Stapedectomy in Children

Causes and Surgical Results in 35 Cases

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Objectives: To study children who had undergone stapedectomy at an age younger than 16 years to determine the causes (particularly frequency of congenital anomalies vs otosclerosis) and to analyze the functional results over the short-term, 1-year, and long-term post-surgery time course.


Setting: Pediatric tertiary care centers.

Patients: A total of 33 patients (35 ears) underwent stapes surgery from October 1998 to October 2008.

Main Outcome Measure: Sex, age, preoperative and postoperative audiometric test results, associated anomalies, type of surgery (stapedotomy or partial stapedectomy), method of stapes surgery, and complications.

Results: The median age of patients at surgery was 13.4 years, ranging from 3.3 to 15.9 years. The major cause, which was found in 25 of 35 ears (71%), was nonprogressive conductive hearing loss due to congenital stapes fixation. The second most common cause, which was found in 6 of 35 ears (17%), was otosclerosis with progressive conductive or mixed hearing loss. Three ears presented posttraumatic stapes luxation (1 child aged 3.3 years at surgery). In 1 ear, the cause was osteogenesis imperfecta. Twenty-two ears were treated via the drill or laser-assisted small fenestra technique, and 13 ears were treated by a partial removal of the footplate covered by fascia. Early functional results were good, with a median postoperative air-bone gap of 9.8 dB, and 94% of the results were considered good or very good. There was no significant difference between early, 1-year, and longer-term audiometric results.

Conclusions: Congenital fixation is the major indication for stapedectomy in children younger than 16 years. Functional results are good and remain stable over time.


TAPEDECTOMY IS A COMMON procedure in adults, owing to the high prevalence of otosclerosis, but is still rarely performed in children younger than 16 years. Hearing aids offer good rehabilitation of conductive or mixed deafness due to stapes fixation, and pediatric otologists used to only operate on children who were old enough to participate in the decision-making process because of the risk of postoperative sensorineural hearing loss (SNHL) caused during surgery as the inner ear is opened. Preadolescents are usually strongly motivated to undergo surgery at age 10 to 12 years, and stapes surgery is uncommon before this age. The situation is different in cases of posttraumatic stapes luxation with hearing impairment and vertigo that may justify stapes surgery at a very young age.

Since the first case series was reported by House et al in 1980, there have been few reports on stapedectomy in children. Classically, the major causes are congenital stapes fixation and otosclerosis, which have a similar prevalence. However, our experience was that otosclerosis was rare compared with congenital stapes fixation. We present herein a review of cases involving stapedectomy performed in children younger than 16 years over a 10-year period. The purpose of this study was to report on etiologic distribution and present the short-term and long-term results in a pediatric population. We observed a large predominance of congenital stapes fixation, and most of the results were judged good or very good (91%) (ie, similar success rates to adult populations) and have remained stable over time.

METHODS

This retrospective review of 35 consecutive stapedectomies performed in 33 children younger than 16 years covered all procedures performed at the Pediatric Otolaryngology Department of Armand Trousseau Children’s Hospital, Paris, France, over the period October

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1998 to October 2008. All patients had a preoperative workup comprising clinical examination, audiometric data review, and a systematic computed tomographic (CT) scan of the temporal bone. Data on age at surgery, technique, complications, hearing results, and length of follow-up were recorded.

The cause was determined according to family and personal history, history of onset, type, severity and progression of hearing impairment, and CT scan and operative findings. The diagnosis of congenital stapes ankylosis was made based on the presence of nonprogressive deafness and/or the absence of otosclerotic focus and was sometimes supported by the operative observation of associated mild ossicular or middle ear anomalies. History of temporal bone trauma was also registered. The diagnosis of juvenile otosclerosis was made based on the presence of progressive deafness associated with a typical otosclerotic focus in the temporal bone as seen on CT scan or during stapedectomy, and/or a positive family history, and/or exclusion of other causes of progressive conductive hearing loss.

All patients were operated on while they were under general anesthesia. The surgical procedure consisted in the removal of the suprastructure, followed by either a small fenestra technique with a drill or laser or a partial removal of the footplate covered by fascia. A polytetrafluoroethylene (Teflon) stapes prosthesis fixed to the long process of the incus was used in all cases.

Audiometric data were obtained at the preoperative visit, at 2 months after surgery, at 1 year ±3 months, and at the last office visit. Preoperative and postoperative air-conduction (AC) and bone-conduction (BC) values at 0.25, 0.5, 1, 2, and 4 kHz were computed. Audiometric results were reported as recommended by the American Academy of Otolaryngology Committee on Hearing and Equilibrium, except for thresholds at 3 kHz, which were in all cases substituted with those obtained at 4 kHz (the Committee recognized in 1995 that there was evidence that data sets using 0.5, 1, 2, and 4 kHz could be compared directly with data sets using 0.5, 1, 2, and 3 kHz). Pure-tone averages for AC and BC were recorded. Preoperative and postoperative air-bone gap (ABG) was also calculated using AC and BC values collected at the same time. The closure of the ABG on the decibel hearing level scale was determined as preoperative minus postoperative ABG. Sensorineural hearing loss was defined as more than a 10-dB decrease in postoperative mean BC.

The early postoperative (2 months), 1 year (±3 months) postoperative results were available for 33 ears (range, 1.4-8.3 years).

### RESULTS

The sex ratio was 57% female and 43% male, with a median (SD) age at the time of surgery of 13.4 (1.9) years. All children but 1 (age, 3.3 years; posttraumatic ear) were older than 10 years at the time of surgery. Findings from preoperative examinations of the tympanic membrane were normal for all patients. All cases but 1 (1 posttraumatic dead ear [total deafness]) presented with preoperative conductive hearing loss.

Twenty-one procedures were performed on the left ear and 14 on the right. During surgery, the exploration of the middle ear confirmed stapes ankylosis in 32 ears and stapes luxation in 3. There was an associated stapedial arch defect in 7 ears and a defective long process of the incus in 7 ears (both anomalies were associated in 5 ears). Surgical treatment consisted of a small fenestra technique in 22 ears (63%), in which a drill was used in 20 ears and a laser in 2 ears, and partial removal of the footplate covered by fascia temporalis in 13 ears (37%).

Congenital stapes fixation was diagnosed in 25 of 35 ears (71%) and juvenile otosclerosis in 6 of 35 (17%). Three ears showed posttraumatic stapes luxation (9%). Three children complained of vertigo and hearing loss (including 1 dead ear) after a temporal bone trauma, and a CT scan demonstrated luxation of the stapes. In 1 ear, osteogenesis imperfecta was the cause.

Postoperative audiometric data were available for 33 stapedectomies at 2 months, 25 stapedectomies at 1 year, and 14 stapedectomies at long-term follow-up. Two patients were excluded from the analysis of early hearing results: 1 traumatic case with preoperative deaf ear and 1 patient who refused any postoperative audiometric testing. Audiometric results are given in the Table.

#### Table. Audiometric Results for 33 Patients (35 Ears) Who Underwent Stapes Surgery

<table>
<thead>
<tr>
<th>Measure, Period</th>
<th>No. of Audiometric Test Results Available</th>
<th>Mean (SD) [Range]</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean ABG</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Before surgery</td>
<td>33</td>
<td>32.2 (10.5) [8.00-56.25]</td>
</tr>
<tr>
<td>Early post-op</td>
<td>33</td>
<td>33.2 (10.5) [8.00-56.25]</td>
</tr>
<tr>
<td>1 Year</td>
<td>25</td>
<td>10.8 (7.2) [0.00-32.50]</td>
</tr>
<tr>
<td>Long-term</td>
<td>14</td>
<td>11.8 (9.1) [1.25-33.75]</td>
</tr>
<tr>
<td>Mean BC</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Before surgery</td>
<td>33</td>
<td>12.1 (5.7) [1.00-25.00]</td>
</tr>
<tr>
<td>Early post-op</td>
<td>33</td>
<td>9.6 (6.9) [0.00-26.25]</td>
</tr>
<tr>
<td>1 Year</td>
<td>25</td>
<td>7.5 (7.2) [0.00-32.50]</td>
</tr>
<tr>
<td>Long-term</td>
<td>14</td>
<td>10.4 (9.8) [0.00-32.00]</td>
</tr>
</tbody>
</table>

Abbreviations: ABG, air-bone gap; BC, bone conduction.

* Early post-op: postoperative results at 2 months after surgery; long-term: for a mean long-term audiometric follow-up of 3.6 years (range, 1.4-8.3 years).
acceptable for 2 (6%). None of the cases was qualified as a bad result (ABG, ≥ 30 dB).

Considering the results in various etiologic groups, among congenital ankylosis, 17 cases (68%) had a very good surgical result and 8 cases (32%) had a good surgical result. Among the 6 cases with juvenile otosclerosis as the cause, 4 were qualified as a very good surgical result and 1 as a good surgical result (1 case was lost to follow-up). There was no significant relationship between cause and result of surgery. After stapedectomy for posttraumatic luxation, vertigo disappeared in both cases, with ABG improving from 25 to 5 dB and 31.3 to 23.8 dB, respectively. A third case involving a child having a dead ear before surgery was excluded from the audiometric results analysis: the vertigos disappeared after surgery.

At 1 year after surgery (25 ears), mean (SD) change from preoperative measurement was still significant in ABG (−22.3 [11.6] dB, P < .001) but not for BC. The result of surgery was very good or good for 23 cases (92%) and was not significantly different from the result observed 2 months after surgery (94%).

Mean long-term follow-up (14 ears) was 3.6 years, with a minimum of 1.4 years and a maximum of 8.3 years. Mean long-term ABG was 11.8 dB (range, 1.3–33.8 dB). Mean (SD) long-term gain from baseline was still significant (−20.4 [13.7] dB; P < .001) but did not differ from the gain obtained after 1 year. There was no significant difference between early, 12-month, and longer-term audiometric results. Of the 35 ears, 20 (57%) had a very good long-term result of surgery and an additional 10 (29%) had a good result. One case of postoperative SNHL (a loss of 12.5 dB compared with preoperative mean BC) was found at the long-term follow-up examination.

**COMMENT**

This 10-year review of stapedectomies performed in children younger than 16 years highlights the large prevalence of congenital stapes ankylosis in this age group, affecting 25 of the ears (71%) in the patient population. This prevalence is higher than in other series: in the largest published series (children < 18 years), De la Cruz et al3 reported similar proportions of congenital fixation (44 of 83 patients) and otosclerosis (39 of 83 patients). In the series of 12 stapedectomies by Bachor et al,2 5 were for otosclerosis and 7 were for congenital ankylosis. Our center includes children younger than 16 years and not the 18-year and 21-year cutoffs in the studies by De la Cruz et al3 and Bachor et al,2 respectively. However, mean age at surgery in our series—excluding surgery for traumas—was 13.5 years (median, 13.7 years), which is older than the mean age of 12.9 years in the series by De la Cruz et al.3 This may be because our purely pediatric referral center for congenital ear, nose, and throat anomalies recruits a specific patient group, whereas other centers care for both adults and children.

In the present series, the number of ears with otosclerosis is low (only 6 ears, of which 1 was without postoperative audiometric data), and postoperative ABG compared between otosclerosis and congenital fixation was not statistically significant. Surgery for ears with congenital fixation gave very good results (ABG, < 10 dB) in 16 cases (64%) and good results (ABG, 11-20 dB) in 8 (30%), while surgery for otosclerotic ears gave very good results in 4 of 5 cases and a good result in the final case. There was 1 case of SNHL detected 3.2 years after surgery, with a 12-dB worsening of the BC threshold. We found no cases of perilymph gusher.

The results in congenital cases were better than usually reported in studies using the same audiometric criteria: De la Cruz et al3 reported that only 44% of children with congenital stapes ankylosis had a postsurgical ABG of 10 dB or lower, compared with 82% of children with otosclerosis. Another study of 25 stapedectomies in children and adults with congenital ankylosis reported 48% of surgical results as very good and 32% as good.5 Raveh et al6 achieved 0- to 10-dB ABGs in only 2 of 12 children with fixed stapes, whereas 8 had postsurgical ABGs higher than 30 dB.6 In comparison, in the 2 largest series (39 and 31 cases) of juvenile otosclerosis operated on before 18 years of age, 82% and 100% of ears, respectively achieved 0- to 10-dB ABGs.3,7

The various authors share the consensus that stapedectomy should be avoided in patients with inner ear anomalies, but instead of a normal middle ear CT scan, it is common to find minor anomalies such as incus or malleus anomalies (7 of 25 patients in the present series) that can reduce the ABG closure. This may explain the slightly higher mean postsurgery ABG in cases of congenital stapes ankylosis.

When a stapedectomy is proposed in the pediatric age group, the information given to both child and family need to take into account the results expected in the 2 main causes. Children with otosclerosis have more than a 90% chance of closing the ABG to within 10 dB. In children with nonprogressive conductive deafness, even with a normal middle ear CT scan, approximately 2 of 3 children can be expected to achieve 0- to 10-dB ABG, while 90% will achieve 0- to 20-dB ABG. Cases of total loss of hearing have not been reported in the more recent series pub-
lished, but SNHL can still occur, even after several years, as in one of our cases.

The age for surgery is still subject to debate. Children have been operated on as young as 3 years, with good results. However, stapedectomy is functional surgery, and in childhood conductive deafness cases, hearing aids offer very good rehabilitation. This means there is never reason to rush into surgical treatment. The decision of whether to opt for surgery should depend on the child's own motivations, on whether they are able to minimize activities in the immediate postoperative period, and on their ability to understand the risk information given to both child and parents. In practice, these conditions are rarely fulfilled before preadolescence, and in the present patient series, excluding 1 posttrauma case, the youngest age at which surgery was performed was 10 years. Except in highly specific cases, 10 years old appears to be a reasonable age for stapedectomy under good, safe conditions.

In conclusion, congenital fixation is the major indication for stapedectomy in children younger than 16 years. In the pediatric age group, stapedectomy is a safe procedure that, in most cases, gives good or very good surgical results. Proposing stapedectomy from 10 years of age enables the child to participate in the decision-making process and to understand the information given on the risks and benefits involved in this functional surgical procedure.

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Author Contributions: Dr Denoyelle had full access to all the data in the study and takes responsibility for the integrity of the data and the accuracy of the data analysis. Study concept and design: Denoyelle, Leboulanger, Roger, Loundon, and Rouillon. Acquisition of data: Denoyelle, Daval, and Roger. Analysis and interpretation of data: Denoyelle, Daval, Leboulanger, Rousseau, and Garabedian. Drafting of the manuscript: Denoyelle, Daval, and Rousseau. Critical revision of the manuscript for important intellectual content: Rousseau, Roger, Loundon, Rouillon, and Garabedian. Statistical analysis: Daval and Rousseau. Study supervision: Denoyelle, Leboulanger, Roger, and Garabedian.

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REFERENCES