

## OTOLOGY

# Combined endoscopic-microscopic approach for vestibular schwannoma removal: outcomes in a cohort of 81 patients

## *Approccio combinato endoscopico-microscopico per l'asportazione del neurinoma vestibolare: risultati ottenuti su un gruppo di 81 pazienti*

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## SUMMARY

Patients affected by vestibular schwannomas typically report a number of symptoms and minor disabilities after surgery. Therefore, surgeons dealing with this pathology should also try to achieve a good QoL for patients who have undergone tumour removal. The aim of this study was to analyse QoL in subjects undergoing surgery for vestibular schwannomas and to try to establish a relationship with both the tumour size and post-surgical alterations (e.g. facial motor dysfunctions, difficulties in balance, persistence of headache and tinnitus). A retrospective analysis was performed on a consecutive series of 81 patients affected by vestibular schwannomas and treated by a combined microscopic-endoscopic approach. Three groups of patients were identified on the basis of tumour size. Group 1 (lesions < 25 mm) with 31 patients (38%); Group 2 (lesions > 26 mm and < 40 mm) with 39 patients (48%); Group 3 (lesions > 41 mm) with 11 patients (14%). Data obtained with the Short Form Questionnaire showed a statistically significant difference in QoL in those undergoing intervention compared with a control group of healthy subjects. The Glasgow Benefit Inventory Questionnaire showed that 25 (31%) patients felt better, 11 (14%) felt similarly, and 45 (55%) felt poorer health conditions in comparison to the pre-surgical period. Concerning the relationship between preservation of facial nerve function and QoL, using the Glasgow Health Status Inventory, it appeared that only 34% of subjects with good facial nerve function (RGS grade I-II) complained of worsening of QoL, while 45% of those with serious facial nerve injury (RGS grade IV-V) referred poorer QoL. Moreover, the possibility of recovery of facial nerve function during the months following surgery was clearly highlighted by our analysis. Our study confirmed the close relation between tumour size and post-surgical QoL, which is worse for patients affected by larger lesions.

KEY WORDS: QoL • Facial nerve • Vestibular schwannoma • Headache • Vertigo • Endoscopic surgery

## RIASSUNTO

*I pazienti affetti da un neurinoma vestibolare tipicamente lamentano un certo numero di sintomi e di piccole disabilità in seguito all'intervento chirurgico di asportazione del tumore. Per questo motivo, i chirurghi che si confrontano con tale patologia dovrebbero anche cercare di ottenere una buona QoL per i pazienti che si vengono sottoposti alla rimozione dei tale lesione. L'obiettivo di questo studio è stato di analizzare la QoL nei soggetti operati per tale patologia e cercare di stabilire una connessione tra le dimensioni del tumore e le alterazioni post-chirurgiche (es. disfunzioni motorie del nervo facciale, difficoltà nell'equilibrio, persistenza di cefalea e acufene). Un'analisi retrospettiva è stata eseguita su una serie consecutiva di 81 pazienti affetti da neurinoma vestibolare e trattati con un approccio combinato micro-endoscopico. Tre diversi gruppi di pazienti sono stati identificati sulla base delle dimensioni tumorali. Gruppo 1 (lesioni < 25 mm) con 31 pazienti (38%); Gruppo 2 (lesioni > 26 mm e < 40 mm) comprendente 39 pazienti (48%); Gruppo 3 (lesioni > 41 mm) con 11 pazienti (14%). I dati ottenuti mediante lo Short Form Questionnaire hanno mostrato una differenza statisticamente significativa nella QoL dei soggetti operati rispetto al gruppo controllo dei soggetti sani. Il Glasgow Benefit Inventory Questionnaire ha mostrato che 25 (31%) pazienti si sentivano meglio, 11 (14%) si sentivano allo stesso modo, e che 45 (55%) si sentivano peggio rispetto al periodo pre-chirurgico. Per quanto concerne la relazione tra preservazione della funzionalità del nervo facciale e la QoL, attraverso il Glasgow Health Status Inventory, è invece emerso che solo il 34% dei soggetti con una buona funzionalità del nervo facciale (RGS grado I-II) lamentava un peggioramento della QoL, contro il 45% di quelli con una seria compromissione del nervo facciale (RGS grado IV-V). La nostra analisi ha inoltre evidenziato la reale possibilità di recupero della funzionalità del nervo facciale durante i mesi successivi all'intervento chirurgico. In conclusione il nostro studio ha confermato la stretta connessione esistente tra la dimensione tumorale e la QoL del periodo post-operatorio che risulta peggiore nei pazienti affetti da lesioni più voluminose.*

PAROLE CHIAVE: QoL • Nervo facciale • Neurinoma vestibolare • Cefalea • Vertigine • Chirurgia endoscopica

## Introduction

Vestibular schwannomas (VS) account for 8-9% of intracranial tumours and 80% of tumours found within the cerebellopontine angle<sup>1</sup>. Unilateral progressive hearing loss, tinnitus, vertigo, and disequilibrium are the most common symptoms at diagnosis<sup>1</sup>. The management of VS has traditionally involved surgical removal of the tumour via skull base surgery. Technical success is measured by surgical outcomes such as preservation of facial nerve function and hearing. However, more recently, examination of patient-oriented outcomes, such as postoperative health-related quality of life (HRQoL) following VS surgery from the patient's perspective, has become an important measure of treatment outcome<sup>2-11</sup>.

Many symptoms and minor disabilities may persist after surgery including hearing loss, facial nerve dysfunction, vestibular dysfunction, visual problems, tinnitus and headaches<sup>5-7 9-11</sup>. Several research teams have addressed this issue by attempting to evaluate the effect on QoL following various treatment options<sup>12-14</sup>. The assessment of QoL has mostly been made using generic widely known assessment tools such as the Short Form Questionnaire (SF-36)<sup>15 16</sup> and the Glasgow Benefit Inventory (GBI)<sup>17</sup>. The aims of the present study were first to evaluate the QoL in patients treated for VS using a combined endoscopic and microscopic approach. Second, we investigated the influence of the anatomical features of the tumour and other post-operative outcomes on post-operative QoL.

## Materials and methods

In September 2013, a retrospective review was performed on the medical charts of 127 patients treated for VS in our department between January 2006 and March 2013.

Inclusion criteria were:

- patients older than 18 years of age;
- patients treated through a retrosigmoid approach with a combined microscopic and endoscopic technique.

Exclusion criteria were:

- patients with bilateral VS affected by NF2;
- patients treated through a trans-labyrinthine or middle cranial fossa approach;
- patients with recurrent pathology.

Facial nerve function was evaluated at hospital discharge using the Rough Grading System (RGS) facial grading system<sup>18</sup>. At least 6 months after surgery, clinical follow-up was performed on all patients and facial nerve outcome was re-evaluated. To investigate the QoL at follow-up, patients were invited to complete a questionnaire including four sections:

- 1) *GBI* to investigate the social, psychological and physical spheres.
- 2) *Glasgow Health Status Inventory (GHSI)* to investigate the correlation between facial nerve dysfunction and QoL.

- 3) *Short Form Questionnaire (SF-36)* to evaluate QoL and compare the results with a control group of healthy subjects.

- 4) *Persistence of headache* (A: no headache; B: mild pain; C: moderate pain not affecting normal activities; D: intense pain limiting normal activities).

### Statistical analysis

Data obtained were analysed with SPSS 19.0 statistical software. To compare the clinical outcome and QoL of the three groups (on the basis of tumour dimensions and involvement of the internal auditory canal), Chi-square, Student's test, Anova test and Kruskal-Wallis test were used; a  $p < 0.05$  considered statistically significant.

### Standard surgical steps

All of the operations were performed under the control of Nerve Integrity Monitoring (NIM). A craniotomy (median diameter 3-4 cm) was performed behind the intersection between the Frankfurt line and the posterior mastoid edge. The dura was incised and the two flaps were set with silk thread. After studying the cisterna magna under microscopic vision, it was opened until complete deliquoration was obtained. The cerebellar lobe was retracted posteriorly to obtain adequate access to the tumour. At this point, endoscopic reconnaissance (performed with a 0° endoscope) could be made to evaluate all structures and, in particular, the course of the facial nerve. Next, the two arachnoid sheets covering the tumour were separated. The intracisternal portion of the tumour was approached and debulking of the lesion could be started with an ultrasonic aspirator in a centrifugal direction. After separation of the tumour from the cerebellum, the entry zone was identified by the surgeon with minimal drilling of the posterior bony part of the internal acoustic pore (the extent of which varied between different patients) to better visualise the acoustic and facial nerves. At this point, an endoscope was introduced (typically we use 30, 45 or 70° endoscopes with 4 mm diameter and 14 or 18 cm length; Storz, Culverly City, CA, USA). During this phase, in most cases the endoscope allowed complete visualisation of the lateral extent of the tumour and its connections with nervous structures. The dissection proceeded in a medio-lateral direction (from the meatus as far as the level of the internal auditory canal) using homemade tools of different sizes. After that, accurate inspection was performed to identify any possible residual tumour and to verify the anatomical integrity of the facial and cochlear nerves. Moreover, in those cases in which major cellularity of the internal acoustic pore was present, damage caused by the opening of petrosal cells could be detected and promptly repaired with muscle fragment and fibrin sealant. The facial nerve was finally stimulated to confirm its functional integrity. An accurate suture of the dura inci-

**Table I.** Summary of post-surgical outcomes in the different patient groups.

	N of patients	Drilling of IAC			Occurrence of post-surgical complications	Facial nerve function at discharge (RGS)			Facial nerve function at clinical follow-up (RGS)			QoL (GBI)		
		None	Slight	Important		I-II	III-IV	V-VI	I-II	III-IV	V-VI	Better	Equal	Worse
Group 1 (diameter < 25 mm)	31 (38.2%)	32%	46%	22%	9%	50%	39%	11%	92%	8%	0%	84%	13%	3%
Group 2 (diameter > 26 and < 40 mm)	39 (48.1%)	33%	54%	13%	17%	18%	51%	31%	55%	35%	10%	5%	41%	54%
Group 3 (diameter > 41 mm)	11 (13.5%)	30%	50%	20%	50%	20%	30%	50%	25%	62%	13%	0%	9%	91%

IAC: internal auditory canal; RGS: rough grading system; QoL: quality of life; GBI: Glasgow benefit inventory.

sion was made and the bony operculum repositioned. At the end of surgery, all patients were monitored within an intensive care unit (ICU) until the following day.

## Results

A total of 81 patients were included in the present study. Mean age at surgery was 52.8 years (SD  $\pm$  1.42) (range 19-84); 51% were male and 49% female. The pathology involved the left side in 55% of patients, and the right side in 45%.

Mean duration of symptoms (since the first symptom until radiological diagnosis) was 31 months (median, 24 months). Hearing loss was the most common symptom of VS in the majority of patients (65%). Tinnitus was the most common symptom in 18% and vertigo in 12% of patients. Concerning hearing capacity before surgery, the majority of our patients (68%) had an inadequate hearing level according to the guidelines of the American Academy of Otolaryngology Head and Neck Surgery (AAO-HNS) <sup>19</sup>. A retrosigmoid approach was performed considering the surgical experience of senior surgeons (LP, AP, GP), although hearing level was not serviceable in most patients. The most frequent presurgical comorbidity was arterial hypertension (28%) followed by diabetes (19%).

Accurate analysis of radiological features of lesions was performed by analysing the final preoperative MRI scan taken using gadolinium contrast agent. The mean diameter of the tumours was 27.65 mm (range 7-50 mm), also taking into account intracanalicular extension. Three different groups of patients were identified on the basis of tumour dimension:

- group 1 comprising small lesions < 25 mm: 31 patients (38%);
- group 2 comprising medium-sized lesions > 26 mm and < 40 mm: 39 patients (48%);
- group 3 comprising large lesions > 41 mm: 11 patients (14%).

A summary of post-surgical outcomes considering the different groups of patients is presented in Table I. Relative to internal auditory canal (IAC) involvement, 51 (63%) patients had a tumour occupying all of the IAC, 10 (12%) had a tumour occupying half of the IAC and 18 (22%) a tumour limited to the medial third of the IAC, while 2 (3%) of patients showed no involvement of the IAC. Drilling of the posterior portion of the IAC was necessary in 20% of cases.

Anatomical integrity of the facial nerve was present in 95% of all patients, while total resection of the nerve was necessary in 5%.

On the other hand, resection of the cochlear nerve was performed in the majority of patients. Anatomical integrity of the cochlear nerve was preserved in 32% of Group 1 patients and 9% of Group 2 patients. Of the 81 patients, according to the AAO-HNS classification, 78 patients had post-operative grade D with anacusis, 1 had grade B, 1 grade C, and 1 grade D with only residual hearing.

Tumour removal was macroscopically complete in all 81 patients considering both the intracisternal and intracanalicular areas.

Overall, 81% of patients had no complications after surgery. The main postsurgical complication was liquor-rhoea, reported in 8% of patients. Other complications were bleeding in the posterior cranial fossa (3/81, of which only 2 required a revision surgery), dizziness (5%), trigeminal deficit (4%), cranial nerve deficits (other than VII and VIII) (3%) and meningitis (2%).

Facial nerve outcome was evaluated in all patients at discharge. A mild level of deficit (I-II by the RGS) was observed in 30% of patients, a moderate deficit (III-IV) in 44% of patients and a major deficit (V-VI) was observed in 26%.

At clinical follow-up, 92% of patients in Group 1 showed good facial nerve function (I-II), while in the immediate postoperative period, only 50% in this group obtained this performance. Among patients in Group 2, 55% showed a

**Table II.** Correlation between facial nerve dysfunction and QoL (sec. Glasgow Health Status Inventory).

Facial nerve grade (sec. RCS)	Better QoL	Same QoL	Worse QoL	Total
Grade I-II	24 (49%)	13 (23%)	19 (34%)	56 (69%)
Grade III-IV	4 (20%)	7 (35%)	9 (45%)	20 (25%)
Grade V-VI	0%	1 (20%)	4 (80%)	5 (6%)

RGS: Rough Grading System; QoL: quality of life.

good facial nerve function (I-II) in comparison to 18% observed at discharge. For patients in Group 3, 25% showed good facial nerve function (I-II) at clinical follow-up, while at discharge only 20% of this group had obtained this performance. Moreover, in this latter group, it must be underlined that there was an important reduction in patients with severe facial nerve deficit (V-VI), which decreased from 50% at discharge to 13% at clinical follow-up, the majority (62%) showing a moderate facial nerve deficit (III-IV).

Overall, at follow-up evaluation, patients in our study showed a positive trend for facial nerve function recovery. In fact, subjects with good facial nerve function (I-II) increased from 30% at discharge to 69% at clinical follow-up. Subjects with moderate facial nerve deficit (III-IV) decreased from 44 to 25% and patients with severe facial nerve deficit (V-VI) decreased from 26 to 6%. Concerning additional motor disturbances related to facial nerve function, taste alteration and lacrimation deficit were both examined. Lacrimation deficit was predominant in comparison to taste alteration in all three groups of patients. No correlations were found between lesion dimensions and post-surgical headache.

Data obtained using the Glasgow Benefit Inventory (GBI) questionnaire showed that, for our patients, 25 (31%) felt better, 11 (14%) felt similarly, and 45 (55%) felt worse in comparison to the pre-surgical period. Concerning these data, no statistically significant differences were found between different age groups or social categories.

A significant correlation ( $p < 0.001$ ) was observed between QoL after discharge and tumour dimensions: 91% of patients in Group 3 complained of a worsening compared with the presurgical condition vs. only 3% of patients in Group 1.

Regarding correlations between facial nerve dysfunction and QoL, the Glasgow Health Status Inventory (Table II) showed that a worsening of QoL occurred in only 34% of subjects when a good function of the nerve was maintained (grade I-II). On the other hand, patients with severe facial nerve injury (grade IV-V) showed a higher frequency of QoL worsening with a rate of 45%.

The absence of vertiginous symptoms before treatment was significantly related to the worsening of QoL after surgery ( $p < 0.05$ ). On the other hand, the presence of vestibular imbalance before treatment was slightly correlated to this aggravation.

From the SF-36, a statistically significant difference was observed for QoL between our patients and the control group of healthy subjects ( $p < 0.05$ ).

Finally, only one case of tumour recurrence (1/81) was observed in our patients ( $< 2\%$ ).

## Discussion

### Quality of life

Although there are numerous definitions of QoL, there is general agreement that it involves the patient's subjective assessment of their life situation. The World Health Organization's definition of QoL states that it is an individual's perception of their position in life in the context of their own culture and value systems. The definition further outlines that QoL is a broad complex concept spanning the person's physical health, psychological state, level of independence, social relationships and their relationships with their environment<sup>20</sup>.

Larger tumours have traditionally been associated with greater surgical morbidity<sup>4</sup>. Irving et al.<sup>8</sup> demonstrated that overall postoperative QoL was worse for patients with a tumour size greater than 1.5 cm compared with those less than 1.5 cm. However, this has not been consistently demonstrated in many QoL studies<sup>3-5,9</sup>.

With the SF-36, a clear dissatisfaction was noted between our patients and the control group. In particular, our patients reported significant limitations in terms of physical function and mental health. However, we found no correlation between VS dimension and QoL after surgery. This finding is similar to those reported by Alfonso et al.<sup>9,21</sup>.

Nevertheless, in contrast to the SF-36 questionnaire, the GBI showed an important relationship between tumour dimension and QoL after surgery. In fact, only 3% of patients with a small VS (Group 1) complained of worsening of QoL, while 54% of patients in Group 2 and 91% in Group 3 referred poorer QoL.

With the Italian version of the GBI and GHSI, 55% of our patients reported a poorer QoL. This result is similar to that reported in other studies<sup>4,11</sup>.

In our study, no correlation was found between QoL and different age groups, occupation, or the patient's qualifications. This result is in contrast with those of Nikolopoulos et al.<sup>4</sup> who found an improvement in postoperative QoL in older patients compared with younger patients. On the other hand, Tufarelli et al.<sup>22</sup> noted that patients



over 45 years of age perceived a worsening of QoL after VS surgery.

Another interesting finding from our analysis concerns subjects who achieved an improvement in symptoms after surgery. Overall, 31% of our patients felt better after tumour removal and, in particular, 84% of these had small lesions (Group 1).

Many patients undergoing surgical intervention for VS feel significantly affected by facial weakness and consider it one of the most difficult aspects of recovery<sup>23</sup>. It is well-known that tumour size is correlated with postoperative facial nerve outcome for VS<sup>24,25</sup>. In this context, it is surprising that several studies failed to demonstrate a statistically significant correlation between tumour size and patient-perceived QoL measures<sup>26</sup>.

Concerning facial nerve function, our results demonstrated a statistically significant difference in QoL obtained by subjects with good facial nerve outcome (grade I-II) in comparison to those with severe nerve damage (grade V-VI). Our data also confirmed that wider tumours with involvement of the IAC are much more commonly associated with post-surgical facial motor dysfunction. This concept should be considered when planning treatment for individual patients, especially when deciding to switch from a 'wait and scan' policy to one of surgical removal. Similar results were reported by Falcioni et al.<sup>27</sup> Those authors observed that the results for lesions larger than 3 cm were not satisfactory in a high percentage of cases; in fact, in this group of patients, there were still 12.1% of cases in which the facial nerve was interrupted plus an additional 20.6% of RGS Grades IV-VI 1 year after surgery in cases with anatomical preservation of the nerve.

#### *Facial nerve function outcomes*

With advances in facial nerve monitoring and surgical techniques for small- and medium-sized tumours, long-term facial nerve preservation rates are reported to be greater than 90%, but which is substantially lower for large tumours<sup>28</sup>. Rates of anatomic preservation are now routinely greater than 90%, although even with anatomic preservation of the nerve functional deficits may still occur<sup>23</sup>.

Despite the fact that total integrity of the facial nerve was obtained in 95% of our patients with a normal electric response at nerve integrity monitoring, only 30% had attained good facial nerve function (grade I-II) at discharge. Nevertheless, our study confirmed the real possibility of recovery during the months following surgery. In fact, at first evaluation 6 months after the operation, the proportion of subjects with grade I-II RGS function increased to 48%. This was more evident in patients in Group I (92% from a previous rate of 50%) compared with subjects in Groups 2 and 3.

Interestingly, we did not observe any correlation between the presence of extra motor symptoms and grade of facial nerve dysfunction. In a publication from 2003, Yen et al. noted the same finding<sup>29</sup>.

#### *Vertigo and dizziness*

A few studies have attempted to correlate validated QoL measures with balance dysfunction. Nicoucar et al.<sup>25</sup> reported that patients with balance problems had lower scores in all 7 categories of the SF-36 questionnaire with values for social functioning and vitality being statistically significant.

A study conducted by Rigby et al.<sup>30</sup> on patients' perception of the impact of postoperative symptoms on activities of daily life revealed that balance dysfunction was the most significant symptom for 14.3% of patients, ranking second to hearing loss. Its impact was rated as even more significant than that of facial weakness.

In our study, the presence of vestibular imbalance was also an important aspect closely related to QoL during the post-surgical period. From our data, it can be noted that a higher percentage of patients who did not complain of vertigo before surgery reported a worsening of QoL (57%) in comparison to subjects who had already experienced vertiginous attacks (26%).

#### *Headache*

Concerning headache, we verified that, in our patients, it did not have an important impact on ability to work and perform normal activities after discharge. In particular, the overall percentage of subjects complaining of disabling headache was 6%. This result appears to contradict previous studies<sup>21,24</sup> that reported higher rates of headache during the follow-up period. We hypothesise that this finding could be related to the lower number of subjects who underwent drilling of the posterior wall of the internal auditory canal.

#### *Hearing function*

Hearing preservation represents a difficult outcome of this surgery<sup>31,32</sup>. The hearing loss that occurred in 95% of our patients after surgery did not appear to be related to better or worse QoL. The high rate of hearing loss, which is lower in some reports, reflects our policy of surgical radicality (100% of subjects had total removal of the tumour). Hearing preservation in patients with medium or large sized acoustic neuromas in the authors' experience is not very likely. Actually, although in selected patients with small tumours and good preoperative hearing good tonal audiometry can be achieved post-operatively, in most of these patients poor post-operative vocal audiometry performances prevent satisfactory results.

#### *Considerations on the role of endoscopy*

Special mention must be made about the rate of liquorrhoea in our patients after surgery. In fact, this complication was present in 8% of patients, which is lower in comparison to data reported in other studies<sup>33,34</sup>. In our opinion, this outcome is closely connected to better visu-

alisation of the air cells guaranteed by the endoscope in the case of a highly pneumatized posterior wall of the internal auditory canal. We must also consider that drilling the posterior portion of the IAC was necessary in only 20% of patients, thanks to the use of endoscopic visualisation, and partially due to the erosion of the IAC by the enlarging neoplasm, which facilitated endoscopic procedures to the intracanalicular portion of the mass.

In this particular condition, endoscopic view allows us to note damage occurring to this area and permit its prompt sealing. Moreover, by using 45 and 30° endoscopes during the intrameatal phase, we could clearly visualise the extent of the tumour within the internal auditory canal, allowing its complete removal in all cases.

The possible disadvantages related to an endoscopic approach to VS are still debated. Application of the endoscope seems to be associated with risks of iatrogenic neural or vascular injury<sup>35</sup>, and King and Wackym<sup>36</sup> reported the possibility of thermal injury caused by heat generated by the light of the endoscope. Nevertheless, thermographic evaluation by Hori et al.<sup>37</sup> did not reveal a significant increase in local temperature using an endoscope. Gerganov et al.<sup>38</sup> concluded that the application of the endoscope does not lead to heat-related or mechanical neural or vascular injuries, because the risk of loss of waves I, II, and V, both transiently or permanently, did not depend on application of the endoscope and was similar in the endoscope-assisted group and the no-endoscope group.

## Conclusions

In conclusion, tumour size seems to be the most relevant factor influencing both facial nerve function and QoL outcomes after VS surgery. In fact, a consistent percentage of our patients with large tumours did not obtain good (RGS Grade I or II) facial nerve function postoperatively and showed QoL outcomes that were clearly worse compared with patients treated for smaller lesions. Nevertheless, this study showed the real possibility for many subjects to recover and improve facial nerve function during the months following the operation. Finally, even when good facial nerve function was obtained and important complications were avoided, our report underlines a possible decline in the patient's QoL. For this reason, patients undergoing VS surgery must always be aware of this possibility and their surgical selection should be carefully evaluated.

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