

## Economic viability of stapes surgery in Germany

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### Abstract

**Objective:** The purpose of this study was to determine the economic viability of stapes surgery in Germany. We compared the cost of the operation to the retail value and average cost of a lifelong supply of hearing aids.

**Study design:** Retrospective study.

**Setting:** Tertiary referral centre.

**Patients:** One hundred and sixty-four consecutive cases of primary stapedotomy performed on patients with otosclerosis at our institution served as the representative group for the calculation. The post-operative air–bone gap average at the frequencies 500, 1000, 2000 and 4000 Hz was less than 10 dB for 62 per cent of the patients, and less than 20 dB for 92 per cent of the patients. There was a post-operative sensorineural hearing loss in 1.2 per cent of the patients.

**Results:** Analysis showed that, even for an elderly patient aged 65 years with a life expectancy of 15 years, the cost of a lifelong supply of hearing aids was greater than that of a stapedotomy procedure. Based on our group of patients, the stapedotomy procedure proved to be €800000 K cheaper than treatment with an averagely priced hearing aid. The economic benefit was still present when taking into account possible revision surgery in 5–10 per cent of cases, and also when, in addition to the surgery, a post-operative hearing aid was required, in for example 20 per cent of cases.

**Conclusion:** Stapes surgery is economically beneficial for the individual patient as well as for the general patient cohort, irrespective of age. The stapedotomy procedure also prevents the known disadvantages of conventional hearing aids, thus improving the patient's quality of life.

**Key words:** Stapes Surgery; Hearing Aids; Cost Analysis; Otosclerosis

### Introduction

The first report of stapes surgery was by Kessel in 1842.<sup>1</sup> The original procedure, which entailed stapes mobilisation and removal, had a post-operative hearing gain of only a few days to weeks, as well as lethal intracranial complications on occasion. The procedure was therefore often criticised and soon brought to an abrupt end. It was not until the middle of the twentieth century that fenestration operations on the inner ear were again taken up. In 1956, Shea performed the first modern stapedectomy procedure, using a Teflon<sup>®</sup> stapes replacement prosthesis.<sup>1</sup>

Since then, this procedure has been modified and refined by various surgeons worldwide. There is an infinite amount of literature on short and long-term post-operative hearing results and complications based on surgical technique (e.g. stapedectomy *vs* stapedotomy) and type of stapes prostheses used. However, it is evident from review of the literature that, irrespective of surgical technique and prosthesis used, post-operative results (such as prolonged improvement in hearing and reduction of tinnitus)

are satisfactory when an experienced surgeon performs the operation.<sup>2–4</sup> With modern microscopic surgical techniques, stapes surgery has evolved into a standard operation with few complications and good post-operative results. However, the operation is still elective, since otosclerosis is not a life-threatening ailment. The aim of the operation is to improve hearing, which can also be accomplished using a hearing aid. Since from a medical standpoint either therapy option would be adequate, we decided to evaluate the financial aspect of each therapy. The aim of this study was to determine the economic viability of stapes surgery in comparison with the retail value and average cost of a lifelong supply of hearing aids, within Germany.

### Materials and methods

We first sought to determine the credibility of stapes surgery at our institution in comparison with results in the literature. We therefore retrospectively evaluated 164 primary stapedotomy procedures performed on patients with otosclerosis over a three-year period.

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This population included 52 men (32 per cent) and 112 women (68 per cent), with ages ranging from 13 to 77 years (mean, 44.1 years). All cases were operated upon by the same surgeon. Post-operative audiological evaluations were obtained at six weeks and thereafter at a minimum of six-monthly intervals. The last hearing test available was used as the post-operative audiogram in this study (range, one to two years post-operatively). The standard audiological evaluation included pure tone thresholds for air and bone conduction, speech reception thresholds, and the abbreviated profile of hearing aid benefit (APHAB) questionnaire for self-assessment.

Comparison of pre- and post-operative air–bone gaps (ABGs) was carried out, as well as documentation of major post-operative complications such as sensorineural hearing loss, vertigo and deafness.

The healthcare reimbursement system in Germany is based on the German diagnosis-related group system. In this system, a lump sum is set for the reimbursement of the operation and for post-operative care, based on the major diagnosis (or diagnoses) of the patient. The lump sum for stapes surgery for a patient with otosclerosis is €2128.52 (based on the diagnosis-related group D 30Z and a base rate of €2868 × 0.718 relative weight). This amount covers surgery, anaesthesia (whether local or general), in-patient hospital cost (usually a 3–5 day in-patient stay in Germany), post-operative care and audiological evaluation.

Two values were used to determine the cost for a lifelong supply of hearing aids, both of which also include a six-year service. The first value was the retail cost for a hearing aid, set at €696. This represents a basic hearing aid with few advanced settings. This is generally the base value of the subsidisation reimbursed by the German healthcare system to the patient. For this price, all dispensing audiologists are required to provide patients with a basic hearing aid. However, most patients are not satisfied with this basic model and prefer more advanced hearing aids. The estimated average cost for these ‘high-end’ hearing aids is €1360.00.<sup>5</sup>

Based on a life expectancy of 80–85 years and the average use of a hearing aid for six to eight years, we estimated that a 30-year-old patient would use about seven hearing aids in their lifetime, a 50-year-old about five hearing aids and a 65-year-old about three hearing aids.

Lastly, calculations were also made to determine the economic viability of the surgical procedure, taking into account the need for revision surgery in 5–10 per cent of cases, as well the need for a hearing aid post-operatively in 20 per cent of cases.

## Results

We performed 164 consecutive primary stapedotomies on patients with otosclerosis (mean age, 44.1 years). The average pre-operative ABG at the frequencies 500, 1000, 2000 and 4000 Hz was 26.1 dB (standard deviation (SD) ± 8.20 dB). The average ABG one to two years post-operatively was 11.1 dB

(SD ± 12.6 dB). Further breakdown of results showed that the post-operative ABG average was less than 10 dB for 62 per cent of the patients, and less than 20 dB for 92 per cent of the patients. The subset of patients over 65 years of age ( $n = 20$ ) showed similar results, with a pre-operative ABG of 28.75 dB (SD ± 8.57), and a post-operative ABG of 12.42 dB (SD ± 8.40 dB). We had one case of post-operative deafness (1.2 per cent), but otherwise no reports of persistent vertigo, facial palsy or sensorineural hearing loss.

In order to determine the economic viability of the procedure, calculations were made using the base values (see Table I) applied to different treatment scenarios (see Table II) for our patient cohort. We chose to base our calculations on a 50-year-old patient, as the average age of our patient group was 44 years, meaning that about five hearing aids would be needed for a life expectancy of 80–85 years. The retail cost for five hearing aids was €3480, and the average cost was €6800 (Table III). If all 164 of our patients had received hearing aids, then the financial burden would have been €570 720 and €1 115 200, respectively. The actual cost for our 164 patients, who all underwent surgery, was €348 992. This shows a substantial economic benefit, of €766 208, compared with an averagely priced hearing aid.

Although stapes surgery usually results in a significant gain in hearing, there are cases in which the results are not as satisfactory or the otosclerotic disease progresses, and a hearing aid is required in addition to the operation. In our patient group, 20 per cent ( $n = 32$ ) still required the fitting of a hearing aid post-operatively. This incurred further costs of €460 352 and €566 592 for retail and average hearing aids, respectively. Lastly, we estimated that about 10 per cent of our patients ( $n = 16$ ) would require revision surgery due to events such as prosthesis displacement, incus erosion or oval window closure. This amounted to an additional cost of €383 040.

## Discussion

In the modern healthcare era of constant financial reform, the importance of the economic aspects of different therapy options has moved into the forefront. In order for hospitals and medical departments to survive and to provide good healthcare within a climate of annually shrinking monetary budgets, analyses of therapies must be carried out in order to determine the standards of care that are medically and financially beneficial to both the patient and the healthcare provider.

TABLE I

BASE VALUES FOR CALCULATION

Lump sum for stapes surgery procedure = €2128.52\*  
Cost of hearing aid:† retail = €696; average = €1360

\*Based on German diagnosis-related group D 30Z, base rate of €2868 × 0.718 relative weight. †Including six-year service.

TABLE II  
ECONOMIC COMPARISON OF STAPES SURGERY WITH LIFELONG HEARING AID SUPPLY

Treatment scenario	Stapes surgery	Hearing aid	
		Retail cost	Average cost
All patients receive surgery ( <i>n</i> = 164)	164 × €2128 = €348 992		
All patients receive a HA at retail cost*		164 × €3480 = €570 720	
All patients receive a HA at average cost*			164 × €6800 = €1 115 200
Post-op HA required (20% of pts; <i>n</i> = 32)		32 × €3480 = €111 360 + €348 992 = €460 352	32 × €6800 = 217 600 + 348 992 = €566 592
Revision surgery required (10% of pts; <i>n</i> = 16)	16 × €2128 = €34 048 + €348 992 = €383 040		

\*Based on 50-year-old patient; *n* = 164. HA = hearing aid

In this study, we compared the economic viability of two different therapy options for a patient with otosclerosis – stapes surgery and hearing aids. From a medical standpoint, both therapies have their advantages and disadvantages. Both therapies provide an adequate improvement in hearing threshold from an objective standpoint; however, the amplification provided by a hearing aid can have distortions, feedback, etc, and is not as natural as the hearing enabled by the operative procedure. On the other hand, stapes surgery entails operative risks such as the development of vertigo, deafness, perilymph fistula and even meningitis, which can be life-threatening. Thus, taking these aspects into account, one could argue medically for either option.

When comparing the financial aspects of each therapy option, it is evident that surgery is more economically beneficial in comparison with a lifelong supply of hearing aids. In our cohort of 164 patients, surgery generated an estimated saving of nearly €800000 K, compared with providing a lifelong supply of averagely priced hearing aids (Table II). Our analysis showed that even for an elderly patient aged 65 years with a life expectancy of 15 years, the cost of lifelong hearing aids was greater than that of a stapedotomy procedure. The economic benefit was still present when taking into account the possible need for revision surgery in 5–10 per cent of cases, and the possible need for a post-operative hearing aid, in addition to surgery, e.g. in 20 per cent of cases (Table II). Published reports estimate that the yearly change in bone conduction threshold in patients with otosclerosis is about 0.7–0.9 dB per year.<sup>6,7</sup> In a

20-year, long-term follow-up study of patients after stapes surgery, 37 per cent were daily or occasional users of hearing aids.<sup>6</sup> Surgery, however, gave a long-lasting hearing improvement that delayed the need for rehabilitation with hearing aids.

- **Stapes surgery is a highly cost-effective means of treating otosclerosis**
- **Stapes surgery is economically beneficial when compared with a lifelong supply of hearing aids, irrespective of patient age**
- **Although complications following stapes surgery are rare, revision surgery and prolonged in-patient stay is on occasion necessary (in 1–2 per cent), significantly affecting expenditure**

Although stapes surgery appeared to have a definite economic benefit in our patient cohort, there will, unfortunately, always be an occasional complication (occurring in approximately 1–2 per cent of cases) that requires prolonged hospital stay, affecting expenditure. The post-operative development of total sensorineural hearing loss or extreme vertigo may require prolonged intravenous steroids or vasodilators, adding further hospital costs. Severe, persistent dizziness for over two to three weeks may require re-exploration of the middle ear. In a 2003 report by Klask<sup>8</sup> which analysed the post-operative complications of German stapes surgery from an economic standpoint, the average hospital expenditure for the procedure was found to be €1016 per patient. Stapes surgery is usually an in-patient procedure in Germany, performed under local anaesthesia. The average hospital stay in Klask’s study was 5.5 days, with an average operating time of 72 minutes. Furthermore, patients with post-operative sensorineural hearing loss or vertigo requiring prolonged in-patient treatment caused additional medical costs of €790 or 82 per cent (per patient), and one case of post-operative perilymph fistula, requiring re-exploration, caused an additional cost of €2540 or 262 per cent. The percentages in these

TABLE III  
COST OF HEARING AID\* PER PATIENT†

Pt age (yrs)	Cost type	
	Retail	Average
30	7 × €696 = €4872	7 × €1360 = €9520
50	5 × €696 = €3480	5 × €1360 = €6800
65	3 × €696 = €2088	3 × €1360 = €4080

\*Lasting 6–8 years; †life expectancy 80–85 years. Pt = patient; yrs = years

calculations are more important than the actual amounts, since each institution has different costs for expenditures and standards of practice (e.g. for in-patient vs out-patient care and for local vs general anaesthesia); however, it can be seen that a complication can cause an economic outlier significantly affecting expenditures. It cannot be said enough that there is no substitute for experience when it comes to obtaining good results and avoiding complications in stapes surgery.

Long-term audiological follow-up evaluation has shown that the post-operative improvement in conductive hearing loss is well maintained for the majority of patients. In a recent study reporting a 32-year follow up for stapes surgery,<sup>9</sup> 75 per cent of patients were found to have maintained their post-operative hearing results. There was a gradual decline in bone conduction over the period (pure tone audiometry (PTA) results fell from 15.9 to 40.5 dB); however, this sensorineural hearing loss, due either to presbycusis or further cochlear otosclerosis, was comparable with population studies. Such population studies actually give a bone conduction PTA of 60 dB in the same age group. This means that the inner-ear function of patients with otosclerosis who have undergone surgery is 20 dB better than that of the normal population, suggesting that a conductive hearing loss may confer a cochlear-preserving effect, protecting the cochlea from excessive noise. Although stapes surgery improves hearing by decreasing the ABG to within 10–20 dB in most patients, it does not exclude future use of a hearing aid due to further sensorineural hearing loss.

### Conclusion

We found that stapes surgery was economically beneficial for our individual patients as well as for the whole patient cohort, irrespective of age. In the long term, stapes surgery is considerably less expensive than hearing amplification with a hearing aid. The stapedotomy procedure not only prevents the known

disadvantages of conventional hearing aids, thus improving patients' quality of life, but also delays the need for hearing aids in most patients with otosclerosis.

### References

- 1 Haeusler R. General history of stapedectomy. *Adv Otorhinolaryngol* 2007;**65**:1–5
- 2 Spandow O, Söderberg O, Bohlin L. Long-term results in otosclerotic patients operated by stapedectomy or stapedotomy. *Scand Audiol* 2000;**29**:186–90
- 3 House HP, Hansen MR, Al Dakhil AA, House JW. Stapedectomy versus stapedotomy: comparison of results with long-term follow-up. *Laryngoscope* 2002;**112**:2046–50
- 4 Esquivel CR, Mamikoglu B, Wiet RJ. Long-term results of small fenestra stapedectomy compared with large fenestra technique. *Laryngoscope* 2002;**112**:1338–41
- 5 Based on reporting from the Federation of Hearing Aid Acoustics [Bundesinnung der Hörgerätekustiker]. [January 2006], <http://www.biha.de/modules.php?op=modload&name=Archive&file=index&year=2006&month=01&order=desc>
- 6 Aarnisalo AA, Vasama JP, Hopsu E, Ramsey H. Long-term hearing results after stapes surgery: a 20-year follow up. *Otol Neurotol* 2003;**24**:567–71
- 7 Kürsten R, Schneider B, Zrunek M. Long-term results after stapedectomy vs. stapedotomy. *Am J Otol* 1994;**15**:804–6
- 8 Klask J, Schmelzer A. Postoperative complications of stapes surgery. An analysis of medical and economic aspects [in Germany]. *HNO* 2003;**51**:893–7
- 9 Karhuketto TL, Lundmark J, Vanhatalo J, Rautiainen M, Sipila M. Stapes surgery: a 32-year follow-up. *ORL J Otorhinolaryngol Relat Spec* 2007;**69**:322–6

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