Instructions to Contributors

Dear Contributor:

Enclosed in this document please find the page proofs, copyright transfer agreement (CTA), and offprint order form for your article in the *Skull Base*, Please print this document and complete and return the CTA and offprint form, along with corrected proofs, within 72 hours.

1) Please read proofs carefully for **typographical** and **factual** errors only; mark corrections in the margins of the proofs in blue or black pen; please be sure to write as clearly as possible so no errors are introduced into your article. **Answer (on the proofs) all author queries marked in the margins of the proofs.** Check references for accuracy. **Please check on the bottom of the 1st page of your article that your titles and affiliations are correct.** Avoid elective changes, because these are costly and time consuming and will be made at the publisher's discretion.

2) Please pay particular attention to the proper placement of figures, tables, and legends. Please provide copies of any formal letters of permission that you have obtained.

3) **Please return the corrected proofs, signed copyright transfer agreement, and your offprint order form,**

4) As a contributor to this journal you will receive one copy of the journal, at no charge.

   • If you wish to order offprints, **please circle the quantity required** (left column) **and the number of pages in your article.** If you wish to order additional copies of the journal please enter the number of copies on the indicated line.

   • If you do not want to order offprints or journals simply put a slash through the form, **but please return the form.**

Please return all materials within 72 hours. E-mail is the easiest way to ensure your corrections are received in a timely manner. You may also return materials via fax or overnight mail to :

Katy Whipple, Editorial Project Manager
Maryland Composition Company
14880 Sweitzer Lane
Laurel, MD 20707
Phone: 774-526-5948
Fax: 410-760-5295
E-mail: kwhipple@marylandcomp.com

Please do not return your materials to the editor, or the typesetter.

Please note**:** Due to a tight schedule, if the publisher does not receive the return of your article proof within 7 days of the date the e- mail was sent to you the publisher reserves the right to proceed with publication without author changes. Such proofs will be proofread by the editor and the publisher.

Thank you for your contribution to this journal.

Thieme Medical Publishers, Inc. (the “Publisher”) will be pleased to publish your article (the “Work”) entitled ______________________________ in the *Skull Base*,

The undersigned Author(s) hereby assigns to the Publisher all rights to the Work of any kind, including those rights protected by the United States Copyright laws.

The Author(s) will be given permission by the Publisher, upon written request, to use all or part of the Work for scholarly or academic purposes, provided lawful copyright notice is given.

If the Work, subsequent to publication, cannot be reproduced and delivered to the Author(s) by the publisher within 60 days of a written request, the Author(s) is given permission to reprint the Work without further request.

The Publisher may grant third parties permission to reproduce all or part of the Work. The Author(s) will be notified as a matter of courtesy, not as a matter of contract. Lawful notice of copyright always will be given.

<u>Check appropriate box below and affix signature.</u>

[ ] I Sign for and accept responsibility for transferring copyright of this article to Thieme Medical Publishers, Inc. on behalf of any and all authors.

Author’s full name, degrees, professional title, affiliation, and complete address:

______________________________ ______________________________

Author’s printed name, degrees Professional title

____

____

____

Complete professional address

______________________________ ______________________

Author’s signature Date

[ ] I prepared this article as part of my official duties as an employee of the United States Federal Government. Therefore, I am unable to transfer rights to Thieme Medical Publishers, Inc.

______________________________ ______________________

Author’s signature Date

Order Form for Offprints and additional copies of the Skull Base
(Effective October 2005)

Please circle the cost of the quantity/page count you require (orders must be in increments of 100)

	Pages in Article / Cost				
Quantity	**1 to 4**	**5 to 8**	**9 to 12**	**13 to 16**	**17 to 20**
100	$198	$317	$440	$578	$693
200	$277	$444	$615	$809	$970
300	$356	$570	$791	$1,041	$1,247
400	$396	$634	$879	$1,156	$1,386
500	$446	$713	$989	$1,301	$1,559
1000	$792	$1,267	$1,758	$2,313	$2,772

Volume/Issue #: ______________________ Page Range (of your article) ______________

Article Title: ____

MC/Visa/AmEx No: ______________________________ Exp. Date: ______________

Signature: ____

Name: ____

Address: ____

City/State/Zip/Country: ____

Corresponding author will receive one complimentary copy of the issue in which the manuscript is published.
Number of **additional** copies of the journal, at the discounted rate of $20.00 each: ______________

Notes
1. The above costs are valid only for orders received before publication of the issue. Reprints ordered after printing will be substantially more expensive. Please return the completed form, even if your institution intends to send a Purchase Order (the P.O. may sometimes be supplied after the issue has been printed).
2. Orders from outside the United States must be accompanied by payment.
3. **A shipping charge will be added to the above costs.**
4. Reprints are printed on the same coated paper as the journal and saddle-stitched.
5. For larger quantities or late orders, please contact reprints department:

Phone: +1(212) 584-4662
Fax: +1(212) 947-1112
E-mail: reprints@thieme.com

Transnasal Skull Base Reconstruction Using a 3-D Endoscope: Our First Impressions

Paolo Castelnuovo, M.D.[1] Paolo Battaglia, M.D.[1] Mario Turri-Zanoni, M.D.[1] Luca Volpi, M.D.[1] Maurizio Bignami, M.D.[1] Iacopo Dallan, M.D.[1]

[1] Department of Otorhinolaryngology, University of Insubria, Varese, Italy.

Skull Base 2012;00:1–6.

Address for correspondence and reprint requests Paolo Battaglia, M.D., Department of Otorhinolaryngology, University of Insubria, Varese, Via Guicciardini 9, Varese, Italy (e-mail: mail.paolobattaglia@gmail.com).

Abstract

Nowadays endoscopic skull base reconstruction is safely and effectively performed by means of two-dimensional (2-D) endoscopic technique. The aim of our study is to compare our 2-D experience with the novel 3-D technology in the field of skull base reconstruction techniques. In this study four patients treated with various kinds of planned duraplasty are included. The new 3-D technology was compared with the high-definition 2-D scopes during the different steps of the procedures. The 3-D endoscopic skull base reconstruction obtained primary closure without complications in all cases. According to the subjective opinion of experienced endosurgeons, this novel technique improved depth perception, distance and size estimation, ability to identify specific anatomic structures, and hand–eye coordination. The main drawbacks detected were inferior sharpness, contrast and lighting that impaired the application of the technique in narrow sinonasal spaces. According to our preliminary impressions, 3-D endoscopic skull base reconstruction is an effective and safe procedure and could represent a significant advantage for accurate managing of the skull base region.

Keywords

- three-dimensional
- stereoscopic
- skull base reconstruction
- endoscopic
- duraplasty

Endoscopic endonasal duraplasty has been demonstrated to be an effective, safe, and reliable approach in most cases of skull base defects, regardless of the size.[1–6]

One of the primary restrictions of the endoscopic technique, however, in contrast with microscopic procedures, is the lack of binocular vision and consequently of third dimension. In fact current endoscopic technology offers excellent resolution (high-definition [HD] cameras) but creates a two-dimensional (2-D) image that impairs depth perception and hand–eye coordination, and reduces the ability to estimate size.[7]

To gain a depth cue in such a 2-D environment, surgeons seek sensorial and tactile feedback during manipulation of instruments by constantly moving the scopes in and out or from side to side. In this manner, depth perception is based on integration of indirect information from a variety of sources, including the surgeon's former knowledge of the spatial relationship between anatomical structures.[8]

Recently introduced HD stereoscopes produce a three-dimensional (3-D) image of the surgical field, with natural binocular ability to perceive depth, volume, and distance accurately.[9] Although in preliminary series, stereoscopic skull base surgery has proved to be a feasible and safe procedure, with outcomes comparable to those achieved with standard 2-D endoscopes.[10,11] Moreover, earlier task-based simulator studies have shown the benefit of 3-D technology in terms of speed, efficiency, and error rates when compared with the 2-D technique.[12]

Thus, on the basis of these considerations and our large skull base reconstruction experience (more than 400 cases), we have begun to use 3-D endoscope in endonasal endoscopic procedures. Accordingly, in this study we report our preliminary impressions about the application of a novel 3-D endoscopic system in the field of skull base surgery. Perceived advantages and limits, possible

received
July 12, 2011
accepted after revision
August 10, 2011
published online
xxx

DOI http://dx.doi.org/10.1055/s-0031-1296043.
ISSN 1531-5010.

drawbacks and developing areas are critically analyzed and discussed.

Materials and Methods

The cohort of this study is represented by our first unselected four patients, treated with various kinds of planned skull base reconstruction. All patients underwent a purely endoscopic transnasal approach to the skull base and were operated by experienced surgeons. All procedures were performed by four surgeons using the two-nostril-four-handed technique. Both HD 2-D (Karl Storz, Tuttlingen, Germany) and 3-D (Visionsense, Ldt., Petach Tikva, Israel) endoscopes were contemporaneously used and compared during the different phases of the procedure. The 3-D system used during the study was composed of 0- and 30-degree rigid endoscopes, sized 150 mm in length and 4 mm in diameter at the distal end. The system requires the use of passive glasses, which emulate the binocular perception in combination with a 3-D screen.

In all the cases, an intraoperative magnetic navigation
Q1 system (Medtronic, Italy[Q1]) was used to well localize the instrument position in the surgical field and to constantly verify the anatomical landmarks (►**Fig. 1**).

Two patients underwent an endoscopic transnasal craniectomy (ERTC) for the management of a sinonasal malignancy with intracranial involvement, and subsequent repair of the resulting defect. The extent of the resection was tailored to specific tumor characteristics (histology, site of origin, and proximity to critical areas), according to the principles of oncological radicality. The other two patients underwent skull base reconstruction for posttraumatic cerebrospinal fluid leaks, located in the ethmoidal roof and in the olfactory cleft, respectively.

Preoperative diagnostic work-up included magnetic resonance imaging with gadolinium enhancement in all cases. A prophylactic antibiotic regimen with third-generation cephalosporin was started intravenously the day before surgery and was continued for at least 5 days.

Patients were transferred directly to the ward after surgery, with no need for intensive care. Nondegradable nasal packs were removed 2 days after surgery and bed rest was maintained for 2 days with trunk and head raised at 25 degrees. A brain computed tomography scan was performed 24 hours after surgery for early detection of any signs of
postoperative pneumoencephalus[Q2] or intracranial bleeding. Q2

All procedures were performed by four surgeons with wide experience in 2-D transnasal endoscopic skull base reconstruction. At the end of each surgical procedure, the "endosurgeons" were asked to qualitatively define the 3-D system, comparing different parameters with the conventional 2-D endoscopic system. Items were scored as follows: score 3, high advantage; score 2, advantage; score 1, low benefit; score 0, no significant difference; score −1, partial drawback; score −2 drawback; score −3, serious drawback (►**Table 1**).

Surgical Technique

The criterion that guides the skull base repair procedure is "integration of the borders." The preparatory stage of duraplasty must include appropriate exposure of the defect, undermining of the dural margins, and smoothing of the

Figure 1 (A) Intraoperative setting showing two endosurgeons working with the 3-D endoscope (monitor located on the left) and the neuronavigation system (monitor located on the right). (B) The surgical procedures were performed by two-nostril-four-handed technique.

Table 1 Subjective Qualitative Evaluation of 3-D Endoscopic System in Comparison with 2-D

Surgeon	Color Perception	Lighting	Sharpness and Contrast	Depth Perception	Distance and Size Estimation	Hand-Eye Coordination	Identification of Skull Base Structures	Speed of the Procedures	Dizziness and Personal Discomfort
No. 1	−1	−2	−3	2	2	1	1	0	0
No. 2	0	−3	−3	2	1	0	2	0	−2
No. 3	1	−1	−1	3	3	3	3	0	0
No. 4	0	−2	−2	3	2	2	2	0	−1

Score 3, high advantage; score 2, advantage; score 1, low benefit; score 0, no significant difference; score −1, partial drawback; score −2 drawback; score −3, serious drawback.

defect edges to get a tensioactive effect for the graft or flap. In two patients who underwent ERTC, skull base reconstruction was performed with a multilayer technique, to repair a large defect extending from orbit to orbit and from the frontal recess to the sphenoethmoidal planum. Resection time included dural resection until margins free from tumor were obtained. Iliotibial tract or fascia lata were the materials employed for all the reconstruction layers (intradural layer; intracranial-extradural layer; extracranial-endonasal layer).

In two cases of posttraumatic skull base defect, an overlay or multilayer reconstruction technique was performed, depending on the site of the defect with different autologous materials.

In all the cases, the reconstruction was covered with strips of Surgicel (Ethicon Inc., Johnson and Johnson, Somerville, NJ) and fibrin glue was placed along the graft margins.

Results

The clinical findings of the patients, specific localization of the skull base defect, and surgical details are summarized in ►**Table 2**.

No intra- or postoperative complications were observed in the patients enrolled in the study. In comparison with our 2-D experience there was no significant difference in the operative time when using the 3-D endoscopic system. The 3-D endoscopic skull base reconstruction obtained primary closure in all the cases without need of lumbar drainage or duraplasty surgical revision.

According to the subjective opinions of the users, collected after each surgical procedure and arranged in a qualitative assessment (►**Table 1**), the 3-D endoscopic technique improved depth perception (mean score, + 2.5), distance and size estimation (mean score, + 2), ability to identify specific anatomic structures (mean score, + 2), and hand–eye coordination (mean score, + 1.5). The main drawbacks detected were the inferior sharpness and contrast (mean score, −2.25) and lighting (mean score, −2) of the 3-D system compared with the 2-D scopes.

There was no color distortion (mean score, 0) or difference in the speed of the procedure (mean score, 0). The users did not complain of significant subjective discomfort attributed to the stereoscopic visualization and to the wearing of polarized glasses (mean score, −0.75).

Discussion

The ability to manage skull base defects with endonasal endoscopic approaches has represented a milestone in otorhinolaryngology and neurosurgical field. Over time, experienced "skull base teams" have proposed different techniques to repair dural defects, focusing on the use of free or pedicle flaps in a single or multilayer fashion.[2,3,13] Above all, regardless of the technique used, 2-D endoscopes nowadays allow to treat transnasally most of the defects localized in the anterior, middle, and posterior cranial fossa, with low morbidity and high success rate.[14]

Table 2 Clinical and Pathological Findings of the Patients

Case	Pathology	Age	Sex	Comorbidity	Previous Treatment	Hospitalization Time (Days)	Site of Skull Base Defect	Skull Base Reconstruction Technique	Material	Complication (Early and Late)
1	Right ethmoidal ITAC[Q3] with dural involvement (T4bN0M0)	56	M	Ischemic cardiopathy	–	11	Anterior skull base resection	Multilayer	ITT	–
2	Left sinonasal poorly differentiated neuroendocrine carcinoma (T4aN0M0)	54	M	–	I-CHT	9	Anterior skull base resection	Multilayer	ITT	–
3	Posttraumatic CSF leak	39	M	–	–	4	Posterior wall of left frontal sinus	Multilayer	TF, B, MP	–
4	Posttraumatic CSF leak	79	M	Multiple bone fractures (clavicle, hip)	–	6	Posterior portion of left olfactory fissure	Overlay	MP	–

B, bone; CSF, cerebrospinal fluid; I-CHT, induction chemotherapy; ITAC, ITT, iliotibial tract; M, male; MP, mucoperiosteum; TF, temporal fascia.

On the basis of our large series of multilayer duraplasty,[2–4,15–17] we tested the recently introduced stereoscopes to evaluate whether they were able to overcome some limits we observed with 2-D endoscopes. In fact one of the major criticisms of traditional endoscopes is the lack of depth perception in comparison with the open or microscopic surgical field. Skilled endosurgeons well compensate this lack by continuous in-out and side-to-side movements of the scope and by integrating tactile information with previous spatial knowledge. This compensatory perception can sometimes be misleading in 2-D environments. In fact it has been well demonstrated that the primary cause of error in laparoscopic surgery is due to a visual perceptive illusion.[18]

From a technological viewpoint, the 3-D system represents one of the most fascinating innovations in the last decade; this technique has been reported to improve the surgeon's ability in recognizing anatomical landmarks and their spatial relationship.[8–10] Moreover, in the laparoscopic field, significant decreases in "visual endoscopic handicap," performance time and error rates have been demonstrated with the use of the 3-D scope compared with the 2-D scope; this is true for both experienced and less experienced surgeons[7] using the 2-D scope.

With the evolution of technology, stereoscopic rigid endoscopes have recently reduced their dimensions (from 6.5 to 4.0 mm) and angled 30-degree scopes have been introduced. This has permitted easier maneuverability inside sinonasal spaces and better visualization around the corner with complete exposure of the anterior skull base.

In recent years, the 3-D system has been applied in the management of skull base and orbital lesions with encouraging results[8–11] and also our preliminary experience in 3-D skull base surgery seems to confirm the good impressions of other authors in terms of improved hand–eye coordination, better tissue understanding,[9,10] and a "more natural feeling" during surgery.[10] Furthermore, also the ability to identify anatomical landmarks seems to be improved by this technology.[11]

In this respect, we maintain that this technology can be really useful when surgery is performed in extremely delicate spaces where neural and vascular structures are often separated by millimeters. Personally, we found that 3-D visualization was really helpful during the intracranial phase in detaching the dura mater from the ethmoidal roof during ERTC because the epidural space was precisely defined, thus making movements better controlled and reducing the risk of dura damage. Once the dura was cut and opened, the relationship between arachnoid, brain, and vascular structures were clearly evident, permitting a safer intradural dissection, thus reducing the risk of vascular and nervous injuries. In multilayer reconstruction, insertion of the first two layers (intradural and extradural-intracranial) was faster and more accurate because of the constant depth perception. Posterior borders of the duraplasty were inserted in a safer manner because of a clear vision of anatomical structures such as optic chiasm, opticocarotic recess, and parasellar portion of the internal carotid artery.

Furthermore, also in the case of posttraumatic cribriform plate defects, in which the surgical field is smaller, 3-D visualization allowed a better definition of the surgical details, thus making the surgeon more comfortable with drilling the bone and placing the flap. On the whole, surgeons felt at ease and well oriented with the surgical procedures.

With reference to the current drawbacks of this technology, we underline the inferior sharpness, lighting and contrast compared with new HD 2-D systems.[11] The short range of focus and restricted viewing angle still make surgery in narrow spaces more difficult.[11] Also our experience confirms that 3-D systems currently show some flaws in terms of visual discomfort and distortion, mainly when working in narrow spaces. To date, in the early phases of the transnasal skull base approaches, the HD 2-D system remains the most efficacious and accurate technique. Notwithstanding this, we maintain that 3-D technological evolution will overcome these limits.

Furthermore, new clear-vision systems are needed, given the fact that a 3-D image is more susceptible to poor visualization when soiled[9] and the resulting image is deeply disturbing.

Despite this fact, although clinical experience is in the early phases and the current limits are well known, we maintain that with further development 3-D endoscopes could represent a really remarkable opportunity for the endosurgeons and the patients of tomorrow.

Conclusion

Although 2-D techniques are able to offer skilled surgeons a valid tool for skull base procedures, we maintain that the 3-D system could represent a significant advantage for managing these complex regions. This is particularly relevant in terms of efficacy and safety of the procedure. Future controlled trials will be necessary to validate this new technology.

Acknowledgment

All the authors certify that they have no conflict of interest or financial relationship with any entity mentioned in the article. No sponsor is involved in the article.

References

1 Kassam A, Carrau RL, Snyderman CH, Gardner P, Mintz A. Evolution of reconstructive techniques following endoscopic expanded endonasal approaches. Neurosurg Focus 2005;19(1):E8

2 Locatelli D, Rampa F, Acchiardi I, Bignami M, De Bernardi F, Castelnuovo P. Endoscopic endonasal approaches for repair of cerebrospinal fluid leaks: nine-year experience. Neurosurgery 2006;58(4, Suppl 02):ONS-246–ONS-256, ONS-256–257

3 Castelnuovo PG, Delú G, Locatelli D, et al. Endonasal endoscopic duraplasty: our experience. Skull Base 2006;16(1):19–24

4 Villaret AB, Yakirevitch A, Bizzoni A, et al. Endoscopic transnasal craniectomy in the management of selected sinonasal malignancies. Am J Rhinol Allergy 2010;24(1):60–65

5 Castelnuovo P, Dallan I, Battaglia P, Bignami M. Endoscopic endonasal skull base surgery: past, present and future. Eur Arch Otorhinolaryngol 2010;267(5):649–663

6 Kassam AB, Prevedello DM, Carrau RL, et al. Endoscopic endonasal skull base surgery: analysis of complications in the authors' initial 800 patients. J Neurosurg 2011;114(6):1544–1568

7 Taffinder N, Smith SG, Huber J, Russell RC, Darzi A. The effect of a second-generation 3D endoscope on the laparoscopic precision of novices and experienced surgeons. Surg Endosc 1999;13(11): 1087–1092

8 Roth J, Fraser JF, Singh A, Bernardo A, Anand VK, Schwartz TH. Surgical approaches to the orbital apex: comparison of endoscopic endonasal and transcranial approaches using a novel 3D endoscope. Orbit 2011;30(1):43–48

9 Brown SM, Tabaee A, Singh A, Schwartz TH, Anand VK. Three-dimensional endoscopic sinus surgery: feasibility and technical aspects. Otolaryngol Head Neck Surg 2008;138(3):400–402

10 Tabaee A, Anand VK, Fraser JF, Brown SM, Singh A, Schwartz TH. Three-dimensional endoscopic pituitary surgery. Neurosurgery 2009;64(5, Suppl 02):288–293, discussion 294–295

11 Wasserzug O, Margalit N, Weizman N, Fliss DM, Gil Z. Utility of a three-dimensional endoscopic system in skull base surgery. Skull Base 2010;20(4):223–228

12 Fraser JF, Allen B, Anand VK, Schwartz TH. Three-dimensional neurostereoendoscopy: subjective and objective comparison to 2D. Minim Invasive Neurosurg 2009;52(1):25–31

13 Hadad G, Bassagasteguy L, Carrau RL, et al. A novel reconstructive technique after endoscopic expanded endonasal approaches: vascular pedicle nasoseptal flap. Laryngoscope 2006;116(10): 1882–1886

14 Hegazy HM, Carrau RL, Snyderman CH, Kassam A, Zweig J. Transnasal endoscopic repair of cerebrospinal fluid rhinorrhea: a meta-analysis. Laryngoscope 2000;110(7):1166–1172

15 Locatelli D, Vitali M, Custodi VM, Scagnelli P, Castelnuovo P, Canevari FR. Endonasal approaches to the sellar and parasellar regions: closure techniques using biomaterials. Acta Neurochir (Wien) 2009;151(11):1431–1437

16 Castelnuovo P, Dallan I, Pistochini A, Battaglia P, Locatelli D, Bignami M. Endonasal endoscopic repair of Sternberg's canal cerebrospinal fluid leaks. Laryngoscope 2007;117(2):345–349

17 Castelnuovo P, Dallan I, Bignami M, Pistochini A, Battaglia P, Tschabitscher M. Endoscopic endonasal management of petroclival cerebrospinal fluid leaks: anatomical study and preliminary clinical experience. Minim Invasive Neurosurg 2008;51(6):336–339

18 Way LW, Stewart L, Gantert W, et al. Causes and prevention of laparoscopic bile duct injuries: analysis of 252 cases from a human factors and cognitive psychology perspective. Ann Surg 2003;237 (4):460–469

THIEME

Author Query Form (SBS/00115)

Special Instructions: Author please write responses to queries directly on proofs and then return back.

Q1: AU: Please provide city and state name.
Q2: AU: Is this pneumocephalus?
Q3: AU: Is this Intestinal-type adenocarcinoma?