multiplying the life expectancy after the intervention (years) by the health utility gain due to that intervention. However, the assumption that a subject will benefit from the intervention until death is unrealistic in case of middle-ear implant application. In any subject, hearing can be expected to deteriorate with age, which makes every hearing aid less effective and eventually ineffective at some stage in life. Therefore, life expectancy after the intervention should be replaced by profitable years, i.e., the number of years of effective middle-ear implant use.

In the United States, England, and Canada, health interventions with a cost-utility ratio of less than about $20,000/QALY are considered to be acceptably cost-effective. The assumed US exchange rate, as of October 10, 2005, for determination of this figure was $1.00 = €0.825292. This is comparable with the ratios of €18,500/QALY and $20,000/QALY calculated in the Netherlands. One exception is the British Cochlear Implant Study Group who use an upper limit of acceptability of €50,000/QALY.

Several cost-effectiveness studies have been performed on hearing devices, especially on cochlear implants. Cochlear implantation was shown to be a cost-effective treatment, with cost-utility ratios that ranged from €10,553 and €12,107/QALY to €22,283/QALY. At a mean cost of €13,933 and €15,807/QALY, conventional hearing aid fitting was also considered to be cost-effective in elderly patients. However, to our knowledge, no research has been done on the cost-effectiveness of middle-ear implantations. The aim of the present study was to determine the cost-effectiveness of middle-ear implantations in patients with sensorineural hearing loss. It was expected that this treatment would be cost-effective in terms of cost per QALY.

### METHODS

#### STUDY DESIGN

The study had a prospective, single-subject, repeated-measures design in which each patient served as his or her own control subject in the QOL reports. Early in the selection phase, prior to being selected for middle-ear implantation, patients filled out 2 HR-QOL questionnaires, the SF-36 and the NCIQ. The same 2 questionnaires were also filled out 6 and 12 months after the middle-ear implant audio processor had been fitted. The GBI questionnaire was added to the protocol later and was filled in by the patients at 6 to 24 months of follow-up. As it concerns a retrospective questionnaire, this change in protocol was not seen as a problem. To minimize enthusiasm bias in the patients who received implants, all the questionnaires were sent by mail, and a relatively long evaluation period was chosen. The QALYs were calculated based on the health utility gain reflected in the questionnaires.

To assess whether the audio processor fittings were adequate while dealing with the nonlinear amplification of the audio processors, it was decided to measure amplification for normal speech levels (speech gain) and to compare this gain with target gain values obtained with the well-validated National Acoustic Laboratories (NAL) nonlinear rule, which prescribes desired gain as a function of input level based on hearing thresholds alone. Speech gain was defined as the shift between the unaided and aided speech audiograms (speech recognition intensity graph) at the 65-dB sound pressure level input.

Differences between baseline and implant-aided scores were analyzed using a paired t test; 2-sided comparisons were considered statistically significant at P < .05. Data are expressed as mean ± SD, while hearing differences between post–middle-ear implantation and baseline are expressed as means (95% confidence intervals [CIs]). SPSS statistical software, version 12.0, was used to make the calculations (SPSS Inc, Chicago, III).

#### STUDY POPULATION

The study population comprised 21 middle-ear implant users who had been operated on between January 2000 and May 2004 at the Department of Otorhinolaryngology, University Medical Center St. Radboud, Nijmegen, the Netherlands. In 13 patients, the Vibrant Soundbridge had been implanted, fitted with the 404 audio processor, and 8 patients received the Otologics
QOL SCALES

SF-36 Questionnaire

The SF-36 is a multidimensional outcome instrument to measure QOL. It has been designed to prospectively monitor patient outcomes in medical and clinical research settings. The questionnaire assesses 8 different health concepts: physical functioning, role limitations due to physical problems, bodily pain, general health perceptions, vitality, mental health, social functioning, and mental health. Because hearing device fitting may not have any direct effect on physical health but may affect mental health, 2 overall scores should be determined. The physical component summary mainly contains physical functioning, role limitations due to physical problems, bodily pain, and general health perceptions. The mental component summary is mainly composed of role limitations due to emotional problems, vitality, mental health, and social functioning. The physical and mental component summary scores are expressed as a value between 0 and 1.

Nijmegen Cochlear Implant Questionnaire

The NCIQ is a prospective questionnaire used to measure QOL. It was specially developed to evaluate how cochlear implantation affects health status. The physical general domain consists of 3 subdomains (basic and advanced sound perception and speech production) and mainly focuses on communication (referred to as NCIQ communication). The psychological domain (NCIQ psychological) contains mainly self-esteem questions, while the social domain (NCIQ social) addresses activity limitations and social interactions. Because our subjects had acquired hearing loss, 6 questions on deaf speech and sign language were deleted (questions 8, 15, 33, 39, 56, and 57; see questionnaire in Hinderink et al). Scores can range from 0 to 100 based on a 5-point scale that indicates the degree of ability in different situations.

GBI Questionnaire

The GBI is a retrospective standardized questionnaire that examines the impact of an otologic treatment, such as middle-ear implantation, on the health status of the patient. Scores can range from –100 to +100 on the basis of 5-point scales that measure from severe deterioration to great improvement in health status.

COST PER QALY

The QALYs were calculated from the health utility gain scores obtained with the QOL questionnaires. The hearing of every subject will deteriorate over time, and any middle-ear implant will eventually become ineffective. Snik et al estimated the maximum hearing loss for proper middle-ear implant application: 70 dB hearing loss for the Vibrant Soundbridge and 80-dB hearing for the Otologics MET (average at 0.5, 1.0, and 2.0 kHz). Individual profitable usage periods in years can be calculated by subtracting the average hearing loss from the maximum hearing loss and dividing this by an assumed deterioration of 1 dB per year (average at 0.5, 1.0, and 2.0 kHz). The formula would be expressed as follows: profitable years (Vibrant Soundbridge) = 70 dB-average hearing loss in decibels (0.5, 1.0, and 2.0 kHz)/1 dB per year and profitable years (Otologics MET) = 80 dB-average hearing loss in decibels (0.5, 1.0, and 2.0 kHz)/1 dB per year.

A QALY was calculated by multiplying the number of profitable years with a middle-ear implant by the health utility gain from that specific middle-ear implant.

Treatment cost was calculated according to the methods described by Severens et al and only included the direct cost of middle-ear implantation, i.e., during the phases of selection, implantation, rehabilitation, and aftercare. It was assumed that the cost of long-term aftercare for today’s semi-implantable devices is comparable to that for conventional hearing aid fittings. The cost of personnel was made up of 3 parts: the gross salary of the employee, a 21% raise for the social liabilities paid by the employer, and a 37% raise by the hospital for the facilities and equipment. Reimplantations were not taken into account because these were assumed to be the result of “growing pains” of the new device and expected to become insignificant in number as experience increases. On the basis of the total cost of middle-ear implantation and the value of 1 QALY, we calculated the cost per QALY.

FITTING AUDIOPROCESSORS

The mean ± SD difference between the measured gain and target gain estimated by the NAL rule was 2.4 ± 6.4 dB (range, –11.5 to 7.6 dB); thus, measured gain was a little higher than NAL target gain. This suggests that the audio processor fitting can be considered as adequate.

QOL SCALES

All 21 patients completed the SF-36 and NCIQ preoperatively and postoperatively, but only 17 patients (81%) returned the retrospective GBI questionnaire. Table 1 lists the overall results of the SF-36 and the NCIQ at baseline and after middle-ear implantation. Because GBI scores implicate effectiveness by definition, only health utility gain is shown for this questionnaire.

Significant differences were found in the physical and mental components of the SF-36 between post–middle-ear implantation and baseline (P = .05 and P = .01, respectively, for the mean individual difference scores). The mental component summary had higher scores after implantation, on the health status of the patient. Scores can range from 0 to 100 based on a 5-point scale that indicates the degree of ability in different situations.

Table 1

<table>
<thead>
<tr>
<th>Questionnaire</th>
<th>SF-36 Physical</th>
<th>SF-36 Mental</th>
<th>NCIQ Psychological</th>
<th>NCIQ Social</th>
</tr>
</thead>
<tbody>
<tr>
<td>Physical</td>
<td>55.4 ± 15.4</td>
<td>67.8 ± 10.9</td>
<td>70.5 ± 15.3</td>
<td>61.0 ± 18.4</td>
</tr>
<tr>
<td>Mental</td>
<td>32.7 ± 11.2</td>
<td>39.6 ± 12.3</td>
<td>60.0 ± 15.1</td>
<td>60.0 ± 15.1</td>
</tr>
</tbody>
</table>

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middle-ear implantation. Social functioning was the only underlying health concept with significantly higher scores after middle-ear implantation ($P = .01$). Surprisingly, the physical component summary was significantly poorer after middle-ear implantation. Bodily pain was the only subdomain that had just significantly lower scores compared with baseline ($P = .05$). The communication-related physical, psychological, and social domains of the NCIQ were significantly higher after middle-ear implantation than at baseline ($P = .002, P = .01$, and $P = .001$, respectively). All of the underlying subdomains of the NCIQ showed significantly higher scores after middle-ear implantation than at baseline ($P \leq .01$ for all subdomains).

Because the SF-36 is the only questionnaire that is widely accepted as a health utility instrument, QALY and cost per QALY values are given only for this questionnaire, using the SF-36 mental component summary score as the health utility gain measure.

**COST PER QALY**

The mean±SD estimated profitable period of middle-ear implant use was 19.4±9.0 years. Multiplying this estimate by the health utility gain score obtained with the mental component of the SF-36 questionnaire produced a QALY value of 0.89.

The overall cost of middle-ear implantation was estimated to be €14 354, based on the costs listed in Table 2. Dividing this amount by the value of 1 QALY, cost per QALY for middle-ear implantation was €16 085 according to the SF-36.

**Table 1. Health-Related Quality of Life Questionnaire Results at Baseline and After Middle-Ear Implantation**

<table>
<thead>
<tr>
<th>Questionnaire†</th>
<th>Baseline</th>
<th>After Implantation</th>
<th>Individual Change</th>
<th>Mean (95% CI)</th>
<th>$P$ Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>SF-36, physical</td>
<td>0.512 ± 0.087</td>
<td>0.479 ± 0.100</td>
<td>−0.033 (−0.063 to −0.002)</td>
<td>.05</td>
<td></td>
</tr>
<tr>
<td>SF-36, mental</td>
<td>0.488 ± 0.099</td>
<td>0.534 ± 0.071</td>
<td>0.046 (0.012 to −0.079)</td>
<td>.01</td>
<td></td>
</tr>
<tr>
<td>NCIQ, communication</td>
<td>61.7 ± 13.6</td>
<td>71.7 ± 11.0</td>
<td>9.7 (3.8 to 15.5)</td>
<td>.002</td>
<td></td>
</tr>
<tr>
<td>NCIQ, psychological</td>
<td>60.2 ± 13.9</td>
<td>71.3 ± 13.1</td>
<td>10.5 (2.8 to 18.2)</td>
<td>.01</td>
<td></td>
</tr>
<tr>
<td>NCIQ, social</td>
<td>62.2 ± 15.9</td>
<td>70.0 ± 12.4</td>
<td>13.6 (6.4 to 20.7)</td>
<td>.001</td>
<td></td>
</tr>
<tr>
<td>GBI</td>
<td>NA</td>
<td>NA</td>
<td>33.9 (27.3 to 41.4)</td>
<td>&lt;.001</td>
<td></td>
</tr>
</tbody>
</table>

Abbreviations: CI, confidence interval; GBI, Glasgow Benefit Inventory; NA, not applicable; NCIQ, Nijmegen Cochlear Implant Questionnaire; SF-36, Medical Outcomes Study Short-Form Health Survey.

†There were 21 respondents to each questionnaire except GBI, which had 17.

The present prospective study addressed the cost-effectiveness of middle-ear implantation in hearing-impaired patients with severe external otitis and is the first to our knowledge to show the cost-effectiveness of middle-ear implantation, although the treatment has been applied for almost a decade. These results can be expected to encourage approval and justification of middle-ear implantation in the future.

Since no other QOL and cost-effectiveness data were available on middle-ear implantation, comparisons were made with studies on cochlear implants. It must be noted that the target populations for the 2 hearing aids are not equal. The middle-ear implant is used in subjects with sensorineural hearing loss, while the cochlear implant is offered to deaf subjects. When we compared the present SF-36 (mental component score) and NCIQ results obtained after middle-ear implantation with those after cochlear implantation in adults at the same research institute, improvement with cochlear implantation was found to be from about 2 to 2.5 times higher than that with middle-ear implantation (Table 3) (the SF-36 physical summary score was not considered because no change in physical functioning was expected to occur as a re-

**Table 2. Estimation of the Overall Cost of Middle-Ear Implantation**

<table>
<thead>
<tr>
<th>Treatment Component</th>
<th>Cost, €*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Selection phase</td>
<td></td>
</tr>
<tr>
<td>ENT specialist</td>
<td>276</td>
</tr>
<tr>
<td>Audiologist</td>
<td>188</td>
</tr>
<tr>
<td>Administration</td>
<td>86</td>
</tr>
<tr>
<td>Assistant</td>
<td>137</td>
</tr>
<tr>
<td>Total</td>
<td>687</td>
</tr>
<tr>
<td>Surgery</td>
<td></td>
</tr>
<tr>
<td>ENT specialist</td>
<td>553</td>
</tr>
<tr>
<td>Surgical nurse</td>
<td>531</td>
</tr>
<tr>
<td>Anesthesiologist</td>
<td>357</td>
</tr>
<tr>
<td>Assistant</td>
<td>158</td>
</tr>
<tr>
<td>Total</td>
<td>1 999</td>
</tr>
<tr>
<td>Hospital stay of 2 d</td>
<td>1 135</td>
</tr>
<tr>
<td>Follow-up care</td>
<td></td>
</tr>
<tr>
<td>ENT specialist</td>
<td>107</td>
</tr>
<tr>
<td>Audiologist</td>
<td>642</td>
</tr>
<tr>
<td>Assistant</td>
<td>282</td>
</tr>
<tr>
<td>Total</td>
<td>1 031</td>
</tr>
<tr>
<td>Materials</td>
<td></td>
</tr>
<tr>
<td>Middle-ear implant†</td>
<td>9 500</td>
</tr>
<tr>
<td>Surgery material</td>
<td>402</td>
</tr>
<tr>
<td>Total materials</td>
<td>9 902</td>
</tr>
<tr>
<td>Total cost</td>
<td>14 354</td>
</tr>
</tbody>
</table>

Abbreviation: ENT, otolaryngologist.

*The US exchange rate on October 10, 2005, the relevant time period, was $1.00 = €0.825292.

†The implant used in this estimate was the Otologics MET device (Otologics LLC, Boulder, Colo); the Vibrant Soundbridge (Med-El, Innsbruck, Austria) would have been about €500 cheaper.
Scores were reported to be 4017 and 4316 while BAHA-treated in other studies. After cochlear implantation, GBI or BAHA system). However, the direct causes of the un-
type of implant (cochlear implant, middle-ear implant,
SF-36 outcome. Increased bodily pain might be a con-
terior in a multicenter study. It is speculated
results is caused by the baseline situation of the par-
ter middle-ear application). This implies that the
middle-ear implant for hearing-impaired subjects is about 2
less effective than a cochlear implant hearing de-
vice for deaf subjects when measured in terms of QOL. However, middle-ear implantation is also cheaper than
cochlear implantation.
It was remarkable that a deterioration in the physical
component of the SF-36 questionnaire was observed af-
ner middle-ear implantation, which was mainly caused
by the increase in the subdomain bodily pain. Such a nega-
tive change in physical health status had been reported
earlier in the cochlear implant study by Krabbe et al11
(Table 3) as well as in the BAHA system and, surpris-
ingly, with the conventional hearing aid.10 Worsening of
physical health has a neutralizing effect on the overall
SF-36 outcome. Increased bodily pain might be a con-
sequence of the event of surgery or of the presence of any
type of implant (cochlear implant, middle-ear implant,
or BAHA system). However, the direct causes of the un-
favorable scores with respect to pain are unknown and
should be clarified to diminish this adverse effect.
Our GBI scores were comparable with those ob-
tained in other studies. After cochlear implantation, GBI
scores were reported to be 4017 and 4316 while BAHA treat-
ment resulted in GBI scores of 3118 and 33.19 Thus, our
reached after cochlear implantation. Sterkers et al3 re-
ported a low GBI score of only 17 after Vibrant Sound-
bridge treatment in a multicenter study. It is speculated
the difference between this low result and the pre-
sum tests did not show any significant differences be-
tween the changes in SF-36 and NCIQ results or be-
tween the GBI scores of the 2 groups. Therefore, in ret-
rospect, pooling these data seems justified.
Regarding the choice of the HR-QOL questionnaires
in the present study, most of the HR-QOL question-
naire organizers are insensitive to audition and communication
problems that are often present as a result of diminished
hearing or hearing aid fitting. Therefore, we decided to
use the additional NCIQ and GBI questionnaires, which
include questions on these topics. A disadvantage of these
questionnaires is that they were not designed to calcu-
late the cost per QALY in that an overall utility score has
not yet been defined for these questionnaires.
In conclusion, this study was the first to our knowl-
edge to address cost-effectiveness of middle-ear implan-

### Table 3. Comparison of Data From a Cochlear Implant Study11 With Data From the Present Middle-Ear Implant Study

<table>
<thead>
<tr>
<th>Domain</th>
<th>Present Study (n = 21)</th>
<th>Cochlear Implant Study (n = 21)</th>
<th>Factor</th>
</tr>
</thead>
<tbody>
<tr>
<td>SF-36, physical</td>
<td>0.033</td>
<td>0.02</td>
<td>NA</td>
</tr>
<tr>
<td>SF-36, mental</td>
<td>0.046</td>
<td>0.11</td>
<td>2.4</td>
</tr>
<tr>
<td>NCIQ, communication</td>
<td>Not available</td>
<td>41.0</td>
<td>NA</td>
</tr>
<tr>
<td>NCIQ, communication-R†</td>
<td>9.7</td>
<td>NA</td>
<td></td>
</tr>
<tr>
<td>NCIQ, psychological</td>
<td>10.5</td>
<td>25.6</td>
<td>2.4</td>
</tr>
<tr>
<td>NCIQ, social</td>
<td>13.6</td>
<td>22.4</td>
<td>1.6</td>
</tr>
<tr>
<td>Cost, €‡</td>
<td>14354</td>
<td>47500</td>
<td>3.3</td>
</tr>
</tbody>
</table>

**Abbreviations:** NA, not applicable; NCIQ, Nijmegen Cochlear Implant Questionnaire; SF-36, Medical Outcomes Study Short-Form Health Survey.

*Unless otherwise indicated, data are reported as scores.
†Reduced number of questions; see “Methods” section for explanation.
‡The US exchange rate on October 10, 2005, the relevant time period, was $1.00 = €0.825292.
tation. With an estimated cost of €16 085/QALY according to the SF-36 QOL questionnaire, middle-ear implantation proved to be a cost-effective and justified health care intervention for the treatment of hearing-impaired patients with severe external otitis. Additional support came from a comparison with a previous study on QOL in cochlear implant users; middle-ear implantation was 2 to 2.5 times less effective but more than 3 times cheaper than cochlear implantation, resulting in a more favorable cost-effectiveness ratio.

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Author Contributions: Dr Snik and Ms Duijnhoven had full access to all the data in the study and take responsibility for the integrity of the data and the accuracy of the data analysis. Study concept and design: Snik and Cremers. Acquisition of data: Duijnhoven. Analysis and interpretation of data: Snik, Duijnhoven, and Mylanus. Drafting of the manuscript: Snik, Duijnhoven, and Cremers. Critical revision of the manuscript for important intellectual content: Snik and Mylanus. Statistical analysis: Duijnhoven. Study supervision: Snik, Mylanus, and Cremers.

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REFERENCES

29. Van den Broek P. Selection of Deaf Adults for Electrical Inner Ear Prosthesis (Cochlear Implant) and Evaluation of the Results With This Prosthesis [in Dutch]. Nijmegen, the Netherlands: Academic Hospital Nijmegen; 1995.