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Safety and usefulness of flexible hand-held laser fibers in microsurgical removal of acoustic neuromas (vestibular schwannomas)

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ABSTRACT

Aims

We performed a retrospective non-randomized study to analyze the results of microsurgery of acoustic neuromas (AN) using two different flexible hand-held laser fibers, CO_2 (Omniguide®) and 2 μ-Thulium (Revolix jr®).

Methods

From September 2010 to June 2015, 84 patients suffering from AN have been operated on with microsurgical technique via retrosigmoid (RS) approach. In 42 cases tumor resection was performed with the assistance of hand-held flexible laser (L-group): in 8 cases CO_2-fiber and in 34 2 μ-Thulium-fiber.

Fortytwo patients, operated on without laser-assistance, were used as comparison group (C-group) (matched-pair-technique).

Facial nerve function was assessed with the House-Brackmann (HB) scale preoperatively, 1 week postoperatively, and 6-month or more after surgery.

Results

Overall time from incision to skin suture changed in relation to size of tumor (165–575 min) and was not affected by the use of laser. In 2 cases preoperative facial nerve palsy was observed. In the remaining 82 cases, at 6-month follow-up facial nerve preservation rate (HB I) was 90.2%. Hearing preservation rate (AAO-HNS A/B classes) was 68.4% (26 out of 38). Adopting a 0–3-scale, the mean surgeon satisfaction rate of usefulness of laser fiber was 2.64.

Conclusions

The use of a hand-held flexible laser fiber in AN-microsurgery seems to be safe and subjectively facilitates tumor resection especially in "difficult" conditions (e.g., highly vascularized and hard tumors). In this limited retrospective trial, the good functional outcome following conventional microsurgery had not further improved, nor the surgical time reduced by laser. Focusing its use on "difficult" (large and vascularized) cases may lead to different results in future.

1. Introduction

The treatment of acoustic neuromas (AN) or, more anatomically correct, vestibular schwannomas, has gradually changed during time, from life-saving measures to preservation of function and quality of life. In particular, further developments in the last decades have shown that the retrosigmoid approach is a safe and efficacious method for surgery on AN of all sizes: intracanalicular without or with extrameatal extension, without and with brainstem contact and compression [1,2]. Preservation of hearing and facial nerve functions are now primary goals in microsurgical treatment of these tumors, especially in patients with AN having maximum diameter inferior to 2 cm [3,4]. Complex tumors make it challenging to achieve these goals, e.g. in cases of (1) Large tumors size, (2) strong adherence of tumor to facial, cochlear nerve, and brainstem; (3) hard consistence; or (4) high vascularization, with enhanced bleeding during excision [4].

The laser has been a well-established instrument in different surgical fields for over 40 years [5–8]. Laser surgery in general showed various advantages, such as reduction of mechanical trauma and minimization of intraoperative bleeding. A major advance in making lasers more applicable to neurosurgery came with the introduction of continuous-wave lasers and improved delivery systems [7]. This type of laser energy eliminated the explosive effects of pulsed-wave lasers and allowed accurate cutting and vaporization by using focused beams, without the need to handle or retract the tissue [29]. The development of flexible CO_2 laser fibers in 2005 [9–11] transformed it in a hand-held tool, bringing the CO_2 laser back to neurosurgery [6,7,12]. The new devices offer the possibility of guiding the laser beam by small and variable handpieces for direct microsurgical application [7,13–15].

Recently, 2 μ-Thulium laser showed to be an useful device in the surgery of intracranial meningiomas [13], especially for debulking, shrinking, and coagulating the mass and its basal implant.

The technique of laser vaporization and cutting of AN offers the possibility of removing large parts of the tumor without direct manipulations at the tumor mass itself, thus reducing the mechanical trauma

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to the adherent seventh and eighth cranial nerves during preparation. In addition, Sameshima et al. [15] and Passacantilli et al. [13,16] demonstrated that laser is more precise and less damaging the surrounding tissues than conventional bipolar cauterization.

First reports on brain tumors [5,7,13,14,16–21] and on AN operated on by middle fossa approach [22] and our own experience with these two hand-held laser fibers has been the rationale for applying this surgical tool in "key hole" retrosigmoid AN surgery too. According to the literature and to our limited experience, direct tumor laser ablation seems to reduce mechanical manipulation of tumor itself, bipolar coagulation and ultrasonic aspiration, limited direct cutting with microscissors and could lead to better surgical results, expecially in "complex" ANs.

2. Materials and methods

2.1. Patients data

Forty-two consecutive patients with AN were enrolled in the study (L-group). Inclusion criteria were: clinical and MRI diagnosis of AN and age of 18 years or older. Hearing preservation was attempted if functional hearing was AAO class A or B [23] in the affected side.

In L-group all patients were operated on by microsurgery combined with assistance of two different flexible hand-held laser fibers, CO_2 (Omniguide®) and 2 μ-Thulium (Revolix jr®), using the retrosigmoid (RS) approach, between July 2012 and June 2015.

The 42 patients of L-group were compared to a matched C-group of 42 patients operated on by the same approach, with microsurgical technique, without laser assistance between September 2010 and June 2012. After this date, all cases with intracanalar ANs having maximum diameter 1 cm or less have been operated on without laser assistance and included in the C-group too. Demographic data was collected and the patients were asked about the symptoms of hearing loss, tinnitus, vertigo and other possible related neurological symptoms.

2.2. Determination of tumor size

Each patient received an MRI scan not exceeding 1 month pre-operatively. Tumor was measured in three spatial dimensions (on axial and coronal MRI section planes) and tumor size was estimated considering its major diameter, including the extension in the internal auditory canal.

2.3. Facial nerve function

Facial nerve function was assessed pre-operatively, 1 week p.o. and 6 months p.o. using the House-Brackmann [24] (HB) classification (1: normal; 6: total paralysis).

2.4. Audiological data

In patients selected for hearing preservation (AAO class A or B) [23] audiological exams were performed pre-operatively as well as 1 week and 6 months p.o. by pure tone audiometry (PTA), auditory brainstem response (ABR), and monosyllabic speech audiograms.

2.5. Surgeon's evaluation of hand-held laser usefulness

The surgeon satisfaction rate of usefulness of hand-held flexible laser fibers was evaluated adopting a 0–3-subjective-rating-scale (0 = not useful; 1 = moderately useful; 2 = useful; 3 = very useful).

2.6. Intra-operative procedures

2.6.1. Monitoring of facial and cochlear nerves

In all cases facial nerve monitoring was used during the entire surgical procedure (Nimbus i-Care 100®, IntraOperative Neurphysiological monitoring, Newmedic division of Hemodia, Labege, France), with electrodes inserted in orbicularis oris and orbicularis oculi muscles. The nerve stimulation was performed with monopolar (on the surface of tumor) or bipolar (close to the nerve) stimulator, starting from 2mAmp or more (on the capsule dorsal surface, for nerve course localization) to 0.3–0.05 mAmp (directly on the nerve, for confirmation of its function).

As well as locating the course of the facial nerve, intraoperative monitoring of facial nerve helped in driving the use of laser fiber.

Each patient selected for hearing preservation received an ABR audiometry (Nicolet Viking III®, Viasys HealthCare, Madison USA/ Hochberg Germany) the day before surgery. In the last 9 cases we used ABR neuromonitoring evoked with CE-Chirp® stimuli (Interacoustics Eclipse EP15 ABR system, Assens, Denmark) [25]. In both L- and C-groups there were 38 patients AAO class A or B, with reproducible responses that allowed a continuous intra-operative ABR-monitoring of the cochlear nerve.

2.6.2. Retrosigmoid approach

All operations were performed using the RS approach with patient in lateral position [4,15]. Continuous lumbar drain was placed in cases operated on for larger tumors (maximum diameter greater than 3 cm) and was left in place for 3–4 days to facilitate cerebellar relaxation during surgery and postoperative wound closure (draining around 10cc/hour).

After a slightly curved 5–6 cm skin incision behind the ear, about 1 cm posteriorly to the mastoid and preparation of a free pericranial flap for dural closure, the retrosigmoid-retromastoid lateral occipital bone was exposed including superior and inferior nuchal lines [4,15]. About 3 × 3 cm craniectomy was performed in all cases, exposing sigmoid and transverse sinuses and the angle between them. The RS dura was opened in a semicircular shape, followed by lateral medullary cistern arachnoid opening for cerebellar detension by cerebrospinal fluid (CSF) aspiration. When adequate relaxation of cerebellar hemisphere was obtained, the tumor surface was exposed, with or without retractors, and possible position of facial nerve was searched with the use of nerve stimulator.

After cutting the dura covering the roof of internal auditory meatus (using the laser fiber in L-group), the canal was unroofed by means of a 4 mm extracoarse diamond burr or, more recently, with Sonopet® Ultrasonic Aspirator (Stryker, Kalamazoo, MI) with dedicated bone tips. The canal was unroofed 7–8 mm in medio-lateral direction and 5–6 mm in superior-inferior direction [4,15]. A V-cut was performed [15] on the dorsal surface of tumor capsule with laser fiber (L-group) or with microscissors (C-group) and debulking of tumor was performed, with microscissors, microcurettes, bipolar forceps, Sonopet® Ultrasonic Aspirator (56 cases, usually with a maximum diameter higher than 2 cm) and hand-held laser (in L-group) for vaporizing and cutting. With standard microsurgical instruments (sharp dissectors, sickle knife, McElveen knife, stright and curved microscissors, ring and cup curettes) the tumor was separated from brainstem and cranial nerves during continuous facial and -in selected cases- cochlear nerve monitoring.

In cases with strong adhesion to brainstem and/or facial nerve, a millimetric fragment of tumor capsule was left.

Accurate hemostasis and tight dura closure using pericranial graft, haemostatics and sealants were performed and a fitted titanium net or the bone operculum was placed on the craniectomy with miniscrews in all cases.

2.6.3. Flexible CO_2 laser system

In 8 cases of L-group, tumor incision and resection were performed using the hand-held CO_2 flexible laser fiber provided by Omniguide® (Omniguide Inc., Cambridge, MA, USA). The start setting was 3 W to a maximum of 18 W, in a continuous wave mode, with 70 psi pressure of helium gas for cooling the laser fiber (which is hindered in its function by the presence of water). Using the laser beam, the tumor mass was vaporized, keeping a safe distance of at least 2 mm to the facial and cochlear nerves. In 25 larger tumors the Sonopet Ultrasound Aspirator helped in intracapsular debulking. Following tumor reduction, the remaining tumor capsule was removed with standard microsurgical tools.

We decided to stop the use of CO_2 and to continue the study with flexible 2 µ-Thulium laser fiber because of its higher coagulating power (in comparison to CO_2) and similar cutting and vaporizing properties in tumors with the same consistency of ANs. We continued to use CO_2 laser in hard-fibrous and low-bleeding intracranial and spinal meningiomas.

2.6.4. Flexible 2 µ-Thulium laser system

In 34 cases of L-group, the capsule incision and tumor debulking was performed with hand-held 2 µ-Thulium flexible laser fiber (Revolix jr®, Lisa laser USA, Pleasanton, CA, USA). The range of power setting was 1–14 W. Standard 0.9% saline solution irrigation was used for cooling the laser fiber (which is *not* hindered in its function by the presence of water). The fiber was used for cutting, vaporizing, and coagulating the capsule and the intracapsular mass, in combination with bipolar forceps, microscissors and Sonopet Ultrasound Aspirator (in 31 cases). Following tumor debulking, the remaining tumor capsule was removed with standard microsurgical tools.

2.6.5. Determination of tumor removal and of procedure time

The amount of tumor removed was assessed by surgeon's opinion and by postoperative contrast enhanced (c.e.) MRI performed within 48 h after surgery and at 6 month followup. The removal has been classified as total (100%), nearly-total (99%: millimetric residual frequently not detectable by MRI), subtotal (90%), and partial (less than 90%).

Total operation time was defined as the period lasting from skin incision until the end of skin suture.

2.6.6. Statistical analysis

Each patient of L-group was matched to a patient of the above described C-group. After matching, a paired sample t-test was performed. For categorical analysis, a Chi-square test was used to calculate differences in facial nerve and hearing preservation rates.

3. Results

3.1. Demographic and clinical data

Demographic, clinical, and MRI data were substantially comparable in the two main groups and in the two laser subgroups, with the exception of mean maximum tumor size (including the extension into the internal auditory canal): 2.0 cm in C-group and 2.8 cm in L-group (2.8 in L-group–2 µ-Thulium subgroup, and 3.0 in L-group-CO_2 subgroup) (p = NS). The mean maximum diameter of the entire cohort was 2.4 cm.

In L-group, 20 females and 22 males were included. Mean age was 53.3 years, and mean duration from first symptoms (hearing loss, tinnitus, vertigo, hemifacial numbness) until operation was 17.9 months; in 8 cases the tumor had one or more cysts inside. According to Samii's grading classification (34), the tumor belonged to grade II in 16 cases, grade III in 17, and in grade IV in 9; no patients in class I. In 6 patients, preoperative clinical or electomyographic (EMG) evidence of facial nerve impairment was observed. A serviceable preoperative hearing (AAO-HNS A and B classes) was present in 16 patients.

In C-group, 15 females and 21 males were included. Mean age was 48.4 years, and mean duration from first symptoms (hearing loss, tinnitus, vertigo, hemifacial numbness) until operation was 21.3 months; in 5 cases the tumor was cystic. The tumor was grade I in 8 cases, II in 21, III in 10, and IV in 3. A clinical or EMG facial involvement was detected preoperatively in 3 cases and the preoperative hearing was serviceable in 22 patients.

3.2. Tumor removal and operation time

Total tumor removal could be possible in 20 cases of L-group and in 25 of C-group. In accordance with patient's will, neither facial nor cochlear nerve (in cases of serviceable hearing) was sacrificed in order to obtain entire tumor resection. In relation to this consideration, a nearly-total or subtotal (99–90%) resection was performed in 15 cases of L-group (total + nearly total + subtotal in 35 cases: 83.3%) and in 11 of C-group (total + nearly total + subtotal in 36 cases: 85.7%).

In 7 cases of L-group and in 6 of C-group a partial removal (less than 90% of tumor) was only possible, because of tenacious adherences of tumor to brainstem and to facial nerve; in all these cases, the tumor had a maximum diameter bigger than 4 cm. The remnants were located into the conduct, or along the facial nerve or adherent to brainstem.

Mean operation time (from incision to suture) changed in relation to size of tumor and ranged from 165 to 575 min (mean 325): it was 335 min (SD 45.5) in L-group and 320 min (SD 57.0) in C-group, with no statistical difference.

Mortality and major permanent morbidity were zero. In 3 patients a transient abducens nerve (6th cranial nerve) palsy was observed, recovered within 6 month. In 2 patients with large AN (3.5 cm and 4.5 cm maximum diameters, respectively) swallowing disorders recovered completely within 3 months. In 5 patients (2 of L-group and 3 of C-group) a CSF leak from the surgical wound was observed and was resolved in all but one with continuous lumbar drain for 5–6 days. In 1 case a surgical revision of the wound with dural repairment was necessary. In 2 patients a transient rhinoliquorrea started 3 days after surgery and was successfully treated with continuous lumbar drain and prophylactic antibiotics.

3.3. Facial nerve function

Table 1 summarizes the facial nerve results in the entire cohort and in the two subgroups.

All patients were considered as HB1 pre-operatively, except 5 patients in L-group and 3 in C-group who had a newly diagnosed HB2 to HB4 facial palsy or, in 2 cases, a preoperative involvement of facial nerve on EMG.

At minimum 6-month postoperative follow-up, 36 patients of L-group had HB1 facial nerve function and 6 a paresis (4 with new postoperative deficit and 2 out of the 5 with preoperative deficit) classifiable as HB2 (2 cases), HB3 (1 case), HB4 (3 cases). In 15 cases the facial function was HB1 immediately after surgery; in these cases the mean maximum diameter of tumor was 2.3 (versus 3.0 cm of cases with transient deficit; $p < 0.05$). Therefore, on considering 40 patients (2 excluded because of a pre-existing facial nerve deficit), the day after surgery a normal face was observed in 37.5% of patients and at last follow-up in 90%.

At the same interval follow-up control, 38 patients of C-group (90.5%) had HB1 facial nerve function and 4 had a paresis ranging from HB2 (2 cases) to HB4 (2 cases). In 27 cases (64.3%) a normal function of facial nerve was observed immediately after surgery. In these cases, the mean diameter of AN was 1.7 cm versus 2.9 cm of cases with transient HB2-HB3 facial palsy, recovered at the 6-month clinical control ($p < 0.05$). When patients returned to normal face mobility, we never observed severe and permanent contractures.

In conclusion, on considering the whole series, 90.2% of patients had a HB1 facial function at minimum 6-month postoperative follow-up and the differences between the two main groups are not statistically relevant (p = NS).

3.4. Hearing results

3.4.1. Preoperative hearing status was comparable in both cohorts

L-group consisted of 16 patients with serviceable preoperative hearing (AAO-HNS A and B classes). Among these, after operation 11 of them presented a hearing competence as before operation (68.7%).

In C-group 15 out of 22 patients had AAO-HNS A and B postoperative hearing (68.2%). Also for this function, the difference is not significant (p = NS).

In conclusion, on considering the whole series, hearing preservation was possible in 68.4% of the entire cohort.

Table 1.
84 cases of acoustic neuromas operated on with (L-group) ans without (C-group) hand-held laser fiber assistance. Postoperative facial nerve funcion.

	MMD	Postop. HB1 (early and late control)	Immediately HB1 and MMD	6-month follow-up HB1 and MMD[a]	*p*
L-group	2.8 cm	90.0%	37.5%–2.3 cm	52.5%–3.0 cm	<0.05
C-group	2.0 cm	90.5%	64.3%–1.7 cm	26.2%–2.9 cm	<0.05
Entire series	2.4 cm	90.2%	50.0%–2.0 cm	40.2%–2.9 cm	NS

Legend: MMD = mean maximum diameter.

[a] Percentage of patients HB2 or HB3 immediately after surgery, recovering at the 6 month(or more) follow-up.

3.4.2. Surgeon's satisfaction rates

The mean surgeon satisfaction rate of usefulness of hand-held laser fiber was 2.64 (ranging from 0 to 3): it was 2.67 in L-group–2 μ-Thulium subgroup, and 2.5 in L-group-CO_2 subgroup (p = NS).

In particular, the use of a hand-held flexible laser fiber appeared to be safe. It subjectively facilitates the tumor resection especially in "difficult" conditions (e.g., highly vascularized and hard tumors), avoiding traction and continuous suction, even if the good functional outcome following conventional microsurgery had not further improved, nor the surgical time reduced.

4. Discussion

Decision making of treatment of AN gradually changed over the years. Introduction of MRI into routine diagnostics of hearing disturbances have led to increasing numbers of AN being detected at an early stage. It is still an open question whether these small tumors really need treatment or not (wait-and-scan option), but irreversible hearing loss must be expected more than 50% of the patients in the course of time [26–33].

Nowadays, the available treatments are: surgical excision, radiosurgery (gamma-knife and Cyber-knife) [34,35], and "wait and see" option. In accordance with some experienced groups [3,4,15,36], we recommend radiosurgery as first treatment only in growing recurrent tumors in patients not suitable for re-surgery because of compromised general conditions. In patients with small tumors (under 2 cm of maximum diameter) with complete loss of hearing we suggest to wait and control the possible growth of tumor with serial MRI, especially if they are older than 65 years. In patients with larger tumors or with small tumors with a serviceable hearing we usually suggest surgical removal.

Life-threatening complications related to surgical treatment of ANs are rare and preservation of functions is the goal to be achieved [3,4,36]. Anyway, patients with larger tumors compressing and displacing brainstem are more challenging and other possible postoperative side effects have to be considered, such as trigeminal, abducens, and lower cranial nerves deficits. Except of 9.8% of patients with permanent HBII-HBIV facial palsy, in our series no major complications nor permanent neurological deficits have been observed; in 7 patients minor complications were related to CSF circulation (wound fistulas and rhinoliquorrea), in all but one cases resolved conservatively.

The availability of intra-operative cochlear and facial nerve monitoring has improved the preservation rates for facial and cochlear nerve function, if patients had a serviceable preoperative hearing (AAO-HNS A and B classes). In our series, we obtained quite satisfying results for facial nerve outcome and hearing preservation in both groups.

Laser assisted AN surgery has been advocated in several studies, mostly using a retrosigmoid and/or translabyrinthine approach [12,37,38] and in the literature there is no completely uniform opinion on an additional advantage of this special non-contact tool. Discussion of the value of hand-held laser assistance in AN surgery for facial nerve outcome has been heterogeneous to date. Cerullo et al. [12] and Eiras et al. [37] demonstrated some advantage with its use in patients with larger tumors. Nissen et al. [39] reported a normal facial function in 90% in tumors smaller than 1.5 cm. On the other hand, Zaouche et al. [38] described a slightly worse outcome in AN of operations performed with a laser fiber.

In our series, at minimum 6-month follow up, HB1 facial nerve function was observed in 90.2% of cases: 90.0% of patients of L-group with normal preoperative facial function and 90.5% of patients of C-group in the same preoperative conditions. In detail, the day after surgery a normal face was observed in 37.5% of L-group patients and in 64.3% of C-group. The temporary worse result of immediately postoperative facial function obtained in L-group seems to be in relation to the dimensions of AN (Table 1). This explanation is also more convincing if we consider the smaller dimensions of tumors of C-group (mean maximum diameter: 2.0 cm): in particular, 27 cases with immediately normal function had a mean maximum diameter of 1.7 cm (versus 2.9 cm in cases with transient palsy) ($p < 0.05$).

The temporary palsy is in relation with necessary microsurgical dissection during separation of tumor from the nerve. The intensity of mechanical manipulations depends on the conditions of facial nerve and on the adherence of the tumor shell to the nerve itself and, consequently, on tumor dimensions. Our long-term rate facial results were similar in both groups and comparable to other reports [1,4,28,36,38,40–42]. Therefore, the use of the laser in proximity of the nerve seems to be safe enough in the RS approach, especially if surgeon always has a direct view of the facial nerve.

The same findings apply for the necessary manipulations of the cochlear nerve. Results of hearing preservation in AN-surgery have also improved over the past decades, especially in treatment of smaller tumors. In our series, the recent use of intraoperative ABRs with CE-Chirp stimulus [25] improved the intraoperative monitoring of hearing, with quick brainstem evoked responses after the stimulus. For attempting hearing preservation we selected patients belonging to classes A and B of the AAO-HNS classification [4,23,33,43,44]. In both L- and C-group, the preservation was possible in about 2/3 of cases (68.7% and 68.2%, respectively). The lack of difference between the two groups seems to be in relation to the evidence that a hearing preservation is feasible if tumor maximum diameter does not trespass 2.0 cm [3,4,45,46], even if in selected patients with larger tumor it is possible obtaining this goal as well.

Eiras et al. [37] compared resection time with or without laser fiber in giant AN operated by RS approach. They report that laser resection takes longer as well. On the contrary, in our series the operation time was not influenced by hand-held laser assistance. Total operation time was 165–575 min (mean 325) and it was very similar in both groups: 335 min (SD 45.5) in L-group and 320 min (SD 57.0) in C-group, with no statistical difference. Vascularization of the tumor as well as its adherence to the facial and cochlear nerves may lead to prolonged resection time, either by more haemostatic procedures or, what seems to be the most important factor, by repeated interruptions during tumor removal due to worsening of intra-operative facial and ABR responses, which necessitate recovery periods for the nerves without any further microsurgical manipulations.

In our limited experience, the use of a hand-held flexible laser fiber seemed to be safe and the usefulness judged by mean surgeon satisfaction rate was 2.64 (ranging from 0 to 3), 2.67 in L-group–2 μ-Thulium subgroup and 2.5 in L-group-CO_2 subgroup (p = NS). In some of the cases the use of the laser was considered very helpful and, subjectively, laser fiber (in particular the 2 μ-Thulium laser) facilitated the tumor removal especially in “difficult” conditions (e.g., highly vascularized and hard tumors), avoiding traction and continuous suction with ultrasonic aspirator. Anyway, on the retrospective analysis, the good functional outcome following conventional microsurgery had not further improved nor the surgical time reduced by laser fibers.

On considering a cost analysis evaluation, the use of hand-held flexible laser fiber adds a further cost to the operation, in addition to those of ultrasonic aspirator we always use for opening of IAC (bone tip) and for debulking the low-consistency portions of large AN (soft-tissue tip). Anyway, the costs of laser fiber, especially of the 2 μ-Thulium laser, are relatively acceptable; moreover, every 2 μ-Thulium laser fiber is not single use, reducing the costs charged for any procedure.

On the basis of our preliminary experience, it seems to be reasonable to recommend the use of hand-held flexible laser fiber in large and vascularized cases, in which this tool promises better results in the future.

5. Conclusion

In our limited retrospective series, the use of flexible hand-held laser fibers in AN surgery by RS approach is a safe procedure, but had no significant influence on postoperative facial nerve function, hearing preservation rate or surgical time. On the other hand, according to surgeon impression, in highly vascularized tumors the necessary reduction of tumor volume before microsurgical dissection of facial and cochlear nerve appears to be easier with flexible hand-held laser fiber in association with ultrasonic aspirator and microsurgical dedicated instruments.

Conflict of interest

All authors certify that they have NO affiliations with or involvement in any organization or entity with any financial interest (such as honoraria; educational grants; participation in speakers' bureaus; membership, employment, consultancies, stock ownership, or other equity interest; and expert testimony or patent-licensing arrangements), or non-financial interest (such as personal or professional relationships, affiliations, knowledge or beliefs) in the subject matter or materials discussed in this manuscript.

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