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Vestibular Schwannomas Microsurgery Assisted by Flexible Hand-Held 2 micro-Thulium-Fiber Laser

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ABSTRACT

Background: Vestibular Schwannoma (VS) is one of the skull base tumors originating from vestibular portion of eighth cranial nerve. Recently, 2 micro-Thulium laser is used in the surgery of some intracranial tumors.
Objectives: Assessing the efficacy of 2 micro-Thulium flexible hand-held laser fiber (Revolixjr®) in microsurgical removal of VS.
Materials and Methods: This retrospective non-randomized study was carried out from July 2012 to November 2015. 39 patients with VS had been operated on with microsurgical technique via retro-sigmoid approach. 2 micro-Thulium-fiber hand-held flexible laser was used for tumor resection in 39 cases. Facial nerves function by House-Brackmann (HB) scale and hearing state were assessed preoperatively and 1 week and 6-month postoperatively.
Results: Overall time of surgery changed only in proportion with the size of tumor (185-575 minutes) and was not affected by the use of laser. In 5out of 39cases, preoperative facial nerve palsy HB2, and in one case HB4 (permanent) was observed. On considering 38 cases, at 6-month follow-up facial nerve preservation rate (HB1) was 92.1% (from May 2015 all patients had not postoperative facial palsy). Hearing preservation rate was possible in 12 out of 15 cases with previously acceptable preoperative hearing state (AAO-HNS A and B classes). The mean surgeon satisfaction rate of usefulness of this technic was 2.7 in a 0-3-scale
Conclusions: A good functional outcome including facial nerve preservation and hearing preservation was obtained by micro-Thulium-fiber hand-held flexible laser microsurgery.

Keywords: Vestibular Schwannoma; Facial Nerve Preservation; Hearing Preservation; 2-micro Thulium Laser

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Introduction

Vestibular Schwannoma (VS) is one of the skull base tumors located in cerebro-pontie angle (CPA) originating from vestibular portion of eighth cranial nerve in internal auditory canal and considered as a retro-cochlear etiologies of sensorineural hearing loss. Its first symptoms include hearing loss (sometimes sudden deafness), tinnitus, and vertigo or hemifacial numbness [1-3].

Nowadays the aim of vestibular schwannoma surgery is preservation of function and quality of life beside to its life-saving objective. Especially the new neurosurgical approach through retro sigmoid approach, is safe and effective for all VS with all different sizes [4,5]. Preservation of facial nerve and hearing functions has always been the most important objectives in treatment of these tumors, especially for small VS less than 2cmin diameter [6,7]. In special conditions such as strong adherence of the tumor to facial and/or cochlear nerves, or brainstem, hard consistence, or high vascularization with continuous bleeding during excision, reaching these goalsand objectives may be very difficult [7].

Laser surgery in different surgical fields showed various advantages, such as reduction of mechanical trauma and of intraoperative bleeding. Laser proved to be more precise and less damaging the surrounding tissues than conventional bipolar cauterization [8,9,10].

Introduction of continuous-wave lasers with flexible hand-held fiber made lasers more useful in different field of neurosurgery [11-14]. Its superiority comes from avoidance of the explosive effects of pulsed-wave lasers and accurate cutting and vaporization by using focused beams, without the need to handle or retract the tissue [15]. At first introduction of flexible CO_2 laser fibers offered the possibility of guiding the laser beam by small and variable hand-held devices [9, 12,13,16-20].

Recently, 2 micro-Thulium laser is used in the surgery of intracranial meningiomas, especially for debulking, shrinking, and coagulating the mass and its basal implant [8]. The most using approach on brain tumors and VS operated through middle fossa [11,13,8,20,10,21-26]. Our own experience with 2µ-Thulium hand-held laser fiberin intracranial tumor surgery have been the rationale for applying this tool in “key hole” retrosigmoid removal of VS. Direct tumor laser ablation reduces mechanical manipulation of tumor. Bipolar coagulation and ultrasonic aspiration leads avoidance of direct cutting of tumor.

Materials and Methods

Patients’ data

Thirty-nine consecutive patients with VS having maximum diameter of 1 cm or less included in this retrospective non-randomized study between July 2012 and November 2015. Inclusion criteria were: clinical and MRI diagnosis of VS, age of 18 years or older and hearing preservation. The last was defined as AAO class A or B [27] in the affected side. Demographic data and the symptoms of hearing loss, tinnitus, vertigo and other possible related neurological symptoms were registered in a designed checklist.

Microsurgical technique in retrosigmoid (RS) approach, with assistance of 2µ-Thulium flexible hand-held laser fiber (Revolixjr®) was used.

Determination of tumor size

By MRI scan not exceeding 1 month before admission the tumor size was measured. It was estimated by measuring its three major spatial dimensions detected on axial and coronal MRI section planes. The part of tumor extending into the internal auditory canal also was considered in calculation.

Facial nerve function

Using the House-Brackmann (HB) classification facial nerve function was assessed preoperatively and 1 week and 6-month post operatively (clinically and with EMG), (1: normal; 6: total paralysis). In this classification both clinical and electro-diagnostic conditions were considered [28].

Audiological data

Audiological exams were performed pre-operatively, as well as 1 week and 6 months post operatively by pure tone audiometry (PTA), auditory brainstem responses (ABR), and monosyllabic speech audiograms for determining of the hearing preservation(AAO-HNS A/B classes) [27].

Surgeon's evaluation of hand-held laser usefulness

The surgeon satisfaction rate of usefulness of the device was evaluated adopting a 0-3-subjective-rating-scale (0=not useful; 1=moderately useful; 2=useful; 3=very useful).

Intra-operative procedures

Monitoring of facial and cochlear nerves

In all cases, facial nerve monitoring was used during all surgical procedure (Nimbus i-Care 100®, Intra Operative Neurphysiological monitoring, new medic division of Hemodia, Labege, France), with electrodes inserted in or bicularisoris and or bicularis oculi muscles. The nerve stimulation was performed with monopolar (on the surface of tumor) or bipolar (close to the nerve) stimulator, starting from 2mA (milli-amperes) or more (on the capsule, for nerve course localization) to 0.3-0.05 mA (directly on the nerve, for confirmation of its function).

As well as locating the course of the facial nerve, intra operative monitoring of facial nerve helped in driving the use of laser fiber. The patients did not receive muscle relaxant during general anesthesia

Each patients selected for hearing preservation received an ABR audiometry with CE-Chirp stimulus (Nicolet Viking III®, Viasys HealthCare, Madison USA/Hochberg Germany) the day before surgery by oneaudiologist.

Flexible 2µ-Thulium laser system

All operations were performed by one surgeon through retro sigmoid (RS) approach [29]. The capsule incision and tumor debulking has been performed with hand-held 2µ-Thulium flexible laser fiber (Revolixjr®, Lisa laser USA, Pleasanton, CA, USA). The range of power setting was 1-14 Watt. Standard 0.9% saline solution irrigation has been used for cooling the fiber. The fiber is used for cutting, vaporizing, and coagulating the capsule and the intracapsular mass, and in some cases in combination with bipolar forceps, microscissors and Sonopet Ultrasound Aspirator. Following tumor debulking, the remaining tumor capsule is removed with standard microsurgical tools.

Determination of tumor removal and of procedure time

The amount of tumor removed has been determined by surgeon's opinion and by postoperative contrast enhanced MRI

performed within 1 week after surgery. The removal has been classified as total (100%), nearly-total (99%: mill-metric 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.

Statistical analysis

The frequency and Mean±SD were used for reporting the results of study.

Results

Demographic and clinical data

Demographic, clinical, and MRI data were substantially irrelevant. From 39 participated cases 18 females and 20males with overall mean age of 50.3 years participated in this study.1 excluded because of a pre-existing long lasting HB4 facial deficit. Mean duration between the first symptoms and the operation time was 18.5 months. In 8 cases the tumor had one or more cysts inside. The mean maximum tumor size (including the extension into the internal auditory canal) was 2.78cm. According to Samii's grading classification [30], the tumor belonged to grade II in 14 cases, grade III in 19, and in grade IV in 6 and no case in class I. In 6 patients (15.4%), preoperative clinical or electro diagnostic evidence of facial nerve impairment was observed (in one long lasting HB4). A serviceable preoperative hearing (AAO-HNS A and B classes) was present in 15 patients.

Tumor removal and operation time

Total tumor removal could be possible in 22 cases. 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 11 cases (total+nearly total+subtotal in 33 cases: 84.6%). In 6 cases only partial removal (less than 90% of tumor) was possible, because of tenacious adherences of the capsule of tumor to brainstem and to facial nerve; all of them had a maximum diameter greater than 4cm. The remnants were located into the conduct, or along the facial nerve course or adherent to brainstem.

Mean operation time (from incision to suture) changed in relation to size of tumor and ranged from 185 to 575 minutes (Mean±SD: 353±45.3 minutes).

No mortality and major permanent morbidity was registered. One patient with large VS (3.5cm maximum diameter) had swallowing disturbance recovered completely within 3 months. In 2 cases 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 repair was necessary.

Facial nerve function

All patients were considered as HB1 pre-operatively, except 5 patients with HB2 to HB4 (long-lasting) facial palsy; in 2 cases, a preoperative involvement of facial nerve on EMG was detected.1case was excluded because of a pre-existing long lasting HB4 facial deficit. And the 38 patients were included in study as previously was mentioned. The course of facial nerve was ventral-superior in 41.0%, ventral-inferior in 35.9% and ventral in 23.1% of cases.

At minimum 6-month postoperative follow-up (from May 2015) the patients had no postoperative complete (nor incomplete facial palsy), 35 of 38 patients had HB1 facial nerve function and 3 a dysfunction ranging from HB2 to HB4. In 15 cases the facial

function was HB1 immediately after surgery; in these cases the mean maximum diameter of tumor was 2.2 (versus 3.4cm of cases with transient facial deficit; $p<0.03$). The day after surgery a normal face was observed in 39.5% of patients and 6 months after operation in 92.1%.When patients returned to normal face mobility, we never observed severe and permanent contractures.

Hearing results

Serviceable preoperative hearing (AAO-HNS A and B classes) was present in 15 patients. Among these, after operation 12 of them presented hearing competences before operation or slightly less valid (80.0%).

Surgeon's satisfaction rates

The mean surgeon satisfaction rate of usefulness of hand-held laser fiber was 2.69from 3.

Discussion

The treatment of VS gradually changed during time with some options including surgical excision, radiosurgery (gamma-knife and Cyber-knife), and "wait and scan". The incidence rate of VS has been increased because of detection the small and early stage VS by routine use of MRI in approach to hearing disturbance [15,31-38].

The most experienced neurosurgeons recommend microsurgery as first treatment of VS and radiosurgery for patients with growing recurrent tumors not suitable for re-surgery because of compromised general conditions. Wait and control the growth of tumor with serial MRI is logical for patients with small VS especially among elderly [6,7,9,39]. Surgery is our optional treatment only in the cases with large tumors or with small tumors with a serviceable hearing.

The goal of VS treatment is preservation of patient's facial and hearing functions and quality of life. The complications related to surgical treatment of VS which are life-threatening are rare [6,7,39]. Larger tumors compressing and displacing brainstem are more challenging and other possible postoperative side effects such as some cranial nerves palsy have to be considered among them. In our series neither major complications nor permanent deficits have been observed. No mortality and major permanent morbidity was registered. One patient reported swallowing disturbance recovered completely within 3 months. Only in two patients minor transient complications related to CSF circulation occurred. One case relieved conservatively and another one needed dural repair.

In our study; we obtained the good results both for facial nerve and hearing preservation due to intra-operative cochlear and facial nerve monitoring in addition to using micro-Thulium-fiber hand-held flexible laser microsurgery.

VS surgery by hand-held laser assistance has been described in several studies with no agreement between them about its benefit and weak points [19,40,41]. Some of them recommended it for patients with larger tumors [19,40]. On the contrary, on study described a slightly worse outcome with this technic [42]. The normal facial function has been reported in 90% in tumors smaller than 1.5 cm [41].

In our study, at 6-month follow up, HB1 facial nerve function was observed in 92.1% of cases and hearing function was preserved in 80.0% of patients with serviceable preoperative hearing (AAO-HNS A and B classes). The facial nerve palsy is probably caused by microsurgical dissection during

separation of tumor from the nerve. The adherence of the tumor shell to the nerve itself and, tumor size and form usually determine the intensity of mechanical manipulation during dissection of tumor. Our 6 month follow up results for facial nerve preservation was similar and comparable to other reports [4,7,33,39,41,43-45]. Therefore, the use of the laser in proximity of the nerve seems to be safe enough and is recommended especially when having a direct view of the facial nerve such as in the RS approach. The same explanation apply for the necessary manipulations of the cochlear nerve. [6,7,27,37,46-49]. Using the intraoperative monitoring with quick brainstem evoked responses and CE-Chirp stimulus effect on the results of hearing preservation [50]. Of course we selected only patients belonging to classes A and B of the AAO-HNS classification pre-operatively for determining the rate of hearing preservation considering that this kind of selection makes selection bias in the results.

Eiras *et al.* [40] compared resection time with or without laser fiber in giant VS operated by RS approach and reported that laser resection takes longer as well. The duration of procedure was (185 to 575 minutes: mean 353 min) in our study. The operation time could not be compared with the surgery not assisted by hand-held laser assistance laser. But it seems that it was not influenced by using hand-held laser in comparison with the other author's experience and it was in relation to tumor size, vascularization of the tumor, its adherence to brainstem and adjacent nerves and the time for haemostatic procedures. In addition the repeated interruptions during tumor removal because of worsening the intra-operative facial and ABR responses are another time using reason.

In our study, the use of a hand-held flexible laser fiber seemed to be safe. The mean surgeon satisfaction rate was 2.69 (according to a scale ranging from 0 to 3). The use of the 2 micro-Thulium laser fiber was considered very useful and facilitated the tumor excision especially in highly vascularized and hard tumors, without any traction and continuous suction which occur when using ultrasonic aspirator. On the basis of our preliminary experience, it seems to be that focusing the use of 2 micro-Thulium hand-held flexible laser fiber on large and vascularized VS may lead to better results in future. According to surgeon impression, in these conditions the reduction of tumor volume before microsurgical dissection of facial and cochlear nerve appears to be easier with 2 micro-Thulium flexible hand-held laser fiber in association with ultrasonic aspirator and microsurgical dedicated instruments.

Conclusion

A good functional outcome including facial nerve preservation and hearing preservation was obtained by micro-Thulium-fiber hand-held flexible laser microsurgery.

Conflict of Interest

All authors certify that they have no affiliations with or involvement in any organization or entity with any financial or non-financial interest in this subject.

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