

Technical notes & surgical techniques

Use of an ultrasonic aspirator in transnasal surgery of tumorous lesions of the anterior skull base



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ABSTRACT

Objective: Ultrasound aspirators are commonly used in open transcranial neurosurgery but are also applied in various other surgical settings. The specific properties of the instrument seem to make it particularly suitable for endoscopic transnasal skull base surgery. Reports about its use in this area, however, showed heterogeneous results.

Methods: In this feasibility trial, advantages and disadvantages of using the Sonopet ultrasound aspirator (Stryker Corporation, Kalamazoo, MI, USA) for the ablation of hard as well as soft tissue was tested in conjunction with extra-long tips in a total of 10 patients who underwent transnasal surgery of various tumorous pathologies of the skull base. Results were evaluated qualitatively and with a standardized questionnaire.

Results: The handling and operating of the ultrasound aspirator (UA) is intuitive and easy to learn. The design of the different tips is suitable to address pathologies of the anterior skull base back to the clivus. However, lesions far off the midline are difficult or even impossible to reach. The UA allows a precise and selective operation. Structures as the dura or large vessels are well respected. The participating surgeons felt that the benefits of using the UA outweighed the extra effort.

Conclusions: The ultrasound aspirator (UA) seems well suited for an application in transnasal endoscopic skull base surgery. It serves as a useful supplement to cold steel instruments, burrs and microdebriders. Limitations of reach become especially apparent when it is used off the midline corridor. Significant additional cost might restrict the use of the UA to single, selected cases. Future large-scale trials will be needed to define in more detail which surgical conditions may benefit most from its use.

1. Introduction

Ultrasonic Aspirators (UA) utilize ultrasonic frequency vibrations generated by a piezoelectric element in the handpiece to remove tissue. Continuous irrigation emulsifies dissected particles, and simultaneous aspiration removes fragments and liquid resulting in a comparatively clean surgical field. Minimal pressure is necessary, which makes tissue dissection better controllable and less traumatic compared to the use of standard drills [1]. There are several different tips available that allow selective dissection of soft or bone tissue and facilitate bone removal, smoothing and re-shaping [2]. Simultaneous cooling by the irrigation fluid emerging from the tip prevents heat injury of adjacent delicate structures.

Use of the ultrasonic aspirator has been reported for various surgical procedures, including ear, nose, and throat, maxillofacial, orbital,

oculoplastic, and open neurosurgical procedures [3–6]. Extra-long thin tips allow for transnasal access through narrow surgical corridors. Reports about the use of the UA in endonasal endoscopically controlled surgery of the pituitary gland or skull base showed promising results [7–9]. Here, maximum bone removal is paramount to gain optimal surgical access while at the same time damage to critical neurovascular structures, such as the optical nerve and internal carotid artery, must be avoided [10]. The UA turned out to be particularly useful and superior to standard high-speed drills in removing small bone fragments next to neurovascular structures in a constricted surgical field. Conversely, the ablation of thicker bone revealed to be very time-consuming and inefficient [1,9].

Based on these reports, we assumed that the UA could prove to be a particularly helpful tool in endoscopic endonasal surgery of tumors of the anterior skull base. Surgery in this region is often challenging

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because of destructive tumor growth and close proximity to essential anatomical structures in an often highly vascularized area. Precise instruments causing minimum collateral damage are crucial for minimizing the risks and maximizing surgical success. In our prospective application study, we analyzed the technical, practical and surgical properties and potential advantages of using the UA in endoscopically controlled transnasal surgery of various tumorous pathologies in the anterior skull base. The results of our study may help surgeons to estimate the potential benefits of using the UA in relation to the expected additional costs.

2. Design, setting and participants

The study was approved by the institutional ethics committee of Ludwig Maximilians University (LMU), Munich, and the ENT department's data protection official. It was conducted in accordance with the declaration of Helsinki and followed the standards of good clinical practice. Written informed consent was obtained from all patients before they were enrolled in the study.

The study was designed as a prospective feasibility trial. Ten consecutive patients presenting to the ENT or neurosurgical departments of the Ludwig Maximilians university Munich with a tumor in the region of the anterior skull base were included if the indication for an endoscopic transnasal approach was interdisciplinarily agreed upon.

Patients were operated via a transnasal endoscopic approach using standard cold steel instruments and high-speed drills in addition to the Sonopet Ultrasonic Aspirator (Stryker Corporation, Kalamazoo, MI, USA) equipped with super-long tips. The UA was used for removing tumorous and osteous tissue in close proximity to neurovascular structures.

The Sonopet Ultrasonic Aspirator has an all-purpose handpiece that is connected with cables, tubing, a pedal and the main console. The main unit contains suction and irrigation functions. The device removes tissue using energy from ultrasonic frequency vibration created by a piezoelectric element. The settings for the oscillating frequency, the suction and the irrigation can be controlled independently. The available tips differ in size, cutting surface and curving. For the transnasal procedures in this study, the following extra-long tips were used:

- Superlong Straight (length 20 cm; tip Ø 1.92 mm)
- Spetzler Superlong Micro Claw (length 20 cm; tip Ø 3.00 mm)
- Spetzler Superlong Open Angle Micro Claw (20 cm; tip Ø 2.92 mm)
- Payner Superlong 360 (length 20 cm; tip Ø 3.15)

The Spetzler Superlong Micro Claw, the Spetzler Superlong Open Angle Micro Claw and the Payner Superlong 360 are recommended for the ablation of hard tissue. For soft tissue ablation, the Superlong Straight tips are recommended.

3. Main outcome measures

The objective of this study was to clinically apply the UA and evaluate its feasibility in transnasal skull base surgery. After each surgery, the surgeons completed a standardized questionnaire comprising twelve questions to be answered using a visual analog scale (−2 to +2) and free text field for specific comments. Beside safety, practicability, usability and reliability, we focused on the potential advantages and special features of the UA during endonasal resection of different tumor entities of the anterior skull base. In particular, the view in the surgical site, the possibility of selective tissue removal, and a precise and accurate operation with the preservation of natural barriers, such as the dura or vital neurovascular structures, were investigated. In addition, we analyzed the cognitive and physical workload.

Table 1
Diagnosis of patients.

Patient number	Diagnosis
1	Orbital schwannoma
2	Clivus chordoma
3	Juvenile angiofibroma
4	Chondrosarcoma
5	Recurrent pituitary adenoma extending along skull base
6	Trigeminal schwannoma
7	Juvenile angiofibroma
8	Olfactory neuroblastoma
9	Craniopharyngioma
10	Juvenile angiofibroma

4. Results

10 patients (5 male and 5 female) were enrolled in the study. The mean age was 40.1 (SD 11.3) years. All patients were diagnosed with benign or malignant tumors of the anterior skull base (Table 1).

After the surgery, both the ENT surgeon and the neurosurgeon separately completed the questionnaire. The application of the new device was easily learned. No serious adverse events were recorded related to the use of the UA. In the survey, surgeons described the operative time and blood loss as comparable to similar surgeries. The specific tips used were well suited for transnasal approaches in skull base surgery, especially if the tumor was located within or close to the midline. The UA was particularly useful to remove soft and tumorous tissue. In addition, thin bone and cartilage fragments could be selectively dissected without damaging the surrounding tissue. Nearby neurovascular structures, such as internal carotid artery and dura, were preserved and no thermal or mechanical injury was observed. In summary, the surgical goals could be achieved in all 10 cases when using the UA.

The evaluation of the questionnaire identified the following key results (Fig. 1): The handling and operating of the UA was described as intuitive and easy, and additional physical or cognitive workload was considered minimal. However, use of the UA did not necessarily lead to a better surgical outcome. Furthermore, the UA prolonged the operation time and impaired the endoscopic view in 40–50% of the cases. Nevertheless, the benefits of using the UA were considered worth the extra effort by all surgeons. In particular, all surgeons agreed that the UA increased safety and allowed a more precise and accurate operation. (See Fig. 2.)

5. Discussion

Several different tumor entities can occur in the area of the anterior skull base, which may differ significantly from each other in terms of growing behavior, tissue properties, vascularization, and extension. Though overall rare, they pose a significant challenge to the surgeon due to the constricted surgical field, the complex anatomy, and the proximity to vital neurovascular structures. The optimal surgical strategy has to be planned individually for each case.

Endoscopic transnasal surgery has been well established as a standard approach for the treatment of pathologies in the area of the anterior skull base [11]. Ideally, ENT surgeons and neurosurgeons work together using the endoscopes and instruments simultaneously. The endoscopic approach provides the surgeon with an excellent view over the surgical field and allows maximally radical surgeries while being minimally invasive at the same time. The surgical instruments have to be precise and configured in a way that allows optimal access to the surgical field. Collateral damage has to be minimized to reduce complications and ensure surgical success [10]. The ultrasound aspirator has been used in several surgical specialties for years and seems to be suited to address many of these issues [2–6]. Simultaneous dissection,

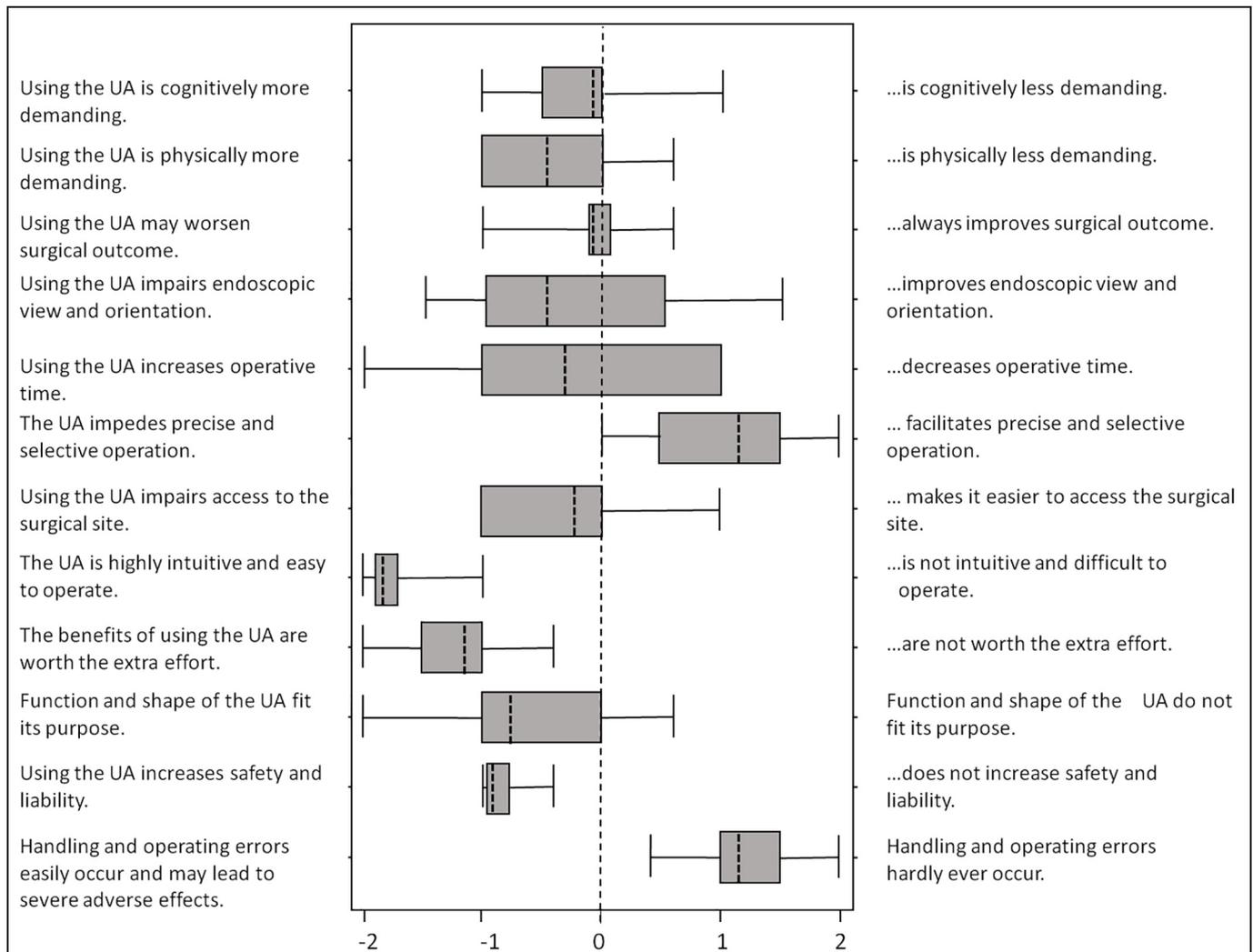


Fig. 1. Boxplot of the results of the standardized questionnaire using a visual analog scale.

irrigation and suction result in a clean surgical field. Special head pieces allow selective tissue ablation independently of tissue texture and consistency and make it possible to reach more remotely located areas of the anterior skull base, such as the sella and beyond [8,9]. However, while the UA is currently frequently used in open brain surgery, its application in transnasal skull base surgery or rhino-neurosurgery is less common.

The results of our prospective application and feasibility study partially confirmed the positive properties of the UA described in previous studies [1,7,9,10]. The device appeared to be easy to handle and worked reliably. It did hardly increase the physical or mental workload for the surgeon. Use of the UA did not require any additional surgical skills. The dimensions of the device, i.e., its length and diameter including the attachment needed for rinsing, allowed to freely move the instrument under endoscopic control. Even pathologies localized further dorsally, such as the clivus, were easily reached. Here, the UA was particularly useful as it simultaneously aspirated the accumulating blood that otherwise impairs the view in the surgical field.

However, since no tilted head pieces were available, the range of movement was restricted to lesions close to the midline. Generally, the surgical field was clean, however the water mist sometimes disturbed the endoscopic view.

Precision was very high when using the UA. It proved particularly well suited for the removal of thin bone and soft tissue. In contrast, it was considerably more difficult to remove thicker bone and cartilage,

irrespective of the head piece selected [1]. Selective tissue dissection was at least partially possible. In particular, dura and large blood vessels were reliably preserved while thinner bone, small nerves or vessels could not always be spared. In our hands, the UA was of particular value for the resection of soft tissue tumors, such as angiofibroma or olfactory neuroblastoma. Removal of bone with the UA, for example when accessing the clivus, was cumbersome and more time-consuming compared to conventional diamond drills. Furthermore, significant additional cost might restrict the use of the UA to specialized centers and carefully selected cases [1]. In summary, the UA was considered a useful additional tool that increased safety and surgical accuracy.

Naturally, the evaluation of the UA in this study was largely based on the subjective assessments by the surgeons involved. Future trials with larger case numbers will be needed to confirm the advantages and define possible pitfalls of this application. A randomized study would be desirable, however might be hampered by the rarity and diversity of the tumor entities in the anterior skull base.

6. Conclusion

The UA equipped with extra-long tips is well suited for transnasal endoscopic surgery of tumorous lesions of the anterior skull base. The UA works reliably and with high precision. It can be easily maneuvered in the constricted surgical field. Natural barriers such as the dura and vital neurovascular structures were reliably preserved. The UA proved

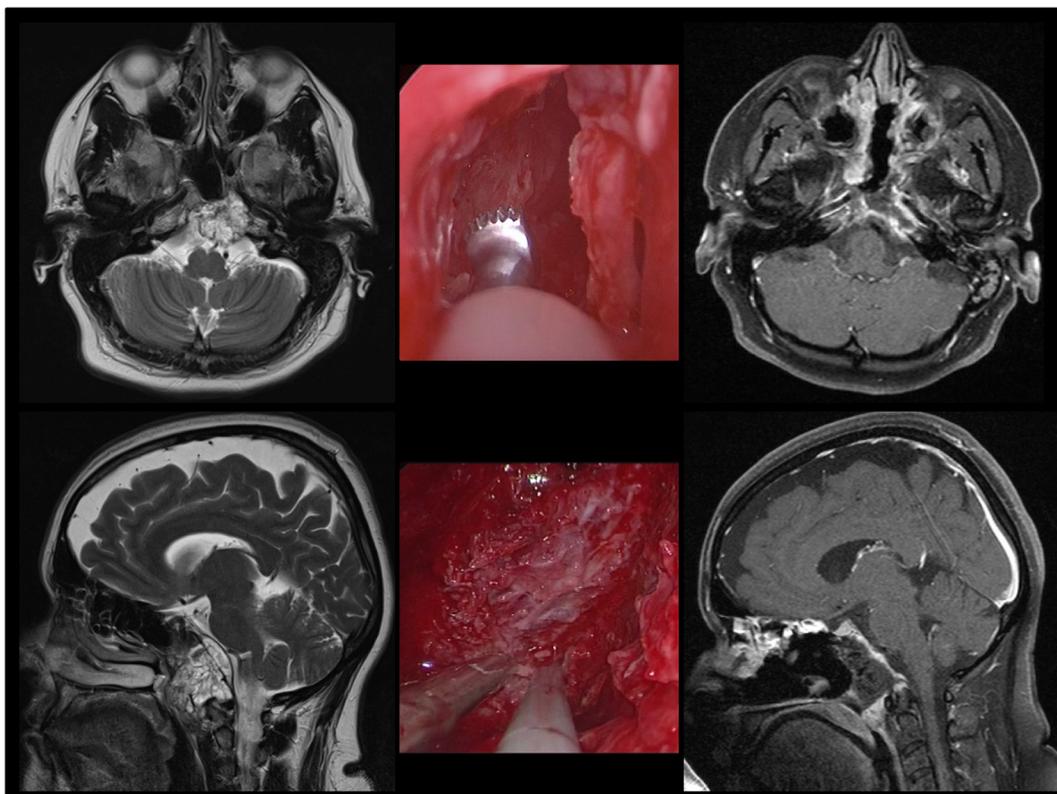


Fig. 2. Case presentation: Clivus chordoma before, during and after transnasal resection featuring the UA.

particularly useful for the exact and selective resection of highly vascularized tumorous soft tissue. In our opinion, the UA cannot substitute for conventional cold steel instruments such as microdebrider or burrs but can present a useful additional device to facilitate surgery for certain indications. Significant additional costs might restrict the use of the UA to carefully selected cases. Further studies are needed to confirm the benefits of the UA, especially with regard to its capability to reduce the risk of injuries.

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Declaration of competing interest

The authors declare that they have no conflict of interest. There is no specific financial interest, relationship or affiliation relevant to the subject of the manuscript.

References

[1] M.M. Rastelli Jr. et al., Application of ultrasonic bone curette in endoscopic

endonasal skull base surgery: technical note, *J Neurol Surg B Skull Base* 75 (2) (2014) 90–95.

- [2] E.A. Pribitkin, et al., Sonic rhinoplasty: sculpting the nasal dorsum with the ultrasonic bone aspirator, *Laryngoscope* 120 (8) (2010) 1504–1507.
- [3] J.D. Greywoode, K. Van Abel, E.A. Pribitkin, Ultrasonic bone aspirator turbino-plasty: a novel approach for management of inferior turbinate hypertrophy, *Laryngoscope* 120 (Suppl. 4) (2010) S239.
- [4] A.P. Murchison, et al., The ultrasonic bone aspirator in transnasal endoscopic dacryocystorhinostomy, *Ophthalm. Plast. Reconstr. Surg.* 29 (1) (2013) 25–29.
- [5] I. Vrcek, et al., Use of an ultrasonic bone curette (Sonopet) in orbital and oculo-plastic surgery, *Proc (Bayl Univ Med Cent)* 28 (1) (2015) 91–93.
- [6] S. Kakehata, et al., Extension of indications for transcanal endoscopic ear surgery using an ultrasonic bone curette for cholesteatomas, *Otol. Neurotol.* 35 (1) (2014) 101–107.
- [7] T. Yamasaki, et al., A new, miniature ultrasonic surgical aspirator with a handpiece designed for transsphenoidal surgery. Technical note, *J. Neurosurg.* 99 (1) (2003) 177–179.
- [8] H.M. Baddour, M.D. Lupa, Z.M. Patel, Comparing use of the Sonopet((R)) ultrasonic bone aspirator to traditional instrumentation during the endoscopic transsphenoidal approach in pituitary tumor resection, *Int Forum Allergy Rhinol* 3 (7) (2013) 588–591.
- [9] P. Cappabianca, et al., Bone removal with a new ultrasonic bone curette during endoscopic endonasal approach to the sellar-suprasellar area: technical note, *Neurosurgery* 66 (3 Suppl Operative) (2010) E118). (discussion E118).
- [10] C.H. Snyderman, et al., What are the limits of endoscopic sinus surgery?: the expanded endonasal approach to the skull base, *Keio J Med* 58 (3) (2009) 152–160.
- [11] V.J. Lund, et al., European position paper on endoscopic management of tumours of the nose, paranasal sinuses and skull base, *Rhinol. Suppl.* (22) (2010) 1–143.