



Image-guided navigation in transnasal surgery of pituitary adenomas

Nevronavigacija pri transnazalnih operacijah hipofiznih adenomov

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Abstract

Background. Endoscopic view inside the sphenoid sinus reveals important bony orientiers that enable maximal trephination of the sellar floor. When the bony wall is thick and irregular, use of image-guided navigation is mandatory.

Patients and Methods. This study reports cases of simple and extended pituitary adenomas, where bilateral sphenoidectomy and adenoma removal was performed bimanually and endoscopically through one nostril only or by two nostrils-four hands technique or by combined micro-endoscopic technique. In all cases image-guided navigation was used during tumor removal followed by final endoscopic revision of the operative field.

Results. Image-guided navigation proved useful in doubtful cases for identification of midline, carotid protuberance and opto-carotid recess and estimation of bone thickness over these structures. Especially useful was identification of paraclival carotid artery during the drilling of the invaded bone of subsellar clivus.

Conclusion. Image-guided navigation enables safer and maximal exposure of sellar floor which provides maximal visualisation of the intrasellar space. Localisation, direction and bone thickness over different segments of parasellar carotid artery and optic nerve can be checked anytime during the surgery. Angular vision enables removal of minute tumor remnants, that can't be seen using microscopic technique.

Key words. Pituitary adenoma, trans-nasal surgery, neuronavigation, endoscopy.



Izveleček

Izhodišča. Endoskopski pregled sfenoidnega sinusa nam omogoča prepoznavanje pomembnih kostnih orientirjev za maksimalno trepanacijo dna turškega sedla. Kadar pa je kostna stena debela in nepravilna, je nujna orientacija z nevronavigacijo.

Bolniki in metode. V študiji predstavljamo več primerov pacientov s hipofiznimi enostavnimi (intraselarnimi) ali razširjenimi makroadenomi, kjer smo izvedli bilateralno sphenoidektomijo in odstranitev adenoma obojeročno in endoskopsko s pristopom skozi eno nosnico, skozi obe nosnici štiročno ali s kombinirano mikroskopsko-endoskopsko tehniko. V vseh primerih smo med odstranjevanjem adenoma uporabili nevronavigacijsko orientacijo in zaključno endoskopsko revizijo operativnega polja.

Rezultati. S pomočjo nevronavigacije smo v dvomljivih primerih natančno identificirali sredinsko črto, karotidno protuberanco in optokarotidni recesus ter ocenili debelino kosti nad njimi. Posebej koristna je bila nevronavigacijska identifikacija poteka paraklivalnega dela karotidne arterije med brušenjem invadirane kostnine subselarnega dela klivusa.

Zaključek. Nevronavigacija omogoča varno in maksimalno trepanacijo dna turškega sedla in s tem maksimalno ekspozicijo in preglednost intraselarnega prostora. V katerikoli fazi operacije poda informacijo o lokaciji, smeri in debelini kosti nad določenimi segmenti paraselarnega poteka karotidne arterije invidnim živcem. S kotno optiko lahko preverimo in odstranimo še zadnje ostanke adenoma, ki jih z mikroskopsko tehniko ne moremo videti.

Ključne besede. Hipofizni adenomi, transnazalni pristop, nevronavigacija, endoskopija.

Introduction

Endoscopic view toward the posterior sphenoidal wall enables panoramic vision and identification of important bony markers which overlay carotid arteries and optic nerves around the sellar floor (1-4). Carotid protuberance is the upper lateral limitation of the sellar floor trephination (2). Carotid protuberance overlays the anterior loop of the intracavernous carotid artery proximal to the distal dural ring.

The optic nerve is separated from the carotid artery by optic strut which constitutes the lateral wall of the optic canal (5). The upper limit of the sellar trephination is the anterior intercavernous sinus. The lateral margin of the trephination is medial wall of cavernous sinus (2). The bottom of the sella is limited laterally by the paraclival carotid artery columns (3,4,6). The distance between the carotid protuberances may be as short as 1-1,5 cm, but is even more limited in kissing-carotid situation (2,4). This small quadriangular dural opening is an entrance to enlarged intrasellar space, where adenoma bulges diaphragm superiorly and medial walls of cavernous sinus and intracavernous carotids

laterally (2,6-8). Endoscopic angular view of the operative field may reveal tumor remnants behind the »dural margins« (8).

Patients and methods

Three illustrative cases of patients with pituitary adenoma are presented here in detail. Bilateral sphenoidectomy and adenoma removal was performed bimanually and endoscopically through one nostril only or by two nostrils-four hands technique or by combined micro-endoscopic technique. In all cases image-guided navigation was used during tumor removal followed by final endoscopic revision of the operative field. Patients gave informed consent. Neuronavigation was performed using Medtronic Stealth Station, USA. Karl Storz endoscope (Hopkins 30° 4 mm diameter) was used for inspection.

Patient 1.

This 57-yrs old man was diagnosed a 2x2 cm large pituitary adenoma intra- and suprasellarly.



MRI scan revealed that the adenoma does not expand beyond the sella. One-nostril trans-nasal approach was performed. A 30°-endoscope was introduced into the left nostril, the sphenoid opening was identified and enlarged, the vomer was drilled off and bilateral sphenoidectomy was performed. The endoscope was held by an assistant and the neurosurgeon worked bimanually. Intraoperative view reveals a recognizable left carotid protuberance, but the right one was not clearly identifiable. An image-guided navigation located the point for drilling the thick bone over the right carotid protuberance.

The dura of the sellar floor was cut as a page in the book as close to carotids as possible and the square dural flap was turned down. The adenoma was removed by piecemeal technique and by aspiration.

The sellar diaphragm symmetrically invaginated into the sella. The final endoscopic check of the operative field revealed no residual tumor and the duroplasty was performed.

Patient 2

A 48-yr old male patient was operated on by transcranial route in 2001 for 3,5x2x2,5 cm large intra-suprasellar non-secretory adenoma. Bilateral hemianopsia resolved completely, but MRI revealed intrasellar residual tumor 2x2 cm. Over the next 5 years, the residual tumor started to grow suprasellarly again and was operated on by transseptal microscopic approach in 2006. The tumor was removed completely. In the next 2 years, a small residual tumor in the clivus was growing for few mm to nearly 2 cm. In fact, this small intracavernous invasion of the tumor was observed in the first MRI scans. During transsphenoidal surgery in 2006, the tumor growth through the dura in the sellar bootem was not observed intraoperatively.

The CT and MRI scans were merged and coregistered for the third surgery. Trans-septal approach was performed using microscopic magnification. The midline of the clivus was identified by neuronavigation. The drilling of the bone started in the midline. The bone was invaded by the tumor, only the core was soft adenoma. The walls of the hole were checked several times during surgery to estimate the direction and thickness of the bone toward both

paraclival carotid arteries. Tumor was removed completely, the carotids were exposed, the dura of the clivus was broadly exposed. The dura of the sellar floor was bulging into the space, where a subsellar part of the invaded clival bone was removed.

Patient 3

A 74-yr old female was diagnosed a intrasellar – intracavernous tumor. There was no suprasellar growth. The bottom of the sella could be still recognised in sagittal MRI scans. The principal problem was unspecific headaches, lasting for the last 4 years. The CT scan was interpreted normal.

The patient was operated on using »two nostrils-four hands« technique. The residual bony bottom of sella was drilled off and intrasellar and intracavernous part of the tumor were conjoined into a single space. The adenoma was removed, leaving normal pituitary tissue subdiaphragmally. Neuronavigation was used for identifying the midline and the bony thickness toward the paraclival arteries and dura of clivus.

Results

The surgical field during drilling the bone of clivus below the sella was regularly checked by pointer to show the exact position of the drill bit, direction of drilling and bone thickness over the paraclival carotid arteries in dorsolateral direction and clival dura dorsally (Fig. 1 and Fig. 2.). Such orientation enabled exposure of carotids and total removal of invaded clival bone.

Discussion

Degree of adenoma removal depends on broad exposure of the sellar floor (1,2,6,8,9,10). The bone must be removed up to the medial margins of carotid protuberances and to the bluish dural transparency at the margins of the cavernous sinus laterally.

The anterior intercavernous sinus delineates the superior border of the trephination. The dural flap should be incised as close to the borders to have all benefit from bone resection (6-8). It must be considered that navigation is not as accurate as wanted, so the surgeon must rely on anatomy and experience. The accuracy of image-



guided navigation is checked in the beginning of the surgery by touching anatomical points outside and inside the nose. The distance from vomer to the anterior wall of clivus is a valuable information. Pointer can be substituted by navigated endoscope or a drill.

Inside the cavity, endoscope offers angular view behind the dural margins to look for adenoma residuals. The space just after the anterior loop (at the proximal part of horizontal intracavernous carotid artery) is another location where adenoma can be left in pure microscopic technique. The subdiaphragm check is most demanding, since the enlarged diaphragm collapses with removal of tumor mass, invaginates and folds. Each fold should be expanded and checked for the tumor. Bimanual manipulation of diaphragm fold is necessary. A systematical approach to tumor removal is a capsular resection (8). Hollowing the adenoma in the central part may broke tumor in several parts too early.

Neuronavigation is especially useful in extended approaches where tumor invades extrasellar areas and other paranasal sinuses (8). Removal of intracavernous extension of adenoma is preconditioned by broad removal of the bone in front of the intracavernous adenoma. The invaded bone in the walls must be drilled into healthy bone or to the dura. The two vertical columns of paraclival carotid arteries limit the area of clivus. Neuronavigation enables neurosurgeon or ENT surgeon to work more confidentially and faster.

The planning of image-guided navigation also enables surgeons to study a 3D model in any direction and any plane cuts and to integrate anatomical and surgical views.

Conclusions

Image-guided navigation enables safer and maximal exposure of sellar floor which provides maximal visualisation of the intrasellar space. Localisation, direction and bone thickness over different segments of parasellar carotid artery and optic nerve can be checked anytime during the surgery. Angular vision enables removal of minute tumor remnants, that can't be seen using microscopic technique.

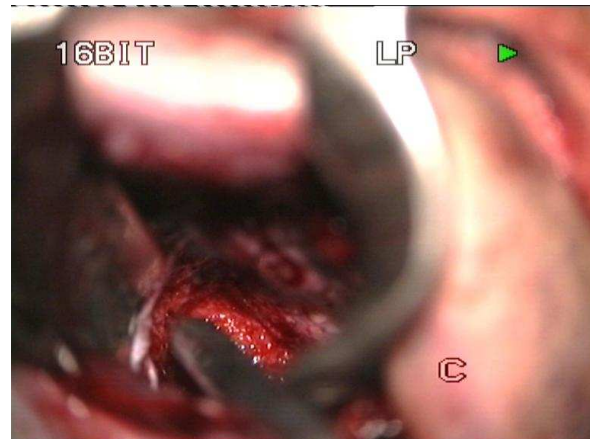


Figure 1

Intraoperative view. Patient 2. Pointer is locating a bone over the right paraclival carotid after drilling a clivus under the sella.

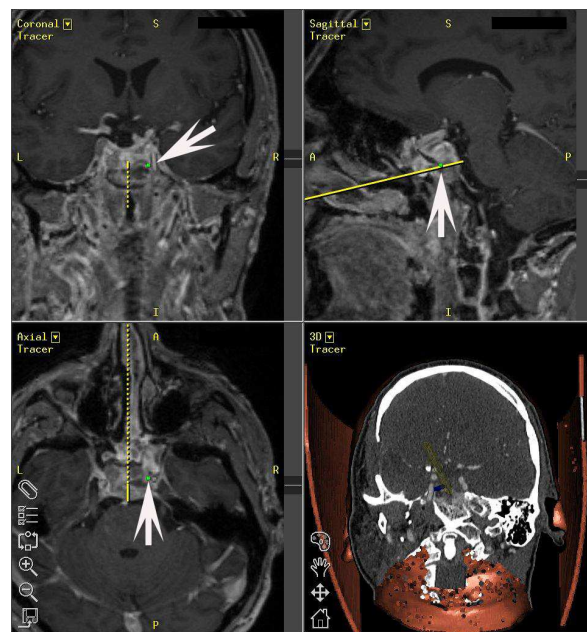


Figure 2

Image-guided navigation screen in Patient 2 is showing surgical trajectory (dotted line) through the left nostril in three orthogonal planes. The dot (arrow) marks the pointer position in Fig. 1. showing the tiny bony lamelle over the right paraclival carotid artery.

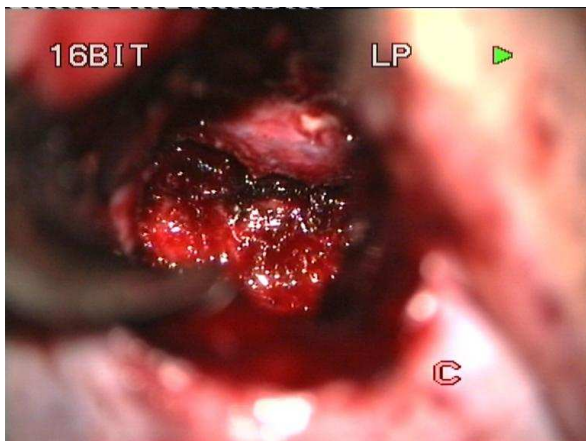


Figure 3

Intraoperative view. Patient 2. The dura of the sellar floor is seen above, the paraclival carotid artery on the right is fully exposed. Posteriorly, the clival dura is exposed in an area of 2,5 x 2 cm.

References

1. Kassam A, Snyderman CH, Mintz A, Gardner P, Carrau RL. Expanded endonasal approach: the rostrocaudal axis. Part I. Crista galli to the sella turcica. *Neurosurg Focus* 2005; 19: E3. Full text available at <http://www.neurosurgery.org/focus/archives.html>
2. Frank G, Pasquini E. Approach to the cavernous sinus. In: de Divitiis E, Cappabianca P (eds): *Endoscopic endonasal transsphenoidal surgery*. New York, Springer-Verlag, 2003: 159-75
3. Kassam A, Snyderman CH, Mintz A, Gardner P, Carrau RL. Expanded endonasal approach: the rostrocaudal axis. Part II. Posterior clinoids to the foramen magnum. *Neurosurg Focus* 2005; 19: E4. Full text available at <http://www.neurosurgery.org/focus/archives.html>
4. Cavallo LM, Messina A, Cappabianca P, Esposito F, de Divitiis E, Tschabitscher M, Gardner P. Endoscopic endonasal surgery of the midline skull base: anatomical and clinical considerations. *Neurosurg Focus* 2005; 19: E2. Full text available at <http://www.neurosurgery.org/focus/archives.html>
5. Bošnjak R, Boršoš I. Endoskopska transsfenoidna dekompresija vidnega živca v optičnem kanalu - prikaz primera. *Endoscopic Rev* 2007; 27: 58
6. Bošnjak R, Boršoš I, Podboj J. Razširjeni transnazalni pristop do hipofiznih in drugih tumorjev na lobanjskem dnu. In: Zbornik predavanj XLI. podiplomskega tečaja kirurgije, 10.-11. februar 2006. Ljubljana: Kirurška klinika, Klinični center, 2006, pp. 198-201
7. Bošnjak R, Podboj J. Kombinirani endoskopsko-mikroskopski transnazalni pristop za odstranitev hipofiznih makroadenomov s širjenjem v paranazalne sinuse. *Endoscopic Rev* 2007; 27: 65
8. Bošnjak R, Podboj J, Boršoš I, Benedičič M, Urbančič J, Knific J. Combined microscopic and endoscopic transnasal access to pituitary macroadenomas spreading parasellary and into the paranasal sinuses and our first experience with image-guide navigation. In: Žargi M. (ed). *Proceedings of the 5th Congress of Slovenian Otorhinolaryngological Association*, [Radenci, Slovenia, Sept 25.-27., 2008], Ljubljana: Medicinski razgledi, 2008; 47 (suppl. 2): 201-4
9. Bošnjak R, Pfeifer M, Kocjan T, Bačovnik U, Popović M, Knific J, Dolenc VV. Surgical outcome in transsphenoidal approach to pituitary adenomas. In: Dolenc VV. (ed.). *Proceedings of the 3rd CENS meeting*, [Ljubljana, Slovenia, September 1-4, 2004]. [Ljubljana: Slovenian neurosurgical society, 2004], p. 43
10. Bošnjak R. Transsfenoidalna kirurgija hipofiznih tumorjev. V: Mrevlje F (ur.), Pfeifer M. (ur.). 3. slovenski endokrinološki kongres z mednarodno udeležbo, Bled, 21. - 23. 9. 2006. Zbornik predavanj in povzetkov posterjev. Ljubljana: Združenje endokrinologov Slovenije, Slovensko zdravniško društvo, 2006: 26-7