2014 Update in Robotic Otolaryngologic Surgery

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Background

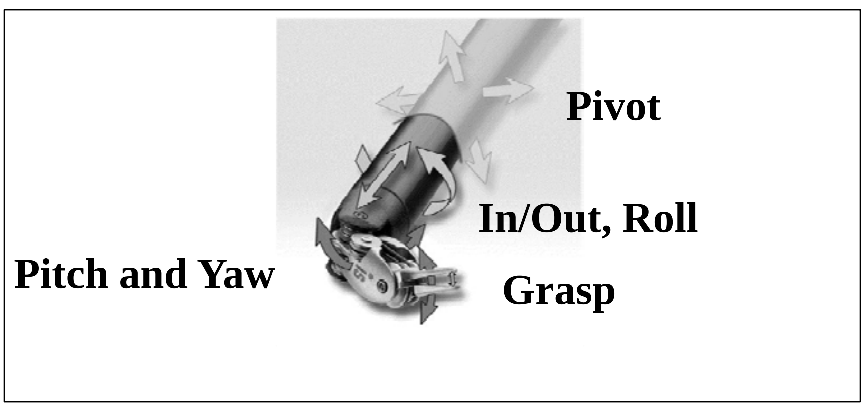
- MIS (minimally invasive surgery) techniques
  - surgeons no longer needed to physically place their hands within the body
- Downsides of MIS:
  - Loss of wrist articulation
  - Poor touch feedback
  - Fulcrum effect
  - Loss of 3-dimensional vision
  - Poor ergonomics

Background

- MIS and beyond…
  - surgeons no longer needed to physically place their hands within the body & be there (*telepresence surgery*)
- Without :
  - Loss of wrist articulation
  - Fulcrum effect
  - Loss of 3-dimensional vision
  - Poor ergonomics

Background

- Degrees of freedom →



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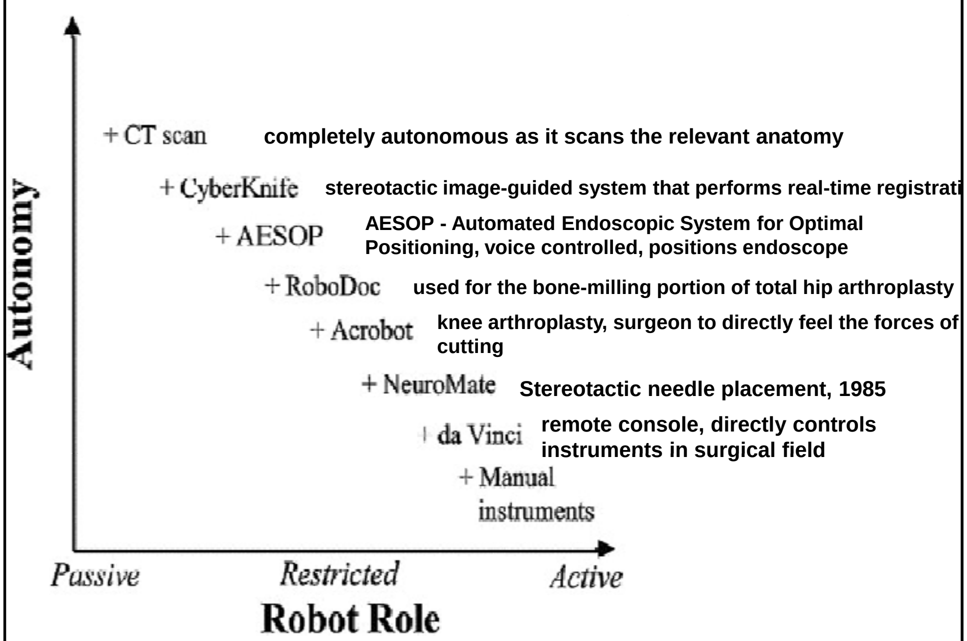


Integrated Surgical Systems, Davis, CA

Head and Neck Applications

- <u>1999</u> > Da Vinci System introduced
- <u>2005</u> > Pre-clinical data suggests feasibility of transoral resection of mucosal lesions of the UADT
- <u>2006</u> > First patient experience is reported. The acronym TORS (Transoral Robotic Surgery) is coined
- <u>2013</u>> OSU TORS experience to date
  - >200 Patients

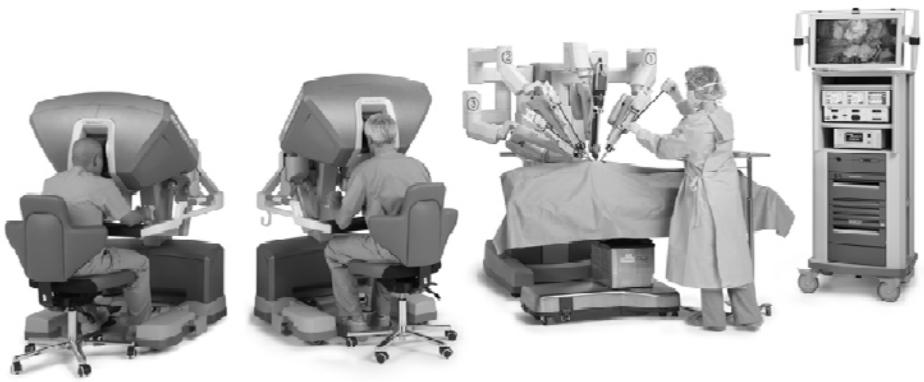
Advantages

- Tremor Ablation
- Wristed Instrumentation
- Motion Scaling
- Three Dimensional Visualization
- Multiplanar Transection of Tissues
- “Minimally Invasive”
  - May obviate mandibulotomy in selected cases
- Potentially shorter operative time, reduced morbidity, decrease in blood loss, reduction in length of stay/ICU days
- Patients will be seeking it out…

(Image Courtesy of Intuitive Surgical, Inc., Sunnyvale, CA.)

Disadvantages

- Cost
- Additional Setup Time
- Safety Issues
- Lack of Tactile Feedback
- Need to Stage Neck Dissection?
- Instrumentation not ENT specific
- Patient Anatomy May Preclude Adequate Exposure and Access
  - Teeth, Tori, Tongue, Trismus
- Learning Curve



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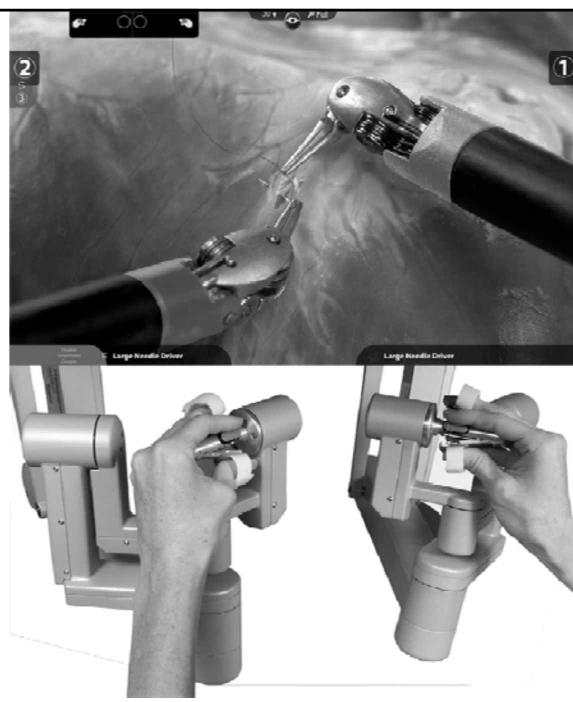

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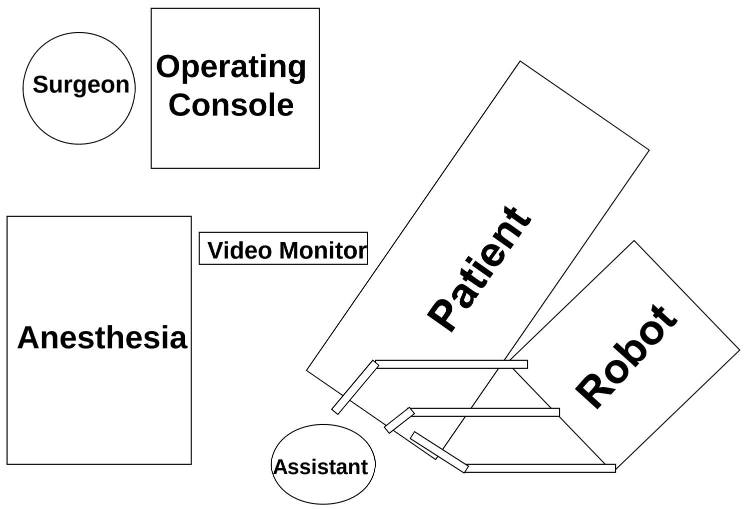
Instrumentation and Setup



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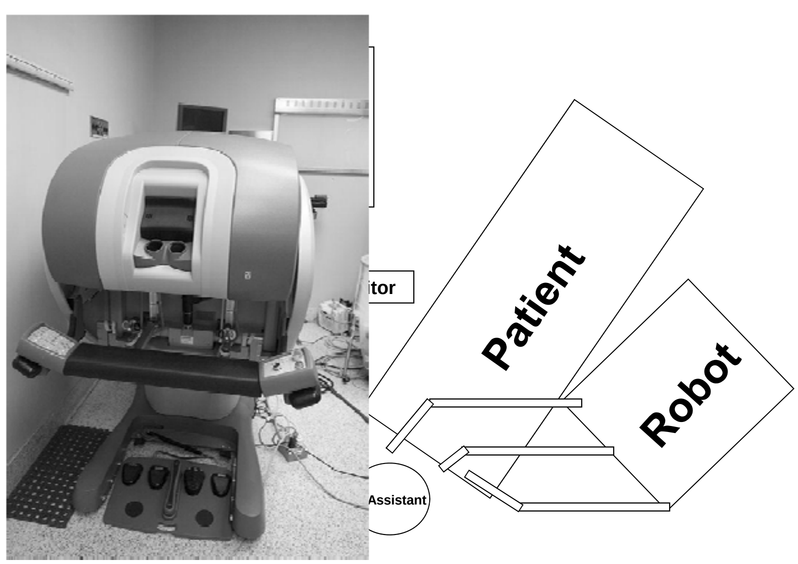

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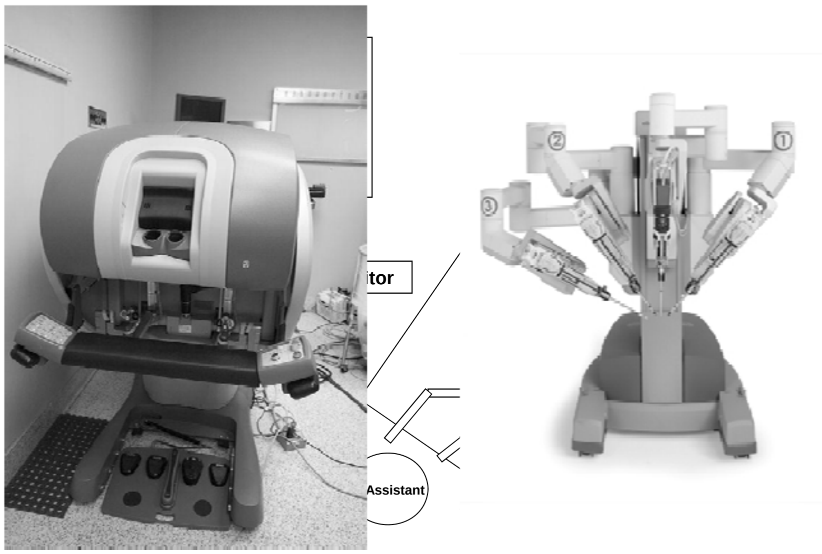

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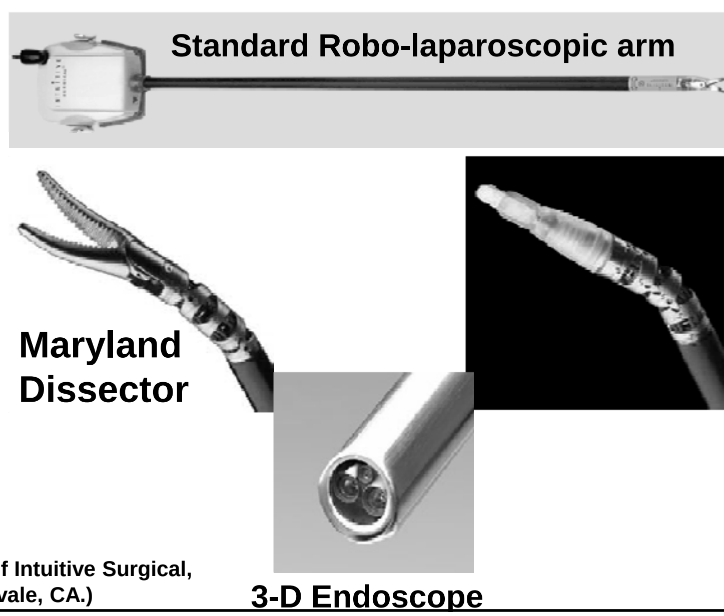

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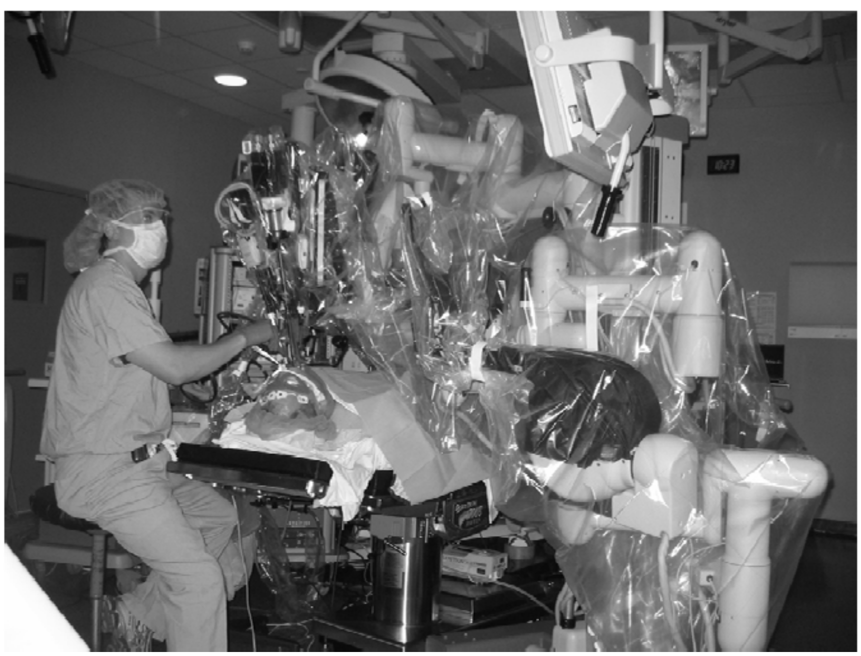
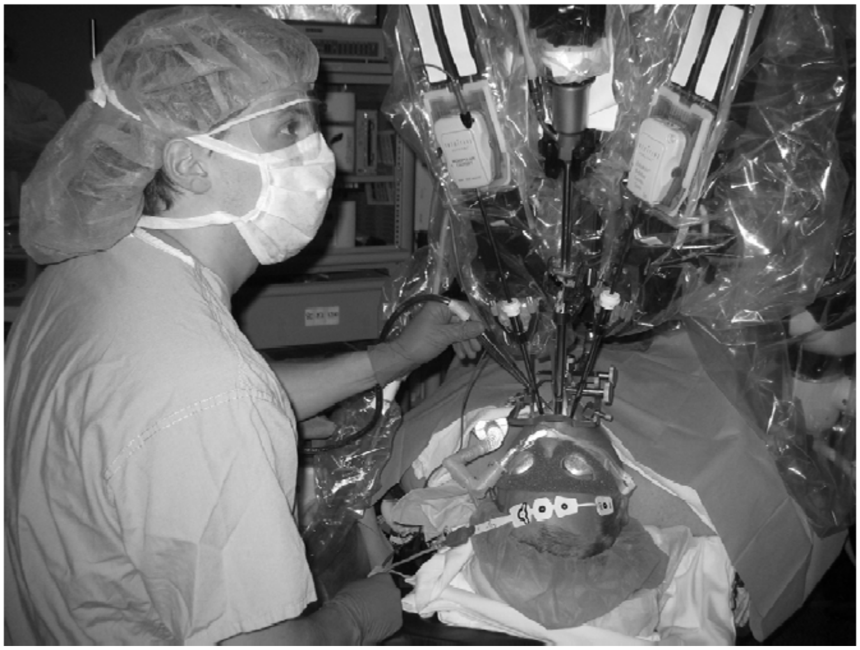




Head and Neck Applications

- **Haus B, et al. Surgical robotic applications in otolaryngology. *Laryngoscope*. 2003;113:1139-1144.**
  - **Endoscopic neck surgery in pigs using da Vin**
  - **3 submandibular gland excisions (39 min.)**
  - **3 SND (85 min.)**
  - **1 partial parotidectomy, 1 thymectomy**
  - **Complications:**
    - **Moderate subcutaneous emphysema**

Head and Neck Applications

- Terris D, et al. Endo-robotic resection of the submandibular gland in a cadaver model. *Head and Neck*. 2005;27;946-951.
  - SM gland excision in cadavers, robotic/endoscopic approach
  - N=11 sm gland excisions with da Vinci
  - Average time 48 min. (65 min. with conventional instruments)
  - Histolopathology confirmed nml glands and no neurovascular inujury

Head and Neck Applications

- Weinstein G, et al. Transoral robotic surgery: supraglottic laryngectomy in a canine model. *Laryngoscope*. 2005
  - Robotic transoral supraglottic partial laryngectomy in the canine model using da Vinci
  - Excellent hemostasis, superb visualization, and multiplanar transection of tissues
  - “Wristed" instrumentation, tremor elimination, motion scaling, and three-dimensional vision

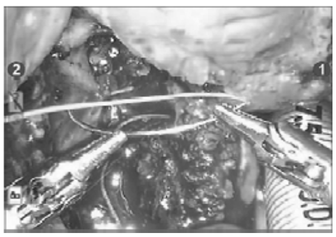
Head and Neck Applications

- **O'Malley B, et al. Transoral robotic surgery (TORS) for base of tongue neoplasms. *Laryngoscope*. 2006**
  - **10 BOT dissections in 3 cadavers, 2 mongrel dogs**
  - **3 BOT cancer excision in humans using da Vinci**
  - **Identify/preserve/resect key structures - glossopharyngeal, hypoglossal, and lingual nerves, lingual artery**

Head and Neck Applications

- **Weinstein G, et al., Transoral robotic surgery: radical tonsillectomy. *Arch Otolaryngol Head Neck Surg*. 2007**
- **Prospective, phase 1 clinical trial of 27 pts.**
  - **TORS radical tonsillectomy for previously untreated tonsil SCC**
  - **Outcomes: margin status and need for g-tube feedings, with a minimum 6-month follow-up**
  - **Margins negative for cancer in 25 of 27 patients (93%)**
  - **26/27 patients (96%) were swallowing without need for g-tube**

Head and Neck Applications



- Contraindications:
  - Unresectable neck nodes
  - Mandibular invasion
  - > 50% of tongue base involved;
  - Need to resect more than 50% of the posterior pharyngeal wall
  - Carotid artery involvement
  - Fixation of tumor to the prevertebral fascia
- Conclusions:
  - Excellent access for resection of tonsil SCC with acceptable acute morbidity

Weinstein G, et al., Transoral robotic surgery: radical tonsillectomy. *Arch Otolaryngol Head Neck Surg*. 2007

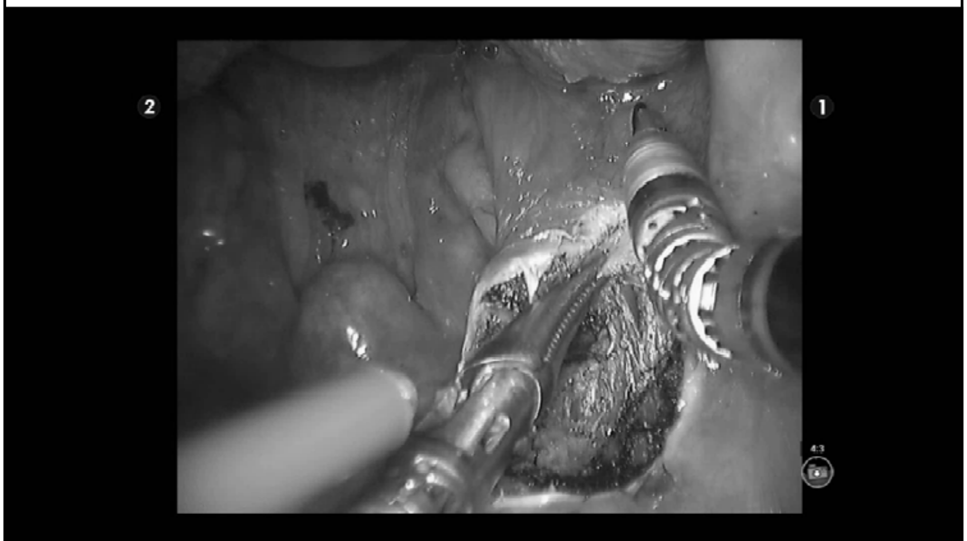
The Ohio State University Robotic Head & Neck Surgery Experience to Date

- Numerous Cadaveric Dissections
- >200 patients, T_0 to T_3 disease
  - Radical Tonsillectomy
  - Tongue Base Resection
  - Supraglottic Laryngectomy
  - Parapharynx tumor resection
  - Nasopharyngectomy combined with EEA
  - Retromolar trigone cancer resection
  - Lingual Tonsillectomy
- Active IRB-Approved Protocol
  - Accruing Patients
- Fellowship
  - Four head and neck fellows in the last 4 years

Variable	TORS SCCA Patients (N=54)
Age (years)	56.9 8.91
Gender (F:M)	9:45
T stage (N=54)	
1	21/54 (39%)
2	27/54 (50%)
3	6/54 (11%)
N stage (N=54)	
0	11/54 (20%)
1	6/54 (11%)
2	33/54 (61%)
3	4/54 (7.40%)
Overall stage (N=54-)	
I	7/54 (13%)
II	3/54 (5.6%)
III	7/54 (13%)
IV	37/54 (69%)
HPV Status (n=46)	
HPV^+	37 (80%)
HPV^-	9 (20%)
P 16 Status (n=45)	
$p16^+$	38 (84%)
$p16^-$	7 (16%)
Neck dissection (n=64)	
None	10 (16%)
Unilateral	51 (80%)
Bilateral	3 (4.0%)
Extracapsular spread (n=44)	
Present	19 (43%)
Absent	25 (57%)
Lymphovascular invasion (n=53)	
Present	17 (32%)
Absent	36 (68%)
Mean number of positive lymph nodes	2.18 4.98
Follow up time (months)	11.8 7.67

Variable	All Patients (N=54)	T_1 (N=21)	T_2 (N=27)	T_3 (N=6)
TORS set up time (min)	23.0 9.30	23.7 9.38	23.3 9.76	23.5 10.0
TORS OR time (min)	20.4 11.5	14.6 7.37	23.9 12.3	28.2 11.0
Diagnostic time (min)	7.09 3.26	7.00 3.87	6.89 2.55	7.17 3.19
Total OR time (min)	179 78.0	187 99.3	178 60.9	185 78.7
TORS Intraoperative EBL (mL)	16.4 14.8	10.7 10.5	19.0 15.7	25.8 19.6
Length of stay (days)	3.00 1.40	3.00 1.41	3.00 1.30	3.60 1.95

	Time, Mean (SD), min		
Cases	**Setup**	**Tumor removal**	**Total OR time**
First 10	34.1 13.7	23.0 11.5	179 64.2
Subsequent 44	21.2 7.43	17.4 10.3	161 77.3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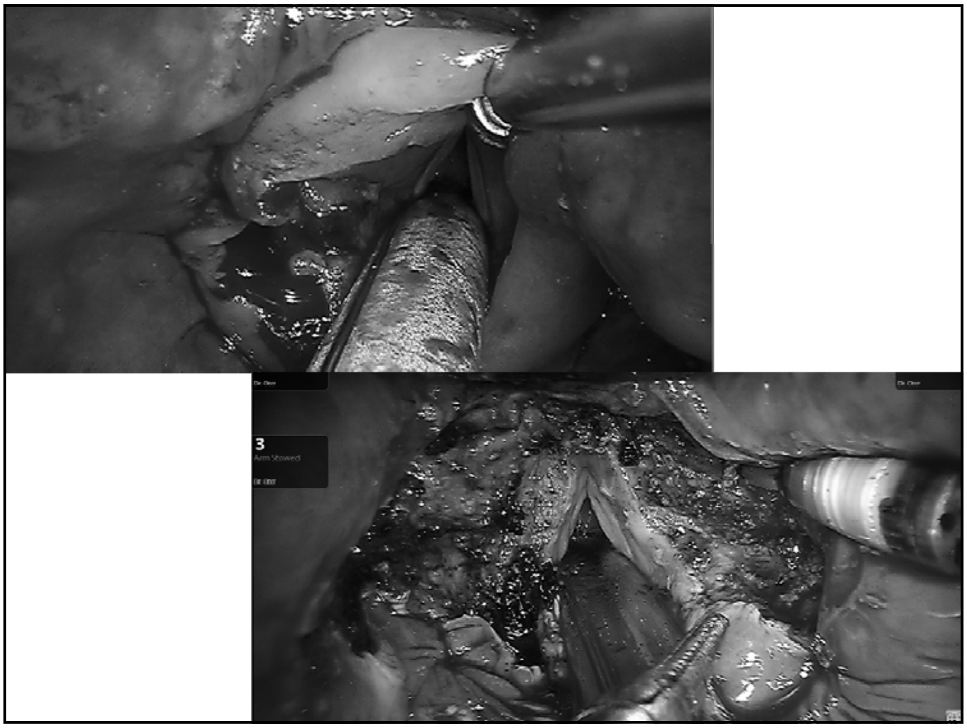
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Arm Stowed

The Laryngoscope
Lippincott Williams & Wilkins
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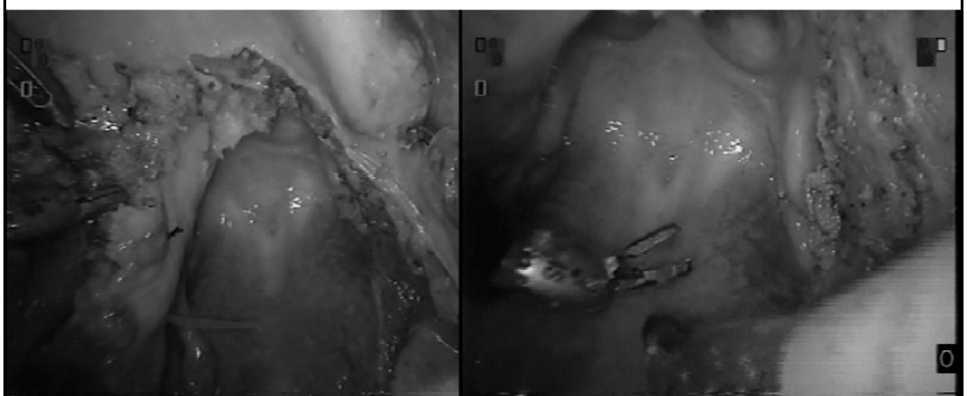
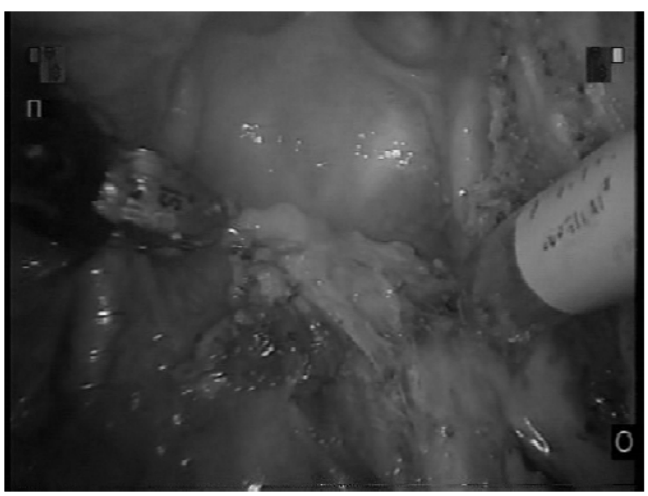
Ozer E, Waltonen J. Transoral robotic nasopharyngectomy: a novel approach for nasopharyngeal lesions. Laryngoscope. 2008 Sep;118(9):1613-6.

How I Do It

Transoral Robotic Nasopharyngectomy: A Novel Approach for Nasopharyngeal Lesions

Enver Ozer, MD; Jashua Waltonen, MD





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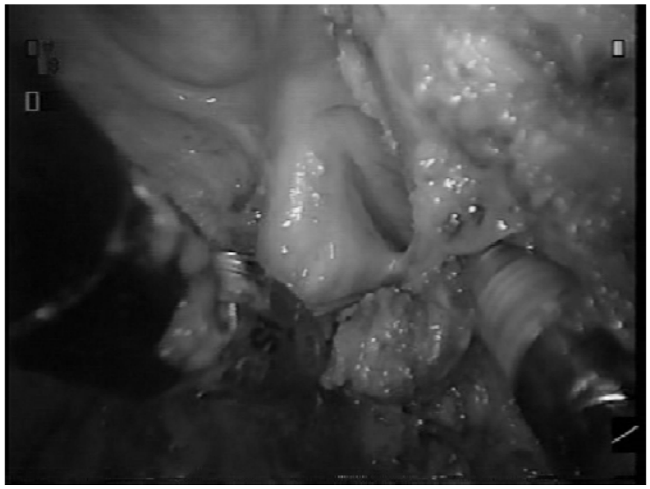

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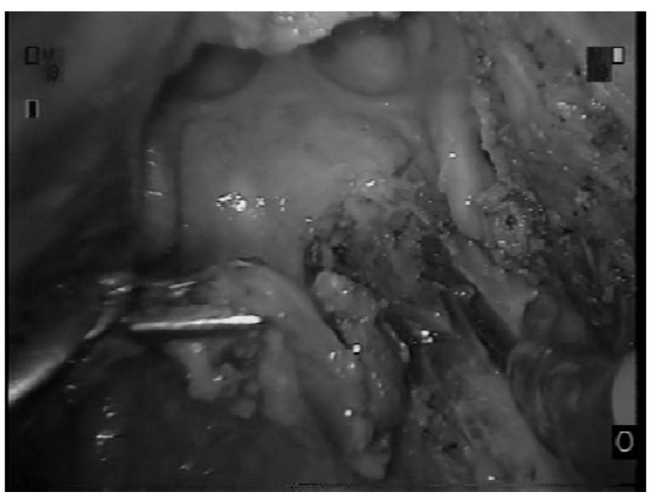

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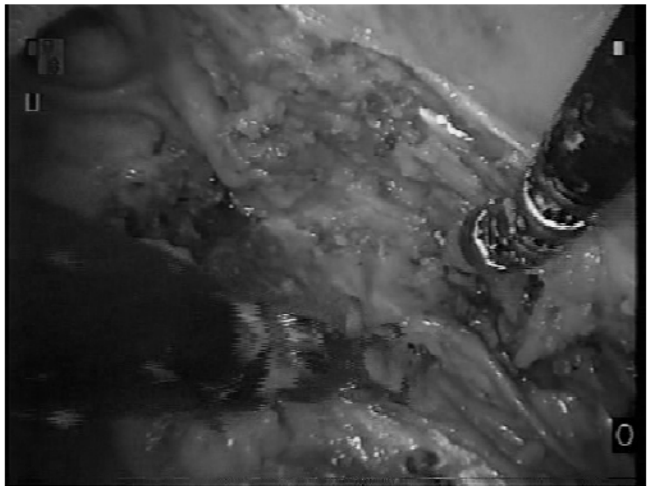

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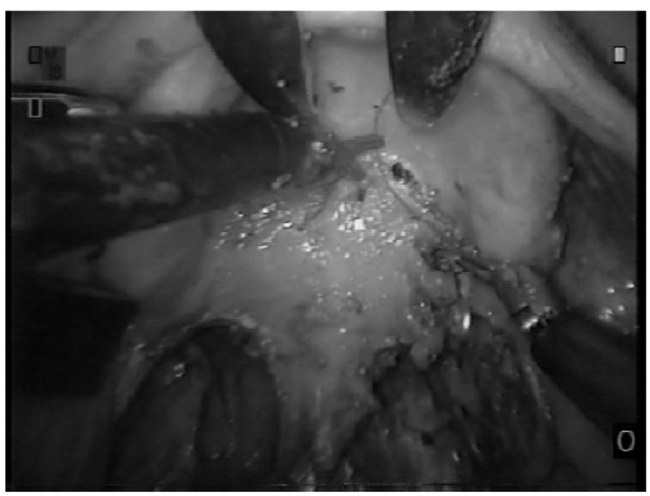

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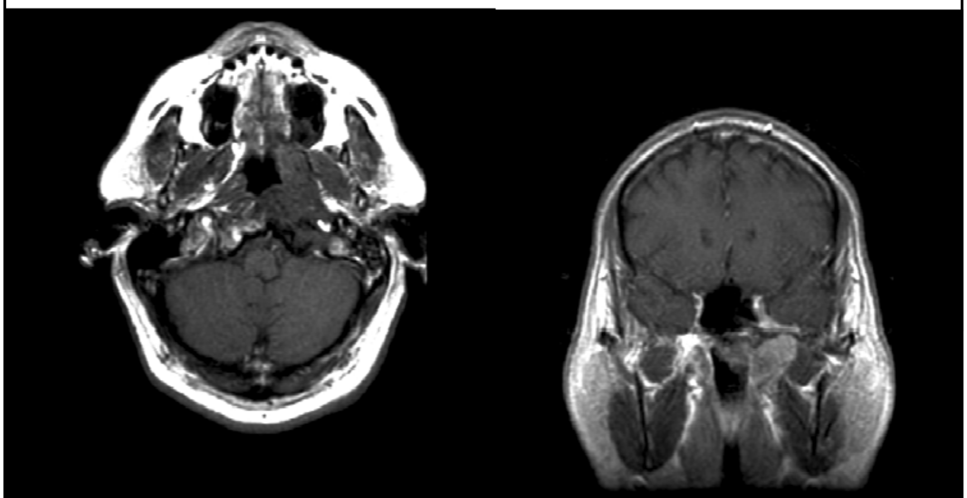
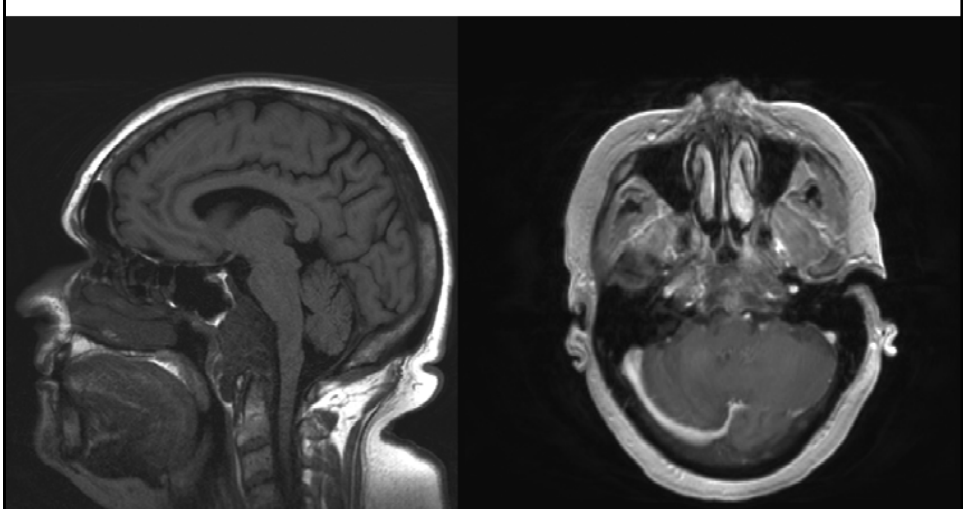
Combined Robotic/Endoscopic Skull Base Resection



Combined Robotic/Endoscopic Skull Base Resection



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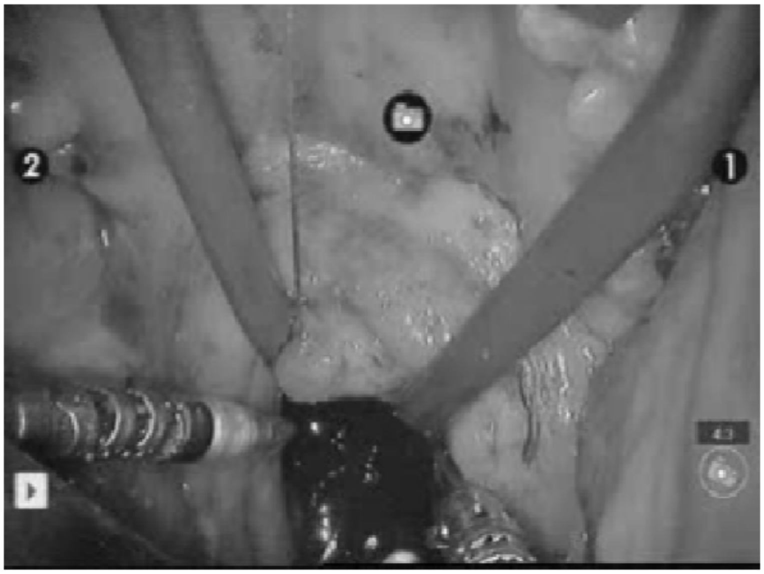

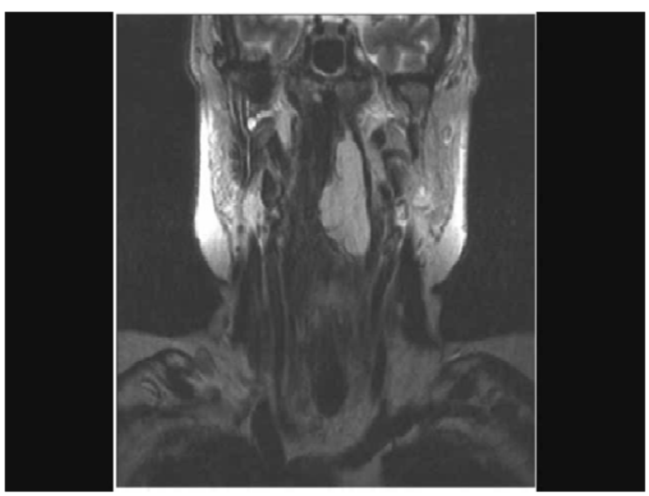

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Transoral Robotic Approach to Carcinoma of Unknown Primary

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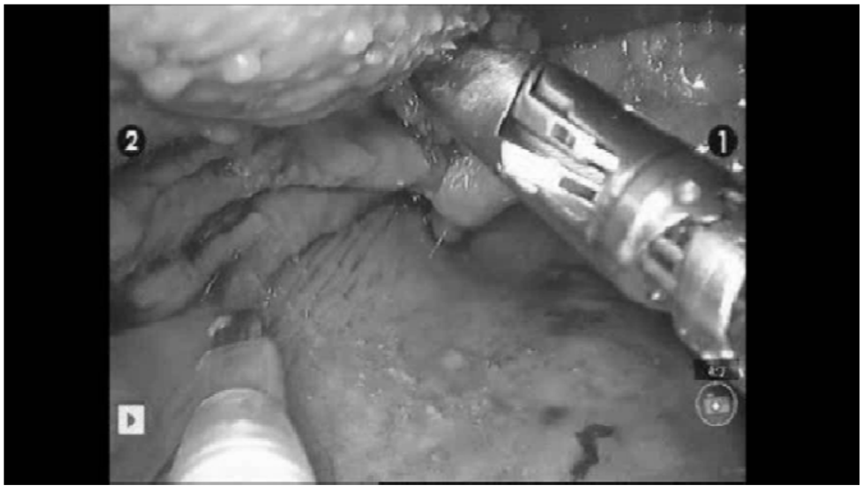
Carcinoma of Unknown Primary (CUP)

- 2%-5%
- Metastatic cervical lymphadenopathy
- Diagnostic Approach (59.6%)
  - History
  - Physical Examination
  - Flexible Endoscopy
  - CT/MRI (9.6 %)
  - PET/CT (44.2 %)
  - Panendoscopy + directed biopsies (17- 40 %)
    - Nasopharynx
    - Oropharynx
    - Hypopharynx

46


Maryland Dissector
Monopolar Cautery



Conclusion

- Occult primary identification with combination of PET/CT + panendoscopy/biopsies + robot: 17/22 (77.3%)
- Intraoperative diagnosis + definitive tumor resection simultaneously
- Avoidance of wide-field mucosal irradiation

50

Robot-Assisted Selective Neck Dissection via Modified Face-lift Approach for Early Oral Tongue Cancer: A Video Demonstration.

Koh, Yoon Woo; Chung, Woong Youn; Hong, Hyun Jun; Lee, So-Yoon; Kim, Won Shik; Lee, Hyoung Shin; Choi, Eun Chang. *Annals of Surgical Oncology* vol. 19 issue 4 April 2012. p. 1334 - 1335

Feasibility of Robot-Assisted Neck Dissections via a Transaxillary and Retroauricular ("TARA") Approach in Head and Neck Cancer: Preliminary Results.

Won Shik Kim, Hyoung Shin Lee, Sung Mi Kang. Annals of Surgical Oncology, 2012, Volume 19, Number 3, Page 1009

Robotic Transaxillary Thyroidectomy

- N: 338 patients
- Median age: 40
- M/F= 1/17
- Total thyroidectomy: 104
- Mean operative time: 144 min (69-347)
- Hospital stay: 3.3 days (2-7)
- Complications
  - RLN paralysis: 3 patients
  - Horner syndrome: 1 patient

Chung WY et. al. Surgery, 2009,

Future Directions: What we need?

- Single arm, single port robotic systems
- Otolaryngology-specific instrumentation
- Standardization of robotic surgery preparation and training
- Integration of tactile feedback sensors into surgical robots
- Fiberoptic CO_2 LASER-coupled TORS

Future Directions

- **Increased reporting of data with respect to oncological, and functional outcomes**
  - **From multiple institutions**
- **Increasing role of the robot in head and neck reconstruction**
  - **Laparoscopic harvest, microvascular anastomosis, neurroraphy, inset**
- **Telesurgery**

Main roles of robotics in otolaryngology

Skull Base Surgery

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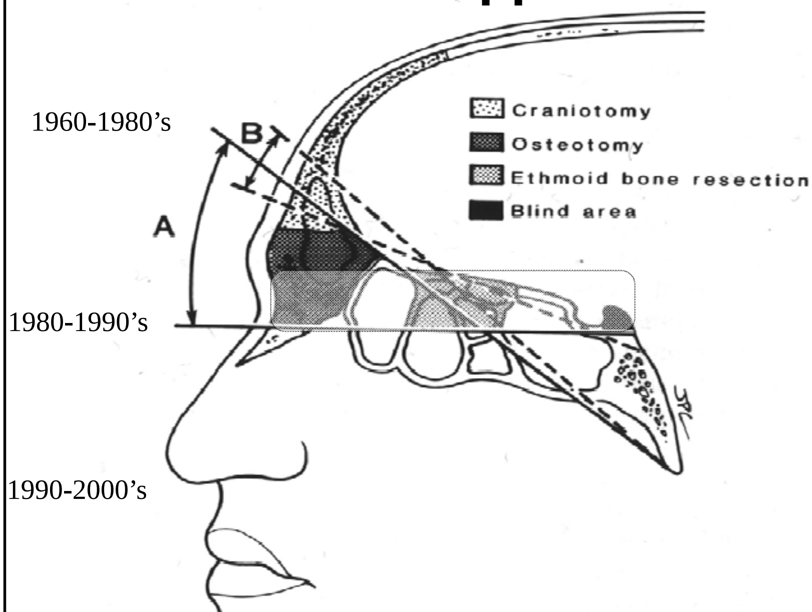
Anterior Approaches



Medscape: The Role of Fibrin Sealants in Cranial-Base Surgery: Authors: Amin Kassam, MD, Ricardo L. Carrau, MD, Michael Horowitz, MD, Carl Snyderman, MD, Barry E. Hirsch, MD, and William C. Welch, MD

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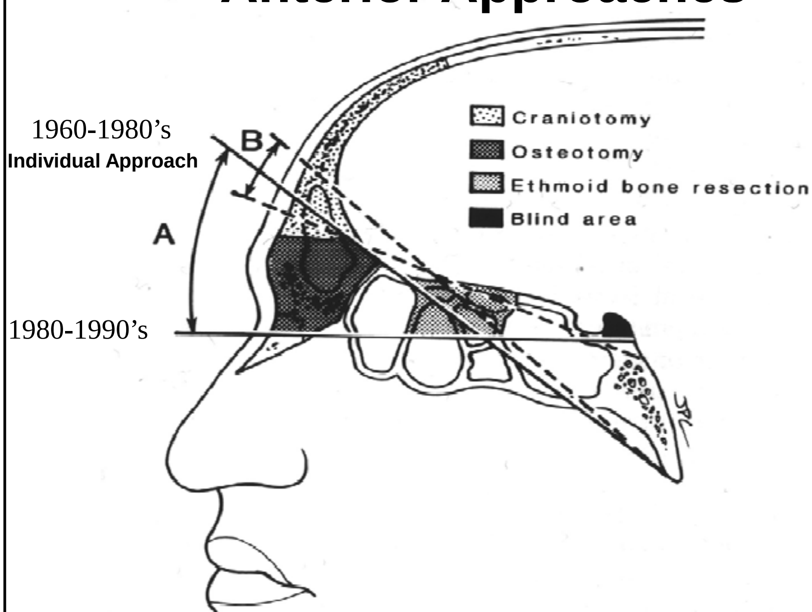

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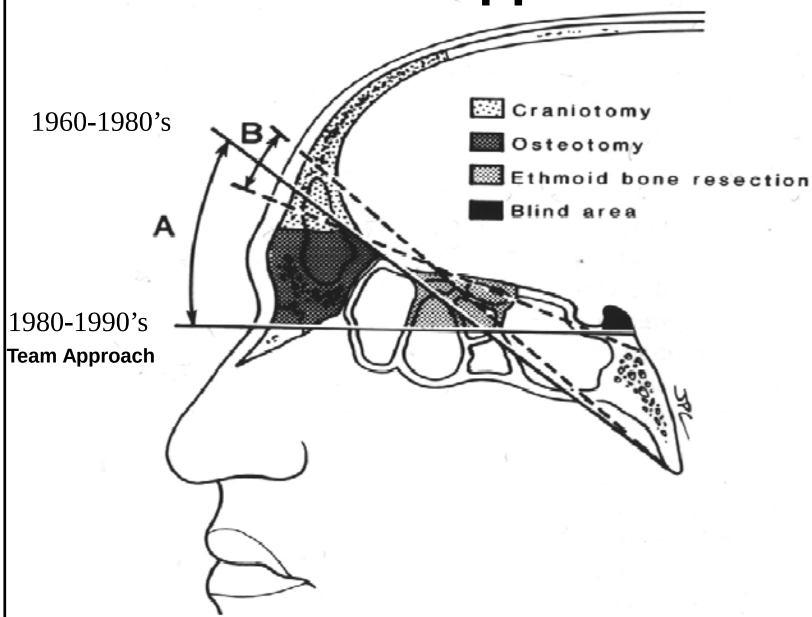

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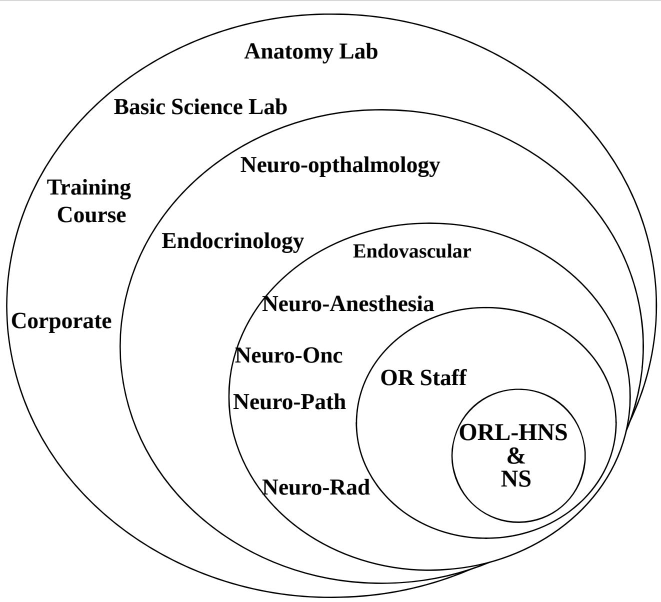
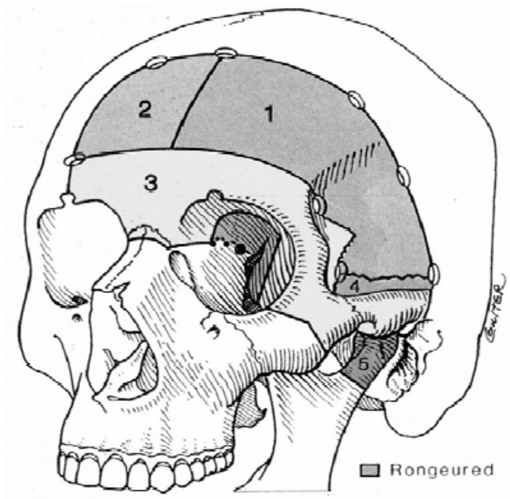


Surgical Outcomes

Oncologic:
local control
palliation

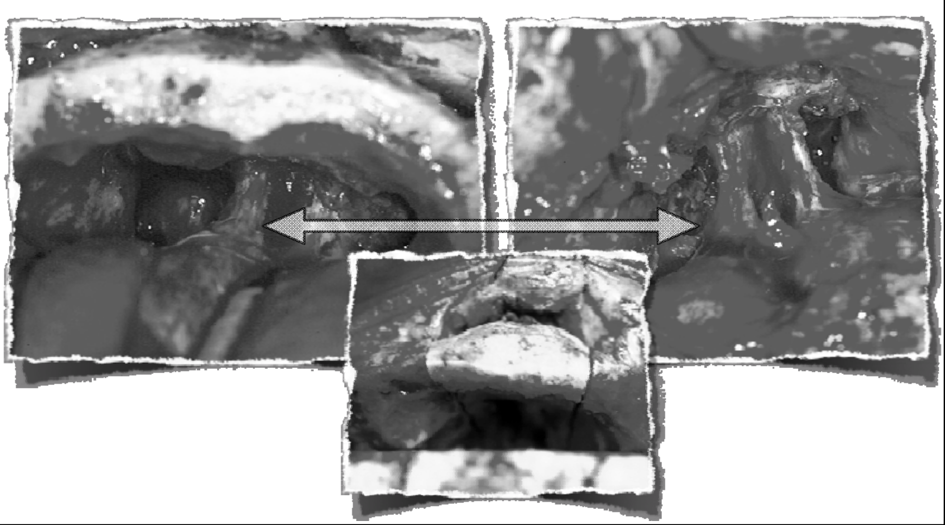
Functional:
brain- retraction/contusion
ocular- orbital volume
EOM's
cranial nerves

Cosmetic:
scars
loss of bone



Sekhar, Laligam N., and Ivo P. Janecka. *Surgery of Cranial Base Tumors*. New York: Raven, 1993. Print.

Subfrontal Approach



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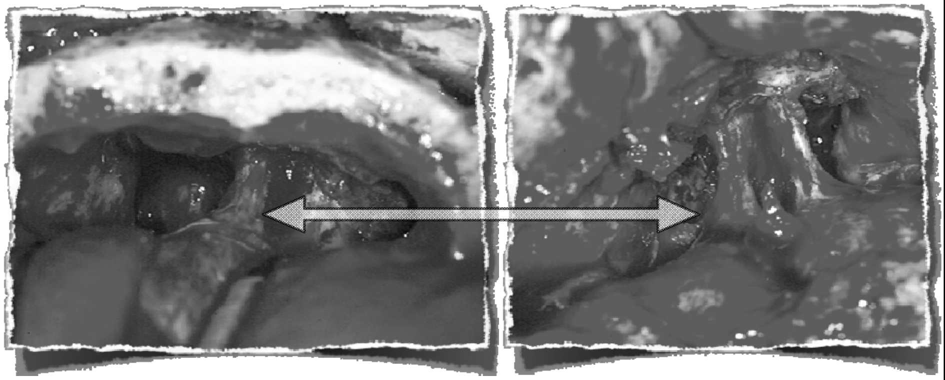

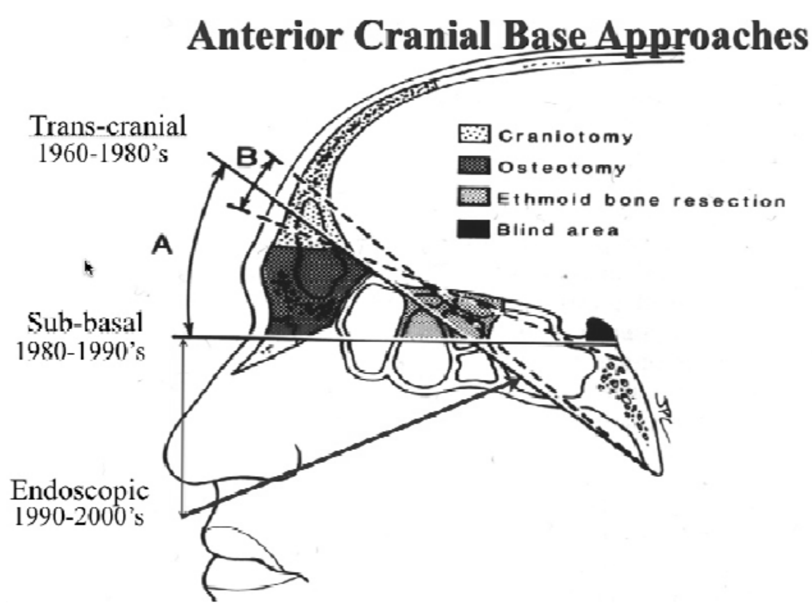

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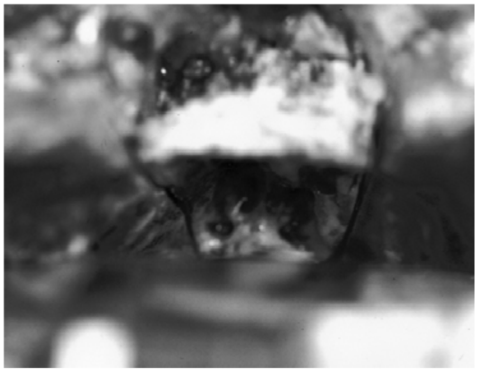
Cranial Base Osteotomies

- **Crista galli**
- **Cribiform plate**
- **Planum sphenoidale**
- **Orbital roofs**



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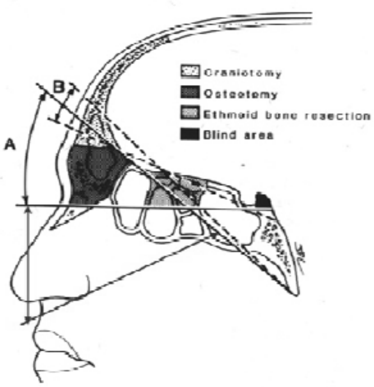

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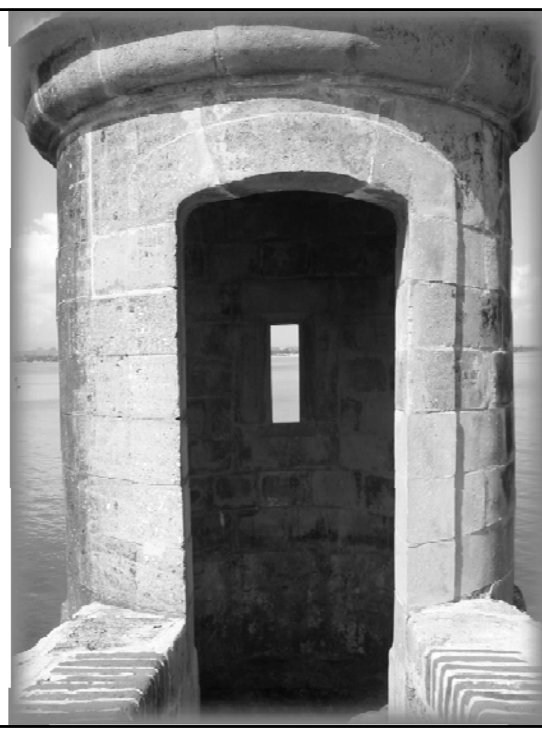
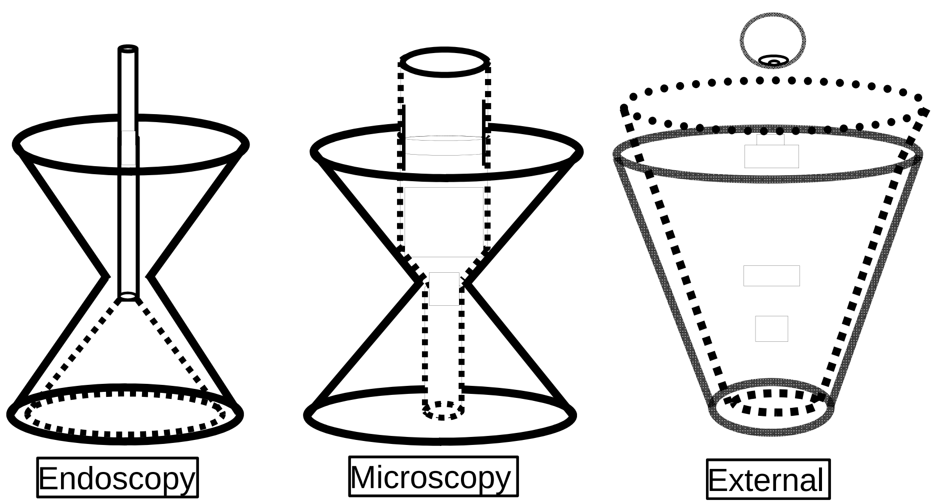
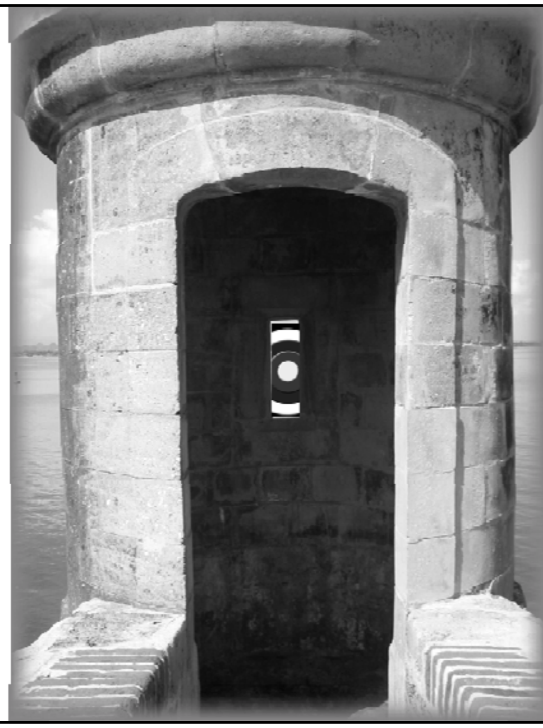
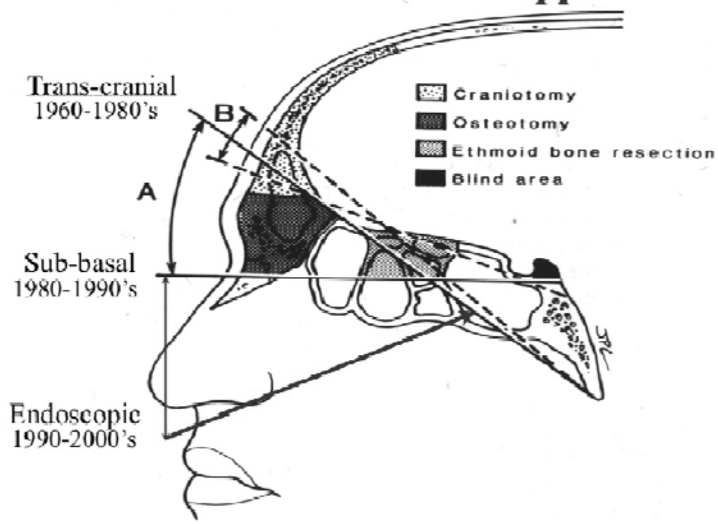




Kasemsiri P, Carrau RL, Prevedello DM, et al.
Advantages and Limitations of EEA
World Neurosurgery (Supplement), In Press



Anterior Cranial Base Approaches



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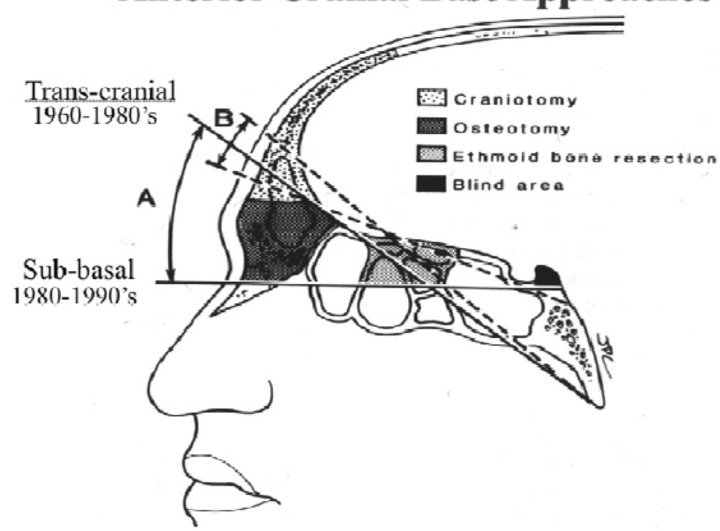
Anterior Cranial Base Approaches



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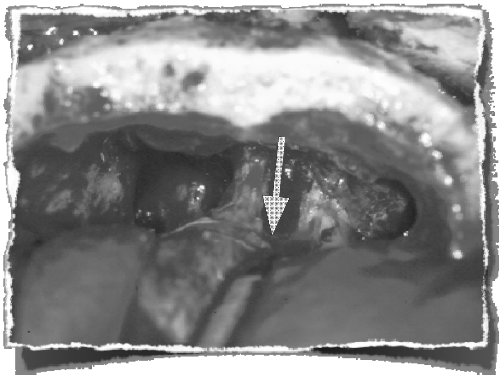
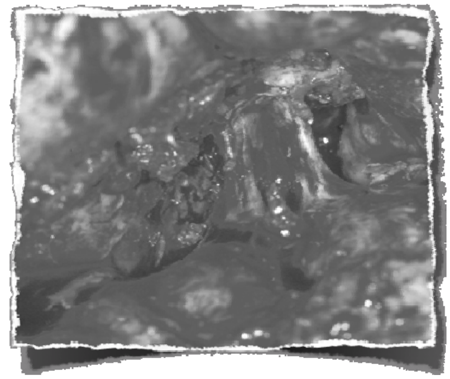
Subfrontal Approach





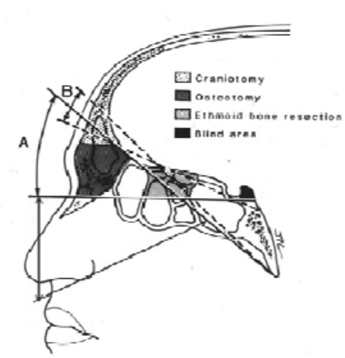
Parenchymal Injury in Open ACR

Edema 28%

Infarction 8%

Contusion 32%

Encephalomalacia 75%



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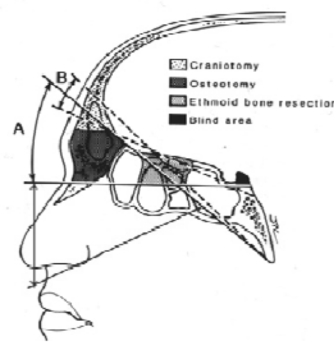
Morbidity & Mortality in Open ACR

Complications: 36%

Wound complications: 20%

CNS complications: 16%

Mortality: 5%



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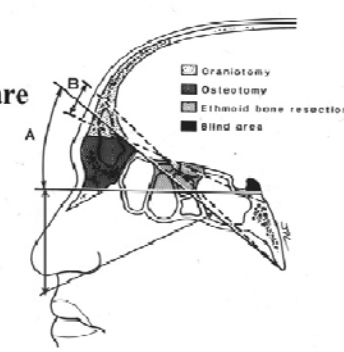
Morbidity & Mortality in Open ACR

Rates of complications & mortality are greater in patients >70 yrs

Complications: 42% *vs* 32%

Mortality: 9% *vs* 3%



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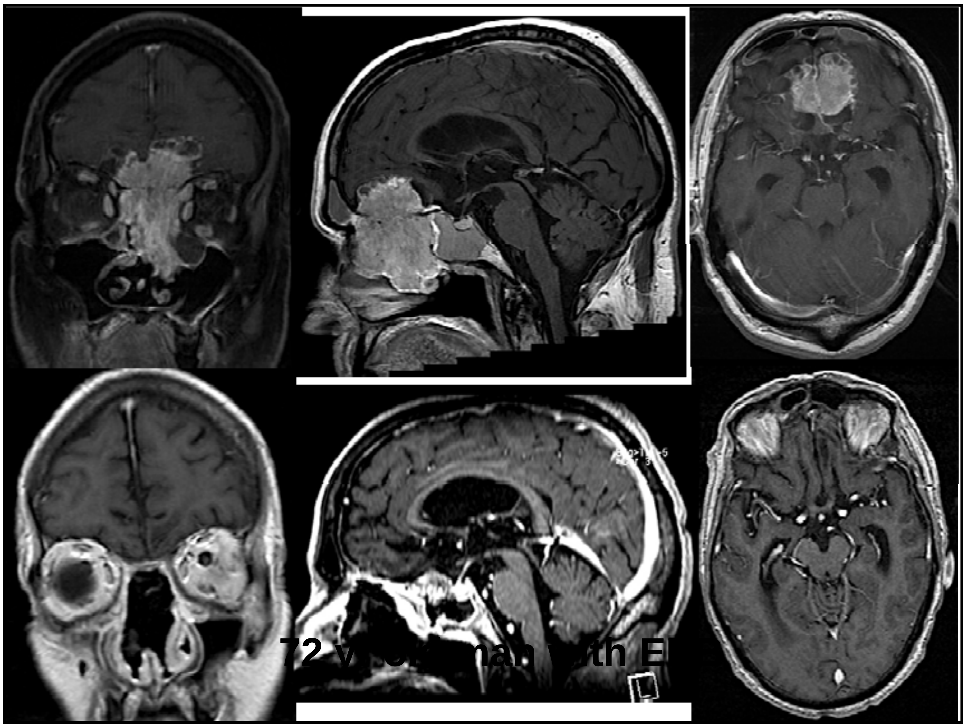


Surgical Outcomes

Oncologic:
local control
palliation

Functional:
brain- retraction/contusion
ocular- orbital volume
EOM's
cranial nerves

Cosmetic:
scars
loss of bone

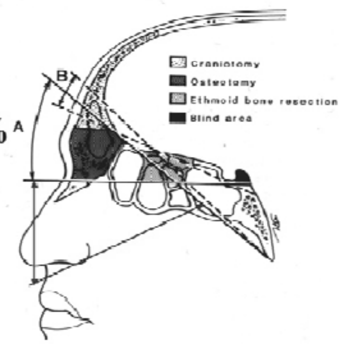
Morbidity & Mortality in Open ACR

Complications: 36%

Wound complications: 20%

CNS complications: 16%

Mortality: 5%



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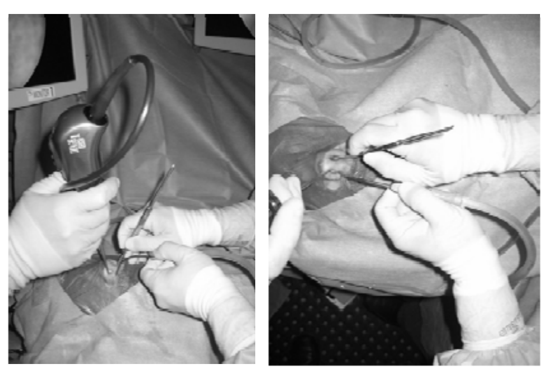
Expanded Endonasal Approaches

Bimanual technique N2S2H4

- **2 nostrils**
  (post. Septum removal)
- **2 surgeons**
- **4 hands**

Instruments:

0^{0} , 45^{0} , 70^{0} endoscopes
long instruments
bipolar cautery
drill
navigation



Bi-manual 3-4 hand dissection

Lots of experience

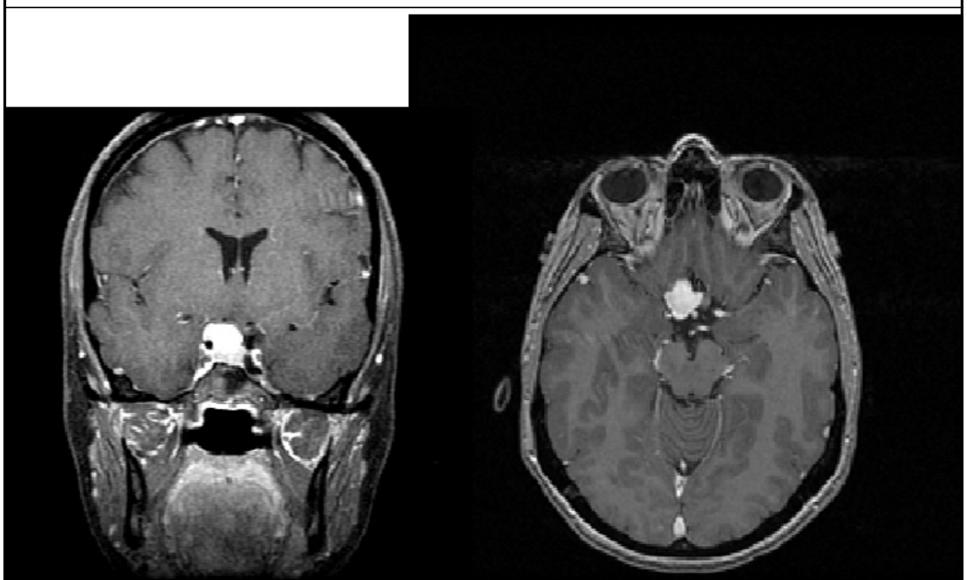
Benefits of a Co-Surgeon

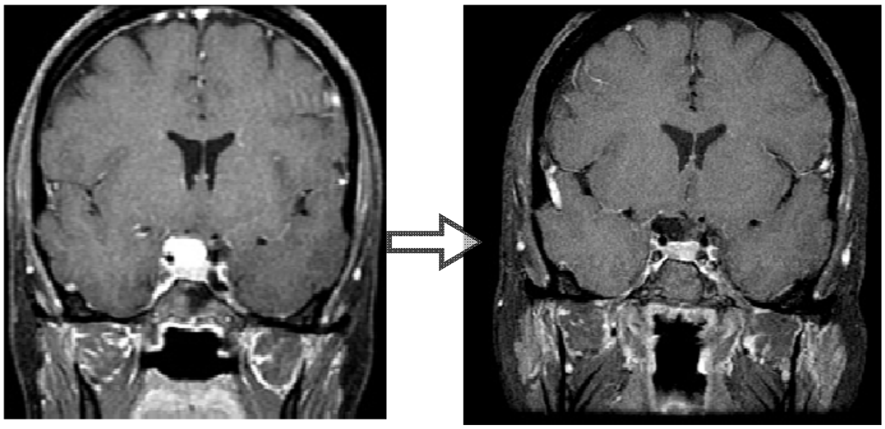
Improved visualization:
- Constant adjustments
- 3D cues
- Introduction of instruments
- Maintain picture during a crisis

Increased efficiency

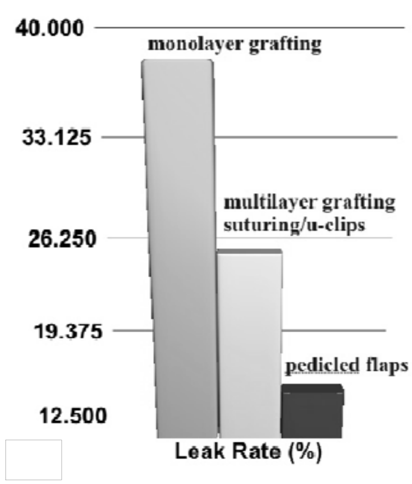
Second opinion (“co-pilot”): avoids complications

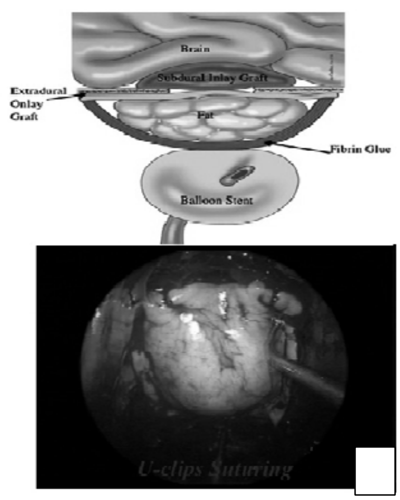
Tuberculum “Subchiasmatic” Meningioma





Vascularized flaps yield more reliable healing for large and/or high flow CSF leaks





One Thousand Endoscopic Skull Base Surgical Procedures Demystifying the Infection Potential: Incidence and Description of Postoperative Meningitis and Brain Abscesses

Yuriko Kono, MD; Daniel M. Prevedello, MD; Carl H. Snyderman, MD; Paul A. Gardner, MD; Amin B. Kassam, MD; Ricardo L. Carrau, MD; Karin E. Byers, MD, MS

Infect Control Hosp Epidemiol 2011; 32(1):77-83

18 patient s (1.8%) developed meningitis.

There were no predominant pathogens.

Risk factors ($p<0.05$):

history of a craniotomy or endonasal surgery
surgery with higher levels of complexity
presence of an external ventricular drain or ventriculoperitoneal shunt at the time of surgery postoperative CSF leak

Endoscopic Endonasal Skull Base Surgery: Analysis of Complications in the Authors' Initial 800 patients

Amin B. Kassam, Daniel M. Prevedello,Ricardo L. Carrau, et al
J Neurosurg / Volume 114 / June 2011

Postoperative CSF leak occurred in 15.9% of the patients.
-All patients with a postoperative CSF leak were successfully treated with a lumbar drain and/or another endoscopic approach, except for 1 patient who required a transcranial repair.
-The incidence of postoperative CSF leaks decreased significantly with the adoption of vascularized flaps for reconstruction (<6%).

Transient neurological deficits occurred in 20 patients (2.5%)

Permanent neurological deficits in 14 patients (1.8%).

Endoscopic Endonasal Skull Base Surgery: Analysis of Complications in the Authors' Initial 800 patients

Amin B. Kassam, Daniel M. Prevedello,Ricardo L. Carrau, et al
J Neurosurg / Volume 114 / June 2011

Intracranial infection were encountered and successfully treated in 13 (1.6%).

Systemic complications were encountered and successfully treated in 17 (2.1%).

Seven patients died during the 30-day perioperative period (overall mortality 0.9%).
6 of systemic illness
1 of infection .

Esthesioneuroblastoma:
U of Miami and UPMC Experience

22 patients

Kadish: A-2, B-11, C-5, D-1 (3 recurrent)

Follow up: 9-104 months (mean 31 months)
all NED

2 positive margins:
1 lateral-conversion to transcranial approach
1 at orbital apex

Complications: 3 (15%) CSF leaks

Folbe A, et al.
Endoscopic Endonasal Resection of Esthesioneuroblastoma: A Multicenter Study.
A J Rhinol Allergy. 2009 Jan-Feb; 23(1):91-94.

Multivariate Statistical analysis

Neurological
<u>Level 4</u> (6.4%); p=0.0008

Vascular complications
<u>Coronal plane</u> (4.5%); p=0.001

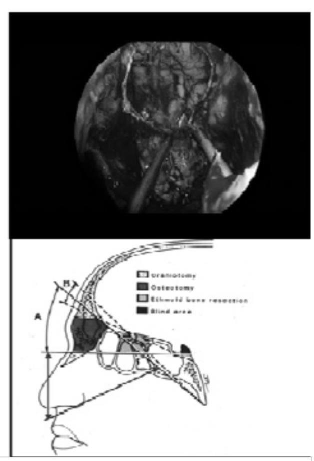
Infection
<u>Level 4</u> (5.1%); p=0.0001
mortality 0.3 %
morbidity 0.3 %

Systemic complications
<u>age>50</u> (4.9%) (18 / 20); p=0.001

LEVEL 1	• Sinonasal surgery	
LEVEL 2	• Pituitary surgery • CSF leaks	
LEVEL 3	Extradural	• Transclival • Transodontoid
LEVEL 4	Intradural	A. With cortical cuff • [illegible] planum [illegible] craniopharyngiomas [illegible] cortical cuff [illegible] Type II/III craniopharyngiomas • Transclival intradural
LEVEL 5	Cerebrov[illegible]ular surgery	• A. Coronal plane • B. Aneurysms

Advantages

- Better visualization
- No need for incisions/craniofacial osteotomies
- 2-surgeons
- May preserve olfactory function
- No brain retraction



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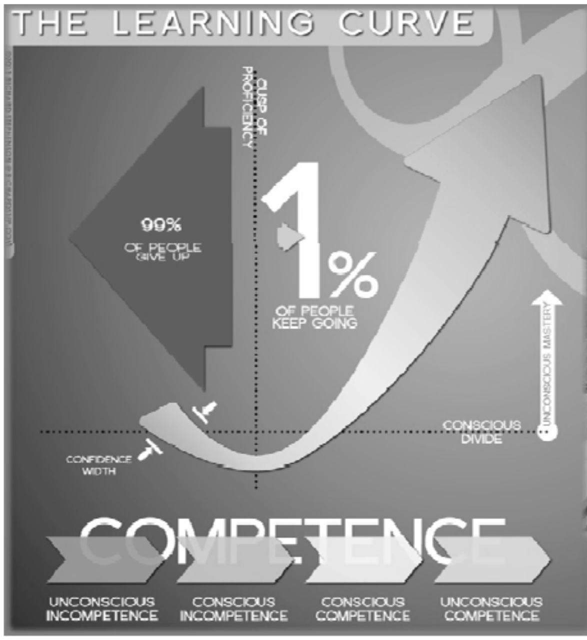
Disadvantages

New and steep learning curve
Instrumentation and technology dependent
2-D
2-surgeons
Reconstruction of the SB/dura
Reimbursement/medical costs issues

http://www.musicbanter.com/lounge/46551-pictures-say-thousand-words-16.html

Motor skills are activity/sport specific.

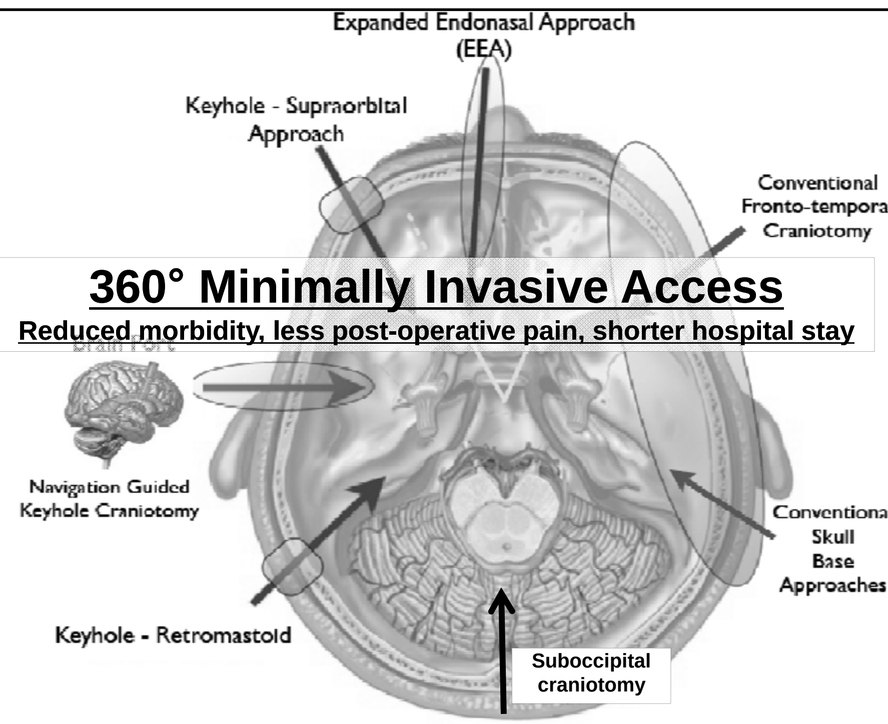
Surgical skills are technique specific.
(eg. laparoscopic experience)



Exposing the Learning Curve. Richard Step. February 1, 2011.
http://richardstep.com/self-help/infographic-the-learning-curve/

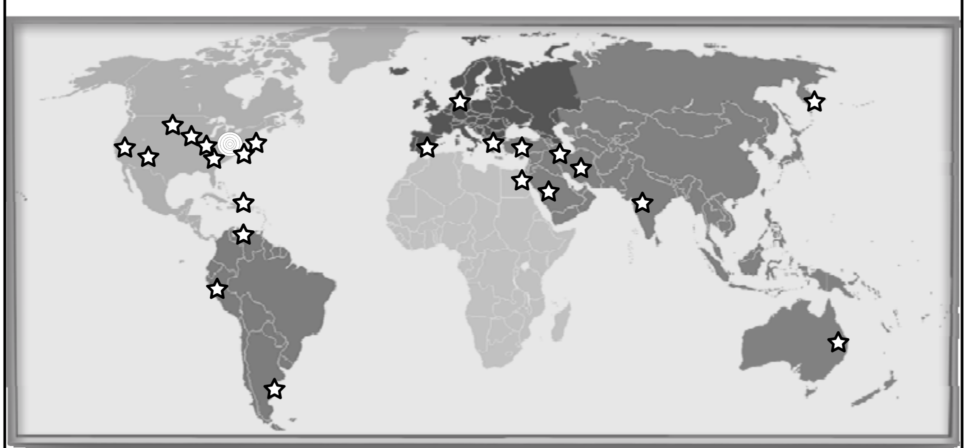
360° Minimally Invasive Access

Reduced morbidity, less post-operative pain, shorter hospital stay



From Excellence to Eminence

http://www.zonu.com/detail-en/2009-11-19-11195/World-color-outline-map.html



International Patients
Distant National

http://www.zonu.com/detail-en/2009-11-19-11195/World-color-outline-map.html

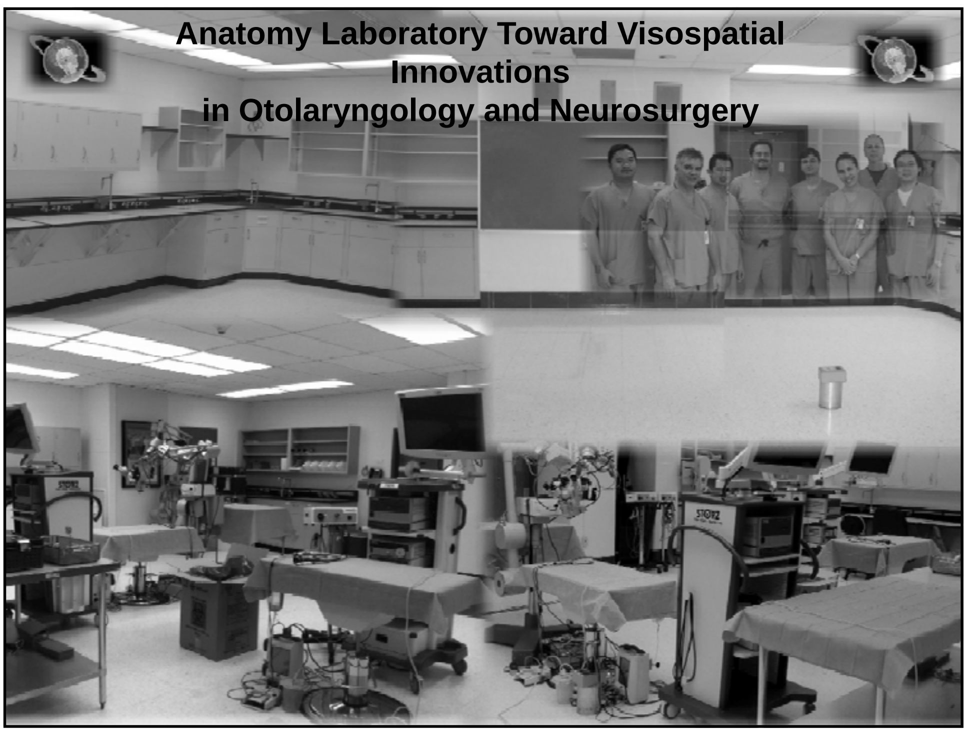
International + National Courses

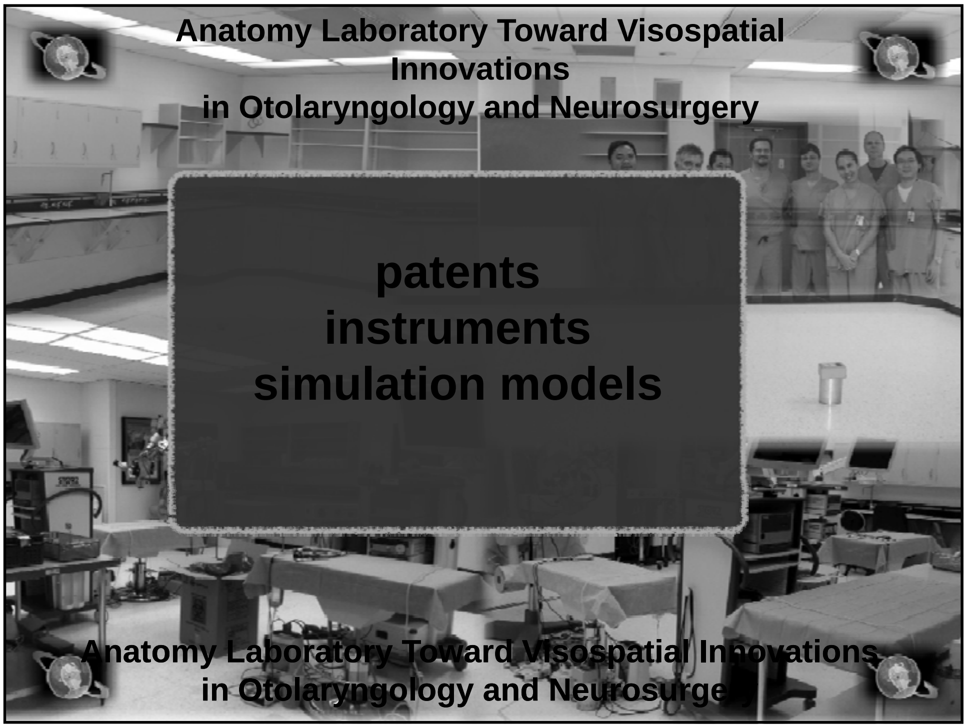
http://www.zonu.com/detail-en/2009-11-19-11195/World-color-outline-map.html

International Visiting Scholars

http://www.zonu.com/detail-en/2009-11-19-11195/World-color-outline-map.html

Anatomy Laboratory Toward Visospatial Innovations in Otolaryngology and Neurosurgery





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