Controversy can be defined as a disagreement typically when prolonged, public and heated, I think that characterizes the last 20 years in skull-base surgery. I also enjoy Ambrose Bierce's definition. But I think controversy is a very healthy part of medicine. It stimulates us to try new things, that you look critically at what we have done and I think is the engine for driving progress.

If we look back at the different advances in skull-based surgery, I think we can divide into several eras starting with the pioneering efforts by Ketchum and others doing the first craniofacial resections back in the 1970s and then that started the, sort of modern era of skull-based surgery in the late 1980s and 1990s with open cranial base surgery techniques and then I think we transitioned to a radiosurgery era with the advent of radiosurgery techniques, replacing many of our aggressive skull-based surgeries. And over the last decade we've been involved in an endoscopic era where endoscopic and the nasal approaches have replaced many of the traditional open approaches. What's next? I'm not really sure but I think robotics will play a big role as the technology develops and drives us forward.

So first question for the day. Where was the first cranial base center established in North America. Was it Boston, New York, Pittsburgh or Brainerd Minnesota? Well the answer of course is Pittsburgh, Pittsburgh has a long tradition of skull-based surgery, the first center was established in 1986 when I was finishing my residency and I was fortunate enough to be the first fellow at the University of Pittsburgh.

Who performed the first craniofacial resection at UPMC? Well you may be surprised to hear that it was Dr. Myers and Dr. Joseph Maroon from the Department of Neurosurgery and they really were the pioneers in getting this all started.

So what are the controversies? The raging controversy really is – what's better, open versus endoscopic approaches and this addresses multiple areas such as optimal access, visualization, the ability to deal with complications and prevent morbidity and finally oncological control.

So what are the benefits of endoscopic endonasal surgery, is it enhanced visualization, the avoidance of brain retraction, faster recovery or decreased blood loss? Well it's really all of these except decreased blood loss. We feel that we can see much better with the endoscope, we can avoid retracting or manipulating the brain and hopefully this translates into faster recovery for our patients.

So these are the kinds of views that you can get with the endoscope, you can see detail that you wouldn't see with any other technique. You can see small perforators, vessels that are important for this optic chiasm, here's the tumor being dissected free, and with this approach you can preserve these little perforators and hopefully maximizing the potential for recovery of optic nerve function. Here's a view into the third ventricle, you can see the choroid plexus at the top here, so really unprecedented views, we can look around corners and see things that we couldn't see with a microscope because of line of sight issues. Hopefully this improved visualization helps us avoid complications and do a more complete tumor removal which may be translated into better

oncological control.

Other potential benefits are not as important, we do feel that we decrease morbidity in some respects but we may be adding other morbidities. And as far as the duration of surgery I think it's shorter in some cases but perhaps longer in others.

Endonasal surgery can be characterized as corridor surgery. It's all about choosing the best pathway for the patient's pathology. Choosing the corridor that minimizes morbidity, that provides the best access. And our golden rule is to avoid displacement of normal neural and vascular structures. So if someone has a large frontal lobe tumor rather than lifting up the brain to get there, we can come straight through the nose and access the tumor without any manipulation of the neural tissue.

And this one case summarizes I think summarizes it all and shows what are the limitations of what we can do through the nose. Here we have a large recurrent chordoma and you can see that it's really extended back to the basal artery out to both internal carotid arteries. It involves the ventral skull base and goes all the way down to the upper cervical spine. So this is really – sort of the maximal tumor that we can take out through the nose and here you see post-operative with complete resection and this patient continues to be disease free. In this particular case, we're able to follow the tumor all the way out to the right intra auditory canal. So once again we're limited by the neural and vascular structures. It doesn't make sense to cross those structures to get to the tumor.

And then sort of giving some examples in the sagittal plane starting anteriorly a large frontal osteoma like this can be accessed through the nose with the avoidance of a transfrontal approach.

Nasal dermoids are really ideal, a pathology and a nasal resection. So here you see a nasal dermoid in a 4 year old going up to the dura with a small intracranial component and rather than do a bifrontal incision and a craniotomy to get this component we can do a complete endonasal resection.

A little more posteriority and transcribriform approach, this is the same tumor I showed you before, this is an olfactory Schwannoma in a 12 year old and once again we can avoid any frontal lobe retraction and get a complete resection.

A transplanum approach is also ideal for large tumors, once again this would be a difficult approach from anteriorly because of the superior extent of the pathology. This was in a 6 year old girl and here you see complete resection post op. Super solid tumors such as a large pituitary adenoma or craniopharyngioma are well situated for an endonasal approach. Once again this gives us the best access, the best visualization for tumors that are displacing the optic chiasm superiorly and especially in a pediatric population where these tumors are very common.

Chordomas are probably one of the most ideal pathologies for an endonasal approach because these arise in the central skull base. These tumors arise in the bone of the clivus and spread outward, the endoscopic visualization allows us to do a very complete drill out of the central bone and once again

we're only limited by the vessels and nerves.

Inferiorly we're limited by the nasal palate C line which takes us all the way down to the second cervical vertebra and here you see a large foramen magnum hemangioma that was excised using a transnasal, trans odontoid approach. Inflammatory disease such as a rheumatoid pannus is often approached this way as well.

In the coronal plane there are many opportunities for endonasal surgery. Here we see a intraorbital tumor, intracoronal tumor and tumors there are medial and inferior to the optic nerve, are accessible through the nose without the use of any external orbital incisions. But this only applies to pathologies that's on the nasal side of the optic nerve. And we can do this with preservation of orbital function. So we're coming in between the medial _____ muscles, they had resection without any loss of extraocular motility.

Tumors that extend out across the top of the orbit can also be accessed endonasally. We can reliably get to the midplane of the orbit by decompressing the medial orbit and drilling off the bone of the orbital roof. By taking off the base of such tumors endoscopically, removing the bone, cauterizing the dura, ligating the feeding vessels, we really can devascularize large tumors like this before we get into the tumor.

Expansile lesions of the petrous apex cannot be accessed endonasally, coming through the sphenoid

sinus posterior to the carotid artery or inferior to the petrous carotid and that allows us to create a large drainage pathway that can be maintained.

And even pediatric populations can be, these principles can be applied to, here's a infant with a large teratoma that required an in utero tracheostomy and then this tumor was removed shortly after birth by using endoscopic approach to its skull base attachment.

So really there are no limitations as far as access but there are a lot of other considerations to consider as well when we look at limitations. Can we get a complete tumor resection, can we avoid and deal with complications? How long is the surgery? What about different patient populations and finally what's your level of training and do you have adequate resources at your institution.

Let's talk about some of the major complications of endonasal skull base surgery. Certainly one of the most vexing areas has been postoperative CSF leaks and there have been significant growing pains in trying to deal with this problem.

So here's your question, what are the risk factors for postoperative CSF leak, morbid obesity, prior skull base surgery, prior radiation therapy or diagnosis of craniopharyngioma. Well it turns that all of these are potential risk factors. Patients with morbid obesity have elevated CSF pressures, prior skull base surgery may also contribute to elevated CSF pressures, radiation therapy obviously interferes with healing and patients with craniopharyngiomas have high flow dural defects following

excision of these tumors.

If we look at the literature regarding open transcranial skull base surgery this is a result of the international collaborative study with which we participated. You can see that the incidence of CFS complications was around 16 percent. And over the last decade we've seen an evolution of our reconstructive techniques starting with inlay and onlay fascial grafts progressing through direct suturing techniques of dural grafts, the use of internasal balloons to support the repair and finally the introduction the nasal septal mucosal flap.

So a patient with – like this with a recurring adenoid cystic carcinoma extending into the third ventricle, you can imagine that this is a high flow leak. This is a patient that needs a sturdy reconstruction if you're going to prevent a CSF leak. And so the nasal septal flap as developed by Hadad and Bassagasteguy from Argentina is based on the sphenopalatine vessel posterior nasal branch that courses across the front of the sphenoid sinus and supplies the whole ipsilateral septal mucosa. The vascular pedicle extends from the sphenoid osteo to the bottom of the rostrum.

So we can raise a flap that incorporates all of this mucosa pedicled on that artery and can reach anywhere from the clivus and here you see a one week postop, that's the flap in the clinic and here's the final result, well-healed flaps in two different patients and here's the MR appearance of the flap. So it provides a good reconstruction, vascularized reconstruction of a ventral skull base defect, the kind that you would anticipate with excision of a sinonasal malignancy such as an olfactory

neuroblastoma.

With the introduction of the flap in 2006 there was a marked reduction in the incidence of CSF leaks in our patient population and since that time we've continued to develop this flap and improve our results. In a review of 150 prospective cases with intraoperative CSF leaks in 2007 and 2008, the incidence of CSF leaks was 4 percent overall and 7 percent in patients with high flow defects.

And then the latest study of 70 consecutive patients with high flow leaks and septal flap reconstruction the CSF leak rate was only 6 percent and in those cases where it did develop we were successful in repairing them all endoscopically. Risk factors in this study included a pediatric population, large defects and the use of perioperatively radiation therapy.

We have other options as well. Sometimes a septal flap is not available due to patient pathology or prior surgery and there are small intranasal flaps – but really our best second option is a pericranial skull flap and we pioneered a new technique for using a pericranial flap and bringing into the nasal cavity extracranially so there's no need for a craniotomy.

And here's an example of that flap being used by a coronal scalp incision, raise a traditional pericranial flap, create a window at the level of the nasion, introduce the flap extracranially through that window and then here's the patient post-op with no loss of frontal forehead function.

So next controversial area can we prevent CSF leaks and can we predict who's going to develop them and based on those criteria can we potentially prevent them? Well we did a study of our first thousand consecutive patients going way back to 1998 and divided those into 2 halves and you can see that our leak rate dropped but still higher than it is now. And we looked at the independent risk factors for leaks and that included prior surgery, the presence of an extraventricular drain, the surgical complexity or level of difficulty of the surgery and the use of a perioperative spinal drain.

So we introduce spinal drains, prevent postoperative CSF leaks, they're often used but with no clear criteria for their use. Well there's not much literature on this, there are really very few randomized studies. Here's one looking at posterior fossa craniotomies showing a benefit in patients who had a perioperative lumbar drain. But there really is no literature looking at its use for intracranial base surgeries and so we're in the process of starting a prospective randomized trial of perioperative lumbar spinal drainage.

Another area of controversy is the use of rigid reconstruction for large skull base defects. Here's an anterior skull base resection using a transcranial approach and here's the same defect with an endonasal approach. And so people have often felt that large defects such as these need rigid reconstruction with bone or plates to prevent herniation of a frontal lobe ___ defect. So we've recently addressed this by doing a retrospective review of patients with a craniofacial resection using a transcranial approach and an endonasal approach, doing measurements as noted here, looking at the degree of sag of the reconstruction relative to the skull base.

And so if we compare our open cases with the endoscopic cases, you can see that there's very little difference in the measurements, about a one millimeter difference. And if we look at just the endoscopic cases comparing pre and post operative measurements, you can see that there's only a 3 mm difference, so that's the amount of sag that you see and I don't think that that is clinically relevant. So in conclusion, you don't need to do rigid reconstruction of the skull base defects which may introduce the risk of an infection or other complications.

One of the big concerns about an endonasal approach to the skull base has been the risk of infection. Neurosurgeons have been very nervous about the potential contamination of CFS space by working in the sinuses and especially with a dural reconstruction that is not water tight. So what are the risk factors for postoperative infection? All of these are risk factors. A postoperative CFS leak, the extent of the surgery, the level, whether someone has had prior skull base surgery and the use of a perioperative extraventricular drain.

I think we've been so successful in preventing meningitis because we treat any inflammatory disease prior to surgery. If someone has coexistent sinusitis that is an absolute contraindication to a transcranial approach. We provide antibiotic prophylaxis for the duration of any nasal packing. We reconstruct the vascularized tissue and avoid the introduction of foreign materials. We anticipate the effects of radiation therapy and use appropriate reconstructive methods and limit our use of spinal drains. And if someone does develop a spinal fluid leak we treat as an emergency and intervene

immediately to repair the leak and we really feel that that is essential in preventing postoperative infection. Dr. Kodo and other colleagues in infection disease helped us perform a review of our first thousand patients to look at the incidence of infectious complications and we had 22 infections or an infection rate of 2.2 percent in our initial cohort of patients. So this compares very favorable with other skull base approaches. And if we look at potential risk factors as noted here, you can see the most significant risk factor is the presence of a postoperative CSF leak.

Well can we predict who's going to develop an infection? And if so could we potentially avoid infection in those patients? Using the logistic regression model we can actually create an equation of these factors and plug patients into that equation and here's just an example of patients where we've done that. And you can take a potential low risk patient, a moderate risk and high risk and actually predict the relative risk of postoperative meningitis. So this may be helpful. If you can identify somebody who's high risk there may be additional measures you would take to help minimize that risk of infection.

What about vascular injuries? That's been another area of controversy, can you deal with vascular lesions. Can you operate around the carotid artery though the nose and if you have a major vascular injury can you deal with that successful. We've demonstrated that we can operate on vascular lesions and here's an arteriovenous malformation in a 4 year old who was having recurrent life threatening nose bleeds. She had 14 embolization procedures with sacrifice of both internal carotid arteries and one vertebral artery and was blind in one eye as a result of all these interventions but

continued to bled and so surgery became the treatment of last resort and with several endoscopic surgeries you can see here's the result with removal of her AVM and she continues to be without nose bleeds about 6 years later.

Even aneurysms in selected cases can be treated endoscopically. Here's the first one that we did, a large aneurysm in the right vertebral artery. In this case you can see it's already coiled, here the vascular clips being placed at the time of surgery and here postop following the removal of the aneurysm. And we've gone on to treat several more aneurysms since that time successfully.

If we look at the literature regarding the carotid artery, one thing we wanted to address is how people handle carotid injuries and this is, these are the individual reports of carotid injuries during endoscopic sinus surgery and pituitary surgeries and so you can see there's a lot of experience. And if we look at this literature we see that the cavernous segment of the internal carotid artery is the most common site for injury. And even if the injury is minimal there is a significant risk of pseudoaneurysm development in the postoperative setting.

The mortality rate when this occurs during endoscopic sinus surgery is 30 percent which is much higher than the mortality rate with pituitary surgery. And this is probably a reflection of the site, the location of the surgery, whether it's done in a large tertiary care hospital, a community hospital and then I think also the anticipation of a potential carotid injury. So surgeons performing pituitary surgery are probably better equipped with the equipment and personnel with such an injury. But you

can see that it is a significant problem with major morbidity. So we looked at your own data over the last decade, we've had six carotid injuries during that time for different pathologies as noted here. In four cases, we sacrificed the artery at the time of surgery, in two cases we preserved the artery but one had to go on to endovascular treatment because of a pseudoaneurysm. Although no patients had acute neurological deficits, there were two delayed deaths, one which is directly attributable to the injury.

So fortunately it's a very rare occurrence, this was no associated with any particular time of development of skull base surgery, it was not necessarily part of our learning curve but we continue to be very vigilant about this potential risk during the surgery.

So when faced with a catastrophic injury to the carotid artery during any endoscopic surgery, what is your best management plan. Should you lower the blood pressure, raise the blood pressure? Should you open the neck and ligate the carotid, should you just pack the nose. Do you run to endovascular sweep? The best strategy is to maintain the blood pressure, you want to maintain cerebral profusion. If you lower the blood pressure you may increase the risk of ischemic injury. You can't just pack the nose and leave the operating room. You need to get control during surgery so that includes a very focal packing of the site of the injury to control the bleeding even if that compresses or seals off the carotid. And then finally take the patient to the angio suite for endovascular definitive management.

So here's our treatment algorithm for carotid injuries and I won't really go through this is in detail

but if you have a carotid injury you want control in the OR and then assess the extent of the injury, patients may develop a pseudoaneurysm in a delayed fashion and this can occur weeks to months later. If you can get by with a covered stent and maintain blood flow that's great but frequently you need to sacrifice the carotid artery.

What about neural injuries, are we really minimizing the risk of CNS morbidity with this approach. Well I think this is really going to be the nail in the coffin if we can demonstrate that an endonasal approach minimizes neurocognitive morbidity. We know that manipulation of the frontal lobes, retraction of the frontal lobes, results in encephalomalacia. In this study done at UPMC in the era of open cranial base surgery, the incidence of postoperative brain edema and contusion was about 30 percent. And so we really like to avoid this potential morbidity because there may be very subtle effects on neurocognitive function, changes in personality and memory loss that aren't well appreciated unless you do the actual testing. So we have a funded study currently in progress looking at patients preoperatively and postoperatively to assess these fine changes in neurocognitive function.

So are we really making a difference as far as other morbidities, are we improving patients quality of life by using an endonasal approach. We've done quality of life scores in our patients postoperatively and here you see that in general our patients have very good to excellent quality of life scores postoperatively. This is using the anterior skull base questionnaire developed by Sid Gil and the only area where it drops down is in specific symptoms. Using a similar instrument the

SNOT 22 sinonasal questionnaire in which a low score is better, you can see once again that overall the nasal morbidity is very low and certainly by year out, patients have equilibrated and have minimal morbidity.

And finally if we compare our craniofacial resections endoscopically with what's in the literature for an open approach you can see that our patient population compares favorably. More work needs to be done in this area to really assess the differences in morbidity of different approaches but at this time it appears that we're decreasing morbidity with this approach.

A lot of what we do is driven by technology and there continues to be new technology that is changing the way we practice skull base surgery and so two things that I want to address are really the introduction of 3D technology and the use of robotics. Do these really offer a technological advantage for us?

Well I think in regards to scopes it's 2D or not 2D is that the question? And there have been many people recently touting the benefits of 3D visualization. When we compare the microscope vs the endoscope especially in pituitary surgery where surgeons have had to make that transition, we found that we could adapt very easily to the environment. There are a lot of 3D cues that you get from the movement of the endoscope relative to the tissues and other instruments as well as the relative size and position of structures and so most people have adapted well to that.

In laparoscopic surgery where large 3D endoscopes are available, there have been some benefits demonstrated such as decreased operative time, increased precision of surgery and a short learning curve. However the technology is difficult to adapt to the nose because the true 3D scopes are too large for a nasal cavity and so other technology using an insect eye approach to the end of the scope has been introduced but as it stands now this device really doesn't provide the resolution and depth of focus that's necessary to do these complex intracranial procedures.

So at this point the technology is not mature although there's intuitive advantage to 3D technology, it has not been proven to be a benefit for our area and there probably will be a greater value for novice surgeons who are at the early part of their learning curve.

What about robotics? We see a lot of work being done with transoral robotic surgery for head and neck malignancies and there have been some initial forays into the skull base especially with transcervical, transoral approaches. There really has not been demonstrated to have a big advantage, some of the potential advantages really are increased dexterity, the ability to do things with your hands that you couldn't do otherwise and to account for surgeons tremor. Robotics will also allow multiple surgeons to work independently at the same time, working in multiple aspects of the tumor.

Some obvious disadvantages include the bulky instruments at this stage, the expense, the lack of proper instrumentation for endonasal work, but I think the greatest disadvantage is a lack of haptic feedback. You need that sensory touch of drilling over the carotid artery to make the surgery safe

and if we give that up with the robotic instrument I don't see that we're advancing in the care of our patients. So we'll have to await further development in this area.

Another big area of controversy is the use of sinonasal endoscopic approaches for the treatment of sinonasal malignancy. Is this appropriate and can we make a difference? So your next question, which of the following tumors is treated surgically using endoscopic means, olfactory neuroblastoma, plasmacytoma, rhabdomyosarcoma or prolactinoma? The only one that has a clear indication is an olfactory neuroblastoma, these other tumors are either treated with radiation therapy or chemotherapy or medical therapy first.

But there are lots of different neoplasms that occur in the nose that are treated surgically including endoscopic means as shown here and really the poster child for endonasal skull base resection has been the esthesioneuroblastoma.

So we've already addressed the technical feasibility of doing these surgeries through the nose, we've demonstrated that it can be done safely with minimal morbidity. But we're just starting to look at the oncological outcomes and address really whether or not we're making a difference in the outcomes for our patients.

Actually one of the main tenets of malignant sinus tumor surgery is that the – is achieving adequate resection margins. And we feel that the margins of resection should be the same as an open

approach and so that includes going from orbit to orbit, from the frontal sinus back to the optic canals and doing a complete resection of the dura and the olfactory tracks.

What are some of the potential benefits of endonasal resection? I think the enhanced visualization allows us to do a more complete resection which may translate into less risk of local recurrence. There's no transgression of normal tissues to get there and that potentially could decrease the risk of tumor seeding. Also, a short recovery period may allow us to get patients into adjunctive radiation therapy at a sooner date.

Are there any contraindications? Well if you have a massive tumor with invasion of orbit and superficial tissues it makes more sense to do an open approach. If there's involvement of neural or vascular structures that cannot be resected then our goal of the surgery has changed and more interested in palliation rather than complete oncological resection.

So which of the following is a contraindication for endonasal endoscopic skull base surgery? Prior surgery, diagnosis of a SNOT, distant metastases or brain invasion? Well you might be surprised to hear that none of these are absolute contraindications. There may be a role for endoscopic resection in all of these situations as shown here. So here is the patient with brain invasion. And if you would resect this tumor using an open approach, the same thing can be done using an endonasal approach. A small amount of brain invasion is resectable. A situation where it would not be resectable is where there's encasement of cerebral vasculature. So if the vessels are spared, you can still take a

cut of normal brain tissue to get a complete resection again send the patient for adjunctive therapy.

Well, how strong is the evidence that we're really making a difference here? Maybe not as strong as the data for global warming but Anand Devaiah did a nice metaanalysis of the literature looking at open and endoscopic resection of olfactory neuroblastomas and shows that there's a greater published survival rates for endoscopic surgeries compared to open surgery, even when you stratify it for the newer publications. His patients did have similar followup plus the endoscopic series tended to have an earlier Kadish stage as you might expect.

Looking at our own limited experience, we've now treated over 40 patients with completely endoscopic endonasal resection for ___neuroblastoma and you can see our followup is still limited with the mean of 30 months. But the early results are very encouraging with the majority of patients being NED, you have to realize that many of these patients have unresectable tumors and had strictly palliative surgery.

So we'll continue to monitor these patients and continue to do complete oncological resections as I outlined before and really, totally can demonstrate that the 5 and 10 survival rates and control rates are the same as open approaches.

The endoscope also provides additional treatment options for patients with sinonasal malignancy. In addition to complete oncological resection, we can debulk patients of tumors prior to

radiochemotherapy. We can provide good palliation with minimal morbidity to the patient and also give the traditional options for salvage of tumors that recur following radiotherapy. So here's an example of a sinonasal undifferentiated carcinoma with skull base and open environment. It was first resected and then went on to receive radiochemotherapy.

This nasopharyngeal cancer with encasement of both internal carotid arteries, had presented with a sixth nerve palsy and we elected to debulk this tumor prior to radiochemotherapy to provide the decompression of the nerve and perhaps decrease the volume for radiation therapy. In this case it was very successful and the patient remains disease free more than five years later.

Even inoperable tumors such as this very large olfactory neuroblastoma, there may be a role for endoscopic resection. So here we are one year later following a partial resection endoscopically, this was performed to help minimize the risk of visual loss in the left eye. The patient has already lost vision in the right eye so we wanted to prevent progression to the contralateral side and complete blindness. And then one year later you can see the tumor has been very stable in size with no additional growth. So these are two good palliations with minimal morbidity for the patient.

And finally surgical salvage, here's that adenoid cystic carcinoma that I showed you before extending into the third ventricle and so we're able to excise this and get a good repair and prevent any further progression of the tumor in this area.

Finally, who should be doing this surgery? There's been a rapid change in the surgeons involved and the skill set required to do endoscopic skull base surgery and so next question, what are acceptable training pathways to cranial base surgery. Is it a traditional oncologic head and neck surgery pathway, rhinology, otology or plastic surgery? I think all of these are potential valid pathways to the skull base and each with their own interest and skill sets. For the otolaryngologist doing ventral skull base surgery, there's been really two main pathways, head and neck oncology and now rhinology. And I think the head and neck oncologist perhaps has an advantage in being well-versed in oncological principles. However, the rhinologist is more facile with the endoscope because that's a daily part of his or her practice.

The training of a neurosurgeon also can include diverse pathways including traditional skull base surgery, pituitary surgery and vascular surgery and increasingly they are using endoscopes in other aspects of their neurosurgical practices with ventricle and pituitary surgery.

The problems with being trained via only one pathway is that you limit the options for your patients. And this can be an issue when you're providing informed consent for patients. You need to have the ability to convert to an open approach if it's necessary, either to complete the tumor resection or because of complications. And we also have different philosophies that may have an impact on how we handle different pathologies. So I think we really need to pay attention to how we train the surgeons of the future. And so what is the best way to train surgeons to do this type of surgery.

There are a number of challenges in the learning curve including relearning the anatomy from an endoscopic perspective, working with new instrumentation, transitioning from a 3D to a 2D environment and learning to function as a team. This is true team surgery. And, finally, dealing with some of the complications that may ensue. This is our own learning curve over the first decade of practice with endonasal approaches and you can see the volume of our practice slowly grew. And while the volume grew the complexity also grew. So this is a good four to five years to really develop a good foundation in techniques and working together as a team prior to embarking on more complex intracranial pathologies.

We have published a recommendation for a training program that characterizes skull base surgeries into five levels of training starting with advanced sinus surgery progressing to pituitary, and extradural procedures, finally to intradural resections.

Based on the literature and the experience with laparoscopic surgery which of the following factors predicts surgical proficiency. Is it proficiency in traditional techniques, your experience with other endoscopic procedures, the duration of practice or the number of cases you have performed doing that specific procedure. Well it turns out that the only one that is significant is doing that specific procedure so we need to be very precise about how we train surgeons, they need to really log enough hours doing the actual techniques that they are going to perform.

Well, how much training is enough? How many pituitaries do you need to do before you can go on

to do more complex ___ surgeries? The first report on this looked at the learning curve in 45 pituitary surgeries and concluded there was no learning curve. However, they did not account for the complexity of the cases, the extent of resection or the experience of the neurosurgeon. A more realistic study performed by Smith and associates once again looked at the endoscopic transsphenoidal skull base surgery and looked at the incidence of complications in the patients. And showed that in the last third of the patients there was a decrease to baseline and so they concluded you probably have to do at least 30 surgeries before you get you complications under control.

Surgical simulation has been used in a variety of different surgical situations to try to improve our training and to deal with the problems inherent in the learning curve. You know why do you need the simulation? Well one reason is that we have limited resources. Human cadavers can be very difficult to obtain in many institutions, they're expensive and areas outside the U.S. there may be cultural or legal restrictions that limit their use. Even with the availability of cadavers our clinical opportunities for learning may be very limited and that depends on where you practice, the volume of cases and even if you have the cases you may be limited in what you get to with complex cases.

So the other thing that simulation does is it provides training for every situation. Not many pilots get to practice landing on the Hudson River but you can do that an unlimited number of times in a simulation situation.

So the benefits include unlimited learning opportunities, the avoidance of health risk associated with

the use of human material, independent self-paced study and I think increasingly important our ability to generate objective data to demonstrate the learning curve for surgical trainees and allow us to compare their progress to other populations of surgeons.

Training systems have been developed for sinus surgery and skull base surgery and this is one particular system that we have been working on and are currently validating this system in the lab to really assess its effect on the learning curve and whether this translates into greater proficiency in the operating room.

With this system we can generate a learning curve that tracks site and incidence of injuries such as the carotid artery and skull base and optic never and hopefully this will improve our ability to train surgeons prior to ever taking a step into the operating room.

Well Picasso has said that every act of creation is first an act of destruction, I think that's very important with any area of surgery. We need to sort of destroy our old ways of thinking and constantly challenge ourselves into looking at things in a new light before we can make progress.

I'd like to thank you for participating in this otolaryngology grand rounds at UPMC and I'd like to open the floor up to any questions at this time. Thank you.