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Cerebrospinal Fluid Leak Prevention After Translabyrinthine Removal of Vestibular Schwannoma

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***Objectives/Hypothesis:* The purpose of the report was to present an update on the authors' results for prevention and management of cerebrospinal fluid (CSF) leak after translabyrinthine approach for vestibular schwannoma. *Study Design:* Retrospective case review. *Methods:* The study was conducted at Gruppo Otologico (Piacenza, Italy), a tertiary referral center for neurotology and skull base surgery. In all, 710 patients underwent translabyrinthine approach for the removal of vestibular schwannoma at that institution between April 1987 and December 2002. The medical records were retrospectively reviewed to identify tumor size, the incidence of postoperative CSF leak, and its treatment. *Results:* The overall rate of CSF leak was 1.4%. *Conclusion:* The use of proper surgical technique minimizes the risk of CSF leak. Study results show that the continued application of the authors' proposed preventive measures resulted in the maintenance of a low rate of CSF leak. Immediate management of CSF fistulae helps prevent meningitis. *Key Words:* Vestibular schwannoma, cerebrospinal fluid leak, prevention, translabyrinthine approach.**

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INTRODUCTION

One of the most challenging and potentially dangerous complications of vestibular schwannoma (VS) surgery is cerebrospinal fluid (CSF) leak. Despite tremendous efforts and investigations directed at solving this problem, it has managed to persist at a significantly high rate. The incidence of its occurrence varies among different reports. In our opinion, the main reasons for this variation are factors related to surgical technique rather than patient variables. We have dedicated a major part of our efforts to the meticulous application of our proposed preventive measures, which in the case of the enlarged translabyrinthine approach (ETLA) were greatly rewarded by the marked reduction of the rate of this complication, sometimes reaching percentage rates as low as zero.[1] In the present report, we endorse the effectiveness of our methods of prevention of CSF leak in the translabyrinthine approach (TLA) by means of studying a larger group of our patients

MATERIALS AND METHODS

A retrospective analysis of the charts of the patients who underwent surgery for VS removal in the period from April 1987 to December 2002 was performed. The charts were analyzed for the date of surgery, age and sex of the patient, size of the tumor, the presence or absence of CSF leak, and when present, its management. To predict the relationship between tumor size and CSF leak rate, the sizes were reported using three different methods. The first was the reporting scheme approved in *Acoustic Neuroma Consensus on Systems for Reporting Results*[2]; Table I shows the size distribution of all our cases according to this classification system with the incidence of CSF leak. In the second method, we divided the tumors into small (<1 cm), medium-sized (1–2 cm), and large or giant (>2 cm) tumors. The third method consisted of dividing the tumors into two size groups of less than 3 cm and greater than or equal to 3 cm. Statistical analysis was performed using the χ^2 and Fisher's Exact tests. The *P* value was set at .05 as being statistically significant.

Diagnosis

In all our cases, the CSF leak was diagnosed clinically. A CSF rhinorrhea was diagnosed when an intermittent, clear nasal discharge occurred on straining, leaning forward, or lowering of head. A wound leak was diagnosed when fluid with a similar character was seen exuding through the wound of the operation. No cases of CSF otorrhea were diagnosed in our series.

Surgical Techniques

A detailed description of the surgical techniques of the ETLA used at Gruppo Otologico has been published previously.[3] In the present study, we present a general description of this technique with emphasis on the precautions taken to prevent CSF leak.

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TABLE I.
Division of Tumor Sizes of Entire Series According to Reporting Scheme Approved in *Acoustic Neuroma Consensus on Systems for Reporting Results*.[2]

Size Category	No. of Cases	No. of Leaks
Intrameatal	53	1
1–10 mm	131	2
11–20 mm	238	1
21–30 mm	185	5
31–40 mm	85	1
>40 mm	18	0
Total	710	10

The problem of CSF leak is kept in mind from the initiation of the surgery. Thus, after performing the retroauricular C-shaped incision, care is taken to preserve the integrity of the anteriorly based skin-subcutaneous flap. The monopolar coagulation is used to create a T-shaped incision in the musculofascial layer, which is subsequently elevated as one flap. The facial and subfacial recesses are kept intact, but if they are accidentally opened, bone wax is used to seal them (Fig. 1).

In none of our cases of ETLA is lumbar drainage of CSF used intraoperatively. To reduce the intracranial pressure, CSF is allowed to escape through the cochlear aqueduct while the bone superior to the jugular bulb is being drilled. The lateral cistern is also opened by means of blunt dissection of the arachnoid at the inferior pole of the tumor after opening the dura to enhance the pressure reduction effect. Tumor dissection is carried out using a combination of bipolar coagulation and microscissors, reducing bleeding into the surgical field. After tumor removal is completed, a 30° endoscope is used to check for any tumor residues, bleeding points, and patent air cells in the approach. Pieces of periosteum collected at the beginning of the approach are used to fill the middle ear cavity through the aditus after removal of the incus (Fig. 2). Thin, long fat strips are introduced deep into the cerebellopontine angle (CPA) (Fig. 3), filling the space originally occupied by the tumor and adding to the seal against leak (Fig. 4).

In cases of highly pneumatized temporal bones, in which the CSF leak could occur through an anterior petrous apex rout,[4] we formerly obliterated the middle ear with a blind sac closure of the external auditory meatus. After analyzing the results of this technique, we found the result to be no different from that achieved with careful closure of the air cells using bone wax. Another fact that encouraged us to abandon this technique was that it is time-consuming. At the end of surgery, meticulous care is taken during wound closure, which is performed in layers creating a watertight seal. A mastoid dressing is applied and kept in place for at least 8 days postoperatively.

RESULTS

Of the 710 patients surgically treated at Gruppo Otologico (Piacenza, Italy), there were 332 male and 378 female patients. The average age of these patients was 50.5 years (age range, 15–80 y). Average tumor size was 2 cm (range, intrameatal to 5.4 cm).

In our series of 709 cases of VS surgically treated through ETLA, there were 10 cases of CSF leak (an overall rate of 1.4%). This is one of the lowest rates reported in the literature.[5–10] To consolidate the success of our preventive

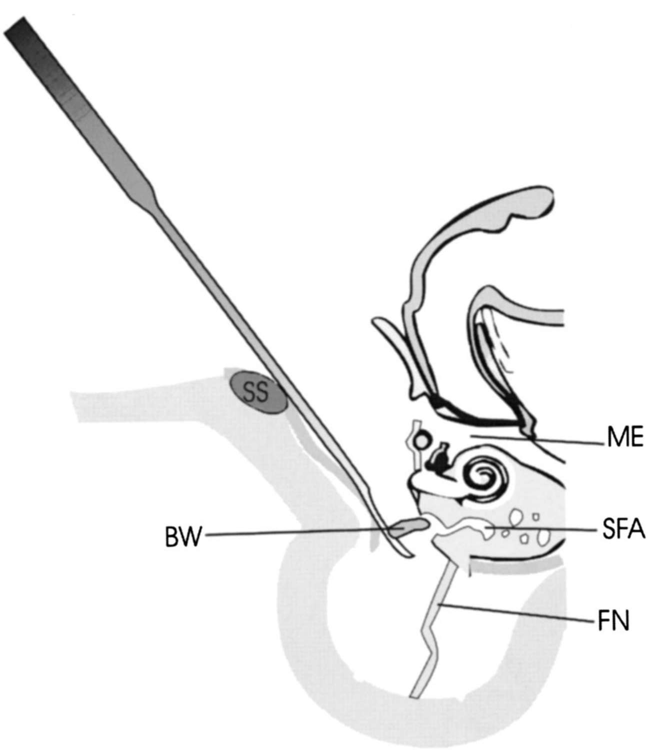

Fig. 1. Closure of the subfacial air cells using bone wax. ME = middle ear; SFA = subfacial air cells; FN = facial nerve; BW = bone wax; SS = sigmoid sinus.

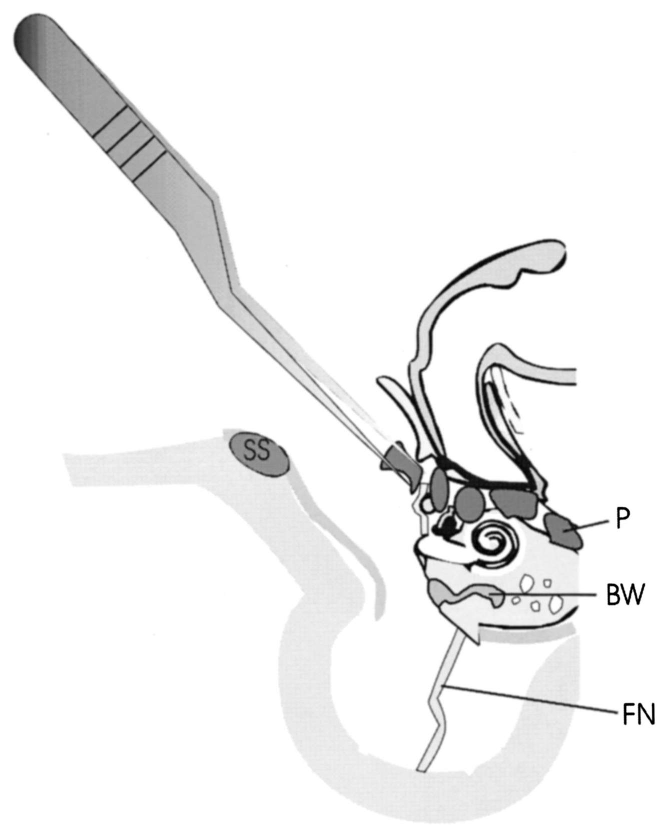

Fig. 2. Obliteration of middle ear cleft using periosteum. P = periosteum; BW = bone wax; FN = facial nerve; SS = sigmoid sinus.

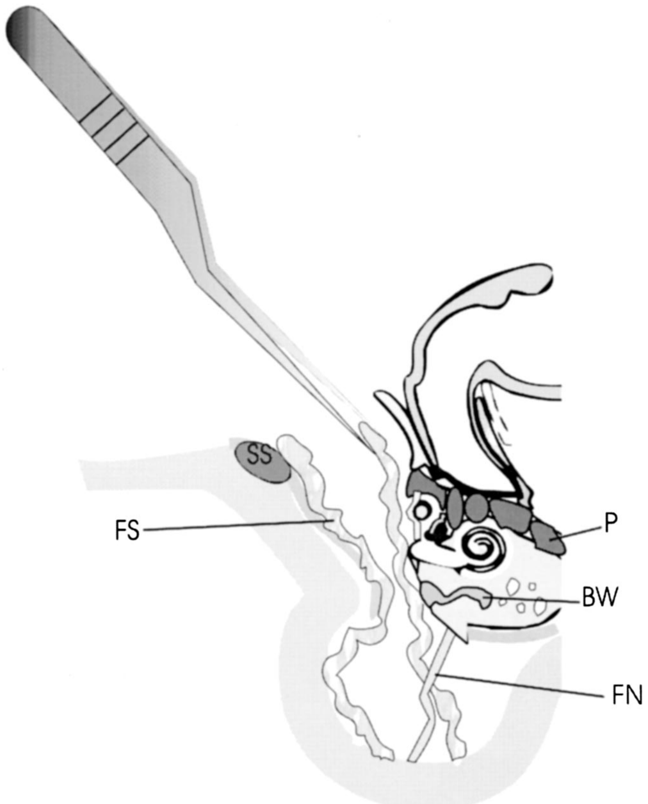

Fig. 3. Filling the surgical defect using fat strips. P = periosteum; BW = bone wax; FN = facial nerve; FS = fat strips; SS = sigmoid sinus.

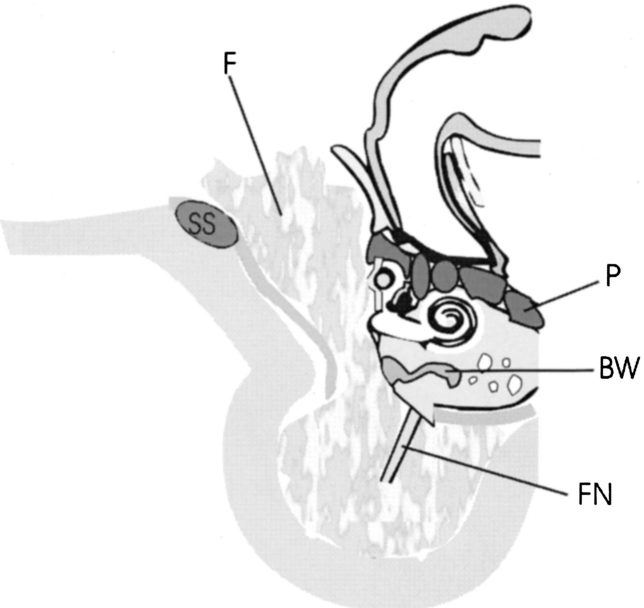

Fig. 4. The intradural space originally occupied by the tumor packed with fat strips adding to the seal against leak. P = periosteum; BW = bone wax; FN = facial nerve; SS = sigmoid sinus; F = fat.

methods used in this approach, we divided the ETLA patients into three groups according to the chronology of our published studies. The first two groups of patients were those whom we have reported previously.[1,11] The third group consisted of patients who received surgery thereafter through December 2002.

The first group consisted of 131 patients, of which 8 (6.1%) developed CSF leak.[11] Given this high rate of leak, we started developing our preventive methods. The success of these methods was confirmed in our study published in 1991,[1] in which we reported a 0% CSF leak rate in the subsequent 200 cases. Since then, an additional 379 cases were surgically treated at our center, and of those cases, only 2 (0.5%) developed leaks. Comparing this result statistically to the previous group of 200 cases with no leaks by means of Fisher's Exact test, we found no statistical difference between these two groups ($P = .55$). We also statistically compared all the cases in which we used our preventive measures (579 cases with 2 CSF leaks [0.3%]) with the first group (131 cases with 8 CSF leaks). Using Fisher's Exact test, the P value ($P < .0001$) gave strong evidence of the effectiveness of our preventive methods in this approach.

The statistical analysis for the relationship of the tumor size to CSF leak rate indicated that there was no relationship between tumor size and CSF leak rate when the size was classified according to the system of *Acoustic Neuroma Consensus* (χ^2 test, $P = .085$) or when the classification used was the small, medium-sized, and large or giant tumor sizes (χ^2 test, $P = .54$). A statistically significant relationship was found when the tumors of the entire series (710 cases) were classified into two size groups of less than 3 cm and greater than or equal to 3 cm (Fisher's Exact test, $P = .024$). Since the majority of leaks (8 of 10) occurred in the first group of 131 patients, we studied the statistical relationship between tumor size and leak rate in this group of patients using the same classifications. Table II shows the size distribution according to *Acoustic Neuroma Consensus* of the 131 cases of the first group with the incidence of CSF leak. When the system of *Acoustic Neuroma Consensus* was applied, the P value using the χ^2 test was $P = .43$; when tumors were divided into size groups of small, medium-sized, and large, the P value using the χ^2 test was $P = .25$; and when we divided this group into tumor size groups less than 3 cm and greater than or equal to 3 cm Fisher's Exact test gave

TABLE II.
Division of Tumor Sizes of First Group From April 1987 to September 1994, According to Reporting Scheme Approved in *Acoustic Neuroma Consensus on Systems for Reporting Results*.[2]

Size Category	No. of Cases	No. of Leaks
Intrameatal	0	0
1–10 mm	16	2
11–20 mm	48	1
21–30 mm	41	4
31–40 mm	22	1
>40 mm	4	0
Total	131	8

a P value of $P = .15$. Thus, no statistically significant relationship was found in any of these groups.

The clinical details of the CSF leaks that occurred in our series are shown in Table III. The leaks in all 10 cases manifested within the first 2 postoperative weeks, with the majority (8 cases [80%]) occurring within the first week. Seven cases presented as rhinorrhea and two cases as wound leaks; one case had both rhinorrhea and wound leak. There were no cases of otorrhea. Management of these cases included medical treatment in the form of bed rest, pressure dressing, antibiotics, and lumbar drainage in five patients. This was sufficient in two cases; the remaining three cases required surgical treatment. In the remaining five cases, surgical treatment was used at the outset. The most common surgical procedure used was obliteration of the middle ear space and cul de sac closure of the external auditory canal.

DISCUSSION

Since the late 1970s, VS surgery has witnessed enormous improvements both in technique and results. Despite the fact that the complication rate has been markedly reduced, CSF leak still represents a significant problem both to the patients and to surgeons. Table IV presents the CSF leak rates of some of the available studies published in the literature since 1988.[1,7,10–19]

One of the reasons for the persistence of this problem is the relationship between the surgical field and pneumatization of the temporal bone. In fact, the complexity of the anatomy provides multiple potential pathways for the connection of the intracranial cavity with the external environment, which can be overlooked or escape identification because of their hidden nature. Thus, we think the solution lies in the implementation of a strategy that includes several preventive methods. Our policy is a clear demonstration of that concept, wherein, at every stage of the procedure, we keep in mind the potential for a leak and take appropriate steps. From the start, we take good care to preserve the integrity and vascularity of the flaps that will form the partition between the intracranial cavity and external environment, thus preventing wound leaks. To provide the necessary strength to such an important barrier, we keep the skin and subcutaneous tissues as one flap and the fascia, muscles, and periosteum as another, thereby achieving a tight, two-layered closure at the end of the procedure in every case.

The subsequent set of steps addresses the bony part of the approach. We cannot overemphasize the importance of elimination of any connection between the middle ear cleft and the defect created in bone. This can usually take the form of an air cell that opens on both sides, and in our practice we try to close all such cells using bone wax. To provide the necessary contact between this material and bone, the mucosa is carefully removed first, and bone wax is applied to the defect. This is always performed before opening the dura because the contact of CSF with bone loosens the adherence between it and the bone wax.

Having completed the tumor removal, we further reinforce our previous measures by a final endoscopic checkup of the approach for any connecting air cells. The infralabyrinthine group of air cells is particularly important because they lie medial to the mastoid portion of the facial nerve hidden from the axis of vision. During closure, we found that the deep introduction of fat into the cranial cavity is much more effective in creating watertight seal against leak.

Various studies have reported a reduction of CSF leak rates as the experience has increased. Two large series (presented by Rodgers and Luxford[12] and by Bryce et al.[13] and Brennan et al.[14]) reported improvement from a rate of 20% to a rate of 6.8% and from a rate of 13.4% to a rate of 7.9%, respectively. In our study, the leak rate in ETLA cases has not only improved markedly but has also stood the test of time (decreasing from 8 leaks in 131 operations to 2 leaks in the next 579 operations [from 6.8% to 0.3%]). Welling et al.[20] reported a reduction in CSF leak rate from 40% to 7.5% between first and last groups of 20 patients each. Buchman et al.[21] reported a decrease in the rate from 17% to 12%. Further evidence of the success of the measures we adopt in ETLA is supported by Mamikoglu et al.[16] Their study showed a marked reduction of CSF leak in ETLA from 17% in their entire series to 2.3% in the

TABLE III.
Clinical Details of Cerebrospinal Fluid Leaks That Occurred in Current Series.

Patient No.	Tumor Size (cm)	Route of Leak	Onset (days)	Treatment	Surgery Type
1	3	Nose	3	M + S	MEO
2	1	Wound	4	M + S	Closure of defect in muscular flap
3	3	Nose + wound	2	M + S	Closure of fistula
4	3	Nose	8	S	Closure of fistula
5	3.4	Nose	4	S	MEO
6	1.2	Nose	5	S	MEO
7	3	Nose	2	M	
8	1	Wound	12	S	MEO
9	3	Nose	3	M	
10	0.0	Nose	2	S	MEO

M = medical management; S = surgical management; MEO = middle ear obliteration.

TABLE IV.
Cerebrospinal Fluid Leak Rates in Different Series of Translabyrinthine Approach.

Institution	Reference No.	Year	No. of Cases	CSF Leak (% of Cases)
University of California	10	2003	100	13
Loyola Center for Cranial Base Surgery	22	2001	209	3.8
House Ear Clinic	12	1993	723	6.8
	17	2001	1225	11
University of Toronto	13	1991	203	11.3
	14	2001	228	8.7
North West University	15	2000	44	2.3
	16	2002	81	17
New York University Medical Center	18	1994	146	21
	19	1996	83	13
Genttofte Hospital	7	1988	300	11
Gruppo Otologico	11	1995	129	6.2
	1	1999	200	0
	Current study	2004	709	1.4

*Some of these percentages have been extrapolated from the reported results.
CSF = cerebrospinal fluid.

cases in which they applied measures similar to ours (namely, obliteration of middle ear space, avoiding opening the facial and subfacial recesses and closing them with bone wax if they are opened accidentally, and the use of fat strips to obliterate the surgical defect). Leonetti et al.[22] have provided another excellent example of the effect of these steps; the CSF leak rate in their TLA cases was 3.8%. Another factor that has an important role in reducing the rates of CSF leak in our ETLA cases is the surgical experience. Figs. 5 and 6 show the intimate relationship between the increase in the number of VS surgeries performed at our center yearly and the decrease in the rates of CSF leak.

Regarding the association between CSF leak and tumor size, most of the available literature has stated that they do not have a statistically significant relationship. We had similar outcomes from our series when the tumor size was divided on the bases of *Acoustic Neuroma Consensus* (χ^2 test, P = .085) and into groups of small, medium-sized, and large tumors (χ^2 test, P = .54). However, a statistically significant relationship was found when the tumors were divided into two size groups of less than 3 cm and greater than or equal to 3 cm (Fisher's Exact test, P = .024). This relationship was nullified when we studied the first group of patients, in whom most of the leaks occurred. The fact that 8 of 10 leaks occurred in the first 131 cases and only 2 leaks occurred in the following 579 cases is most probably the confounding factor responsible for this change in statistical significance.

CONCLUSION

Recent studies have stated that CSF leak rate has reached a plateau rate of approximately 10% since the 1970s. Our study is ample proof that further lowered rates of CSF leak can be achieved and maintained by paying meticulous attention at various steps of the procedure. We agree that a plateau can be reached, albeit toward a percentage rate of zero.

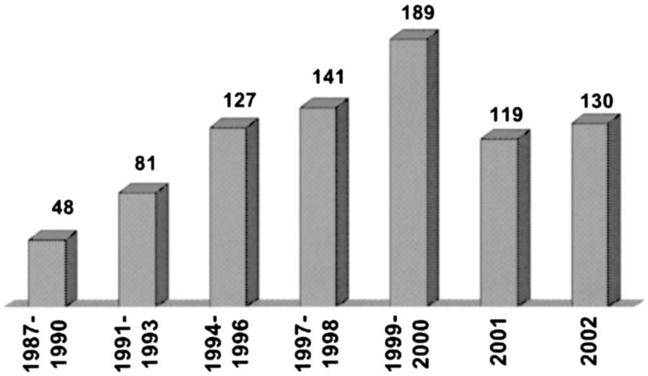

Fig. 5. The increase of the number of vestibular schwannoma surgeries over time in Gruppo Otologico.

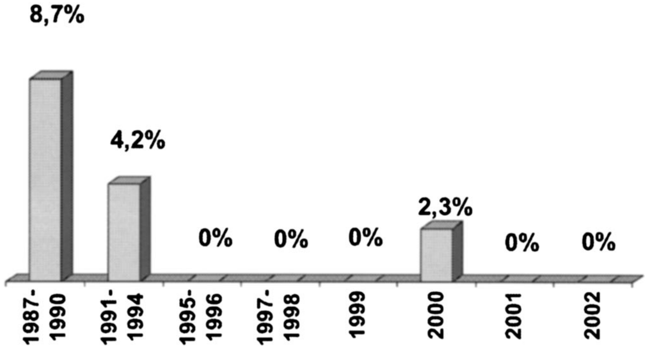

Fig. 6. The change of cerebrospinal leak rate over time after translabyrinthine removal of vestibular schwannoma in Gruppo Otologico.

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