The principles of any skull based approach and the same holds rue for endonasal surgery is that there is three phases. There is an exposure phase, a resection phase and there is a reconstruction phase and this is important with any approach, and like I said especially for endonasal.

The principles of exposure for most skull based surgery is that you wan to remove craniofacial structures in order to avoid neural and vascular retraction, that's the basic concept behind it as you become comfortable with moving some of these structures I order to avoid neurovascular manipulation. An endonasal approach is just a different corridor for doing this. And so the exposure itself should provide the same kind of access where you can do bimanual dissection and you create a single cavity whether it's out of a sphenoid sinus that's slightly open or incorporating multiple sinuses like the sphenoid and ethmoid, etc. which we'll do in the lab. And there are modules that extend all the way from the cribriform plate down to the Christa galli, rather the cribriform plate and the Christa galli all the way down to the posterior clinoids and even the upper cervical spine.

The way we work and the way I would encourage you to work in the lab is working with two surgeons after the initial exposure where the endoscope is held by the endoscopist, the sort of driving surgeon, at the 12:00 o'clock position within the nostril and then the surgeon who is dissecting works below with a suction in the same nostril and a dissecting instrument in the other nostril and this is for two right handed surgeons we'll stand both on the right side of the patient and work over in the way that you see there. So I would really - you know this takes some getting used to, it's not necessarily a natural thing at first but you really have to drive up on the nostril in order to have - give yourself the most access possible below it.

But working in this way allows you to do microsurgical dissection. And the resection itself should follow the same principles of microsurgical resection that you would use where we do internal debulking, extracapsular dissection with countertraction, blunt and sharp dissection and neurovascular control with early identification of the critical vessels. And it's really important to constantly remind yourself that you need to do this. We try to never pull tumors out but rather do the same kind of dissection you would do if you had a big wide open exposure.

In the modules we'll talk about today extend in the rostral caudal axis so from the anterior of cribriform to the planum and of course the transsphenoidal and transcellular approaches all the way down to the clivis and the upper cervical spine. Obviously the sella is the center of our endonasal and the skull based universe, it's where these approaches first developed and here is a relatively straightforward tumor though decent size tumor and the thing that makes this one, a pretty good one, challenging is it turned out to be a very fibrous tumor. Well what you'll see here is there is a very wide exposure, so this field is opened all the way out to the middle fossa on either side and all the way up to the tuberculum so we have really very wide access. And what this allows and all the bone has been removed all the way out to the carotids as well overlying the sella. What this allows is this bimanual dissection that you see here. So we are using two instruments, there is a suction for countertraction, we are generally having countertraction with this scissor on this fibrous tumor. It's not a typical adenoma that you could just suction out, but because it's very fibrous it not only provides us a capsule but also provides a challenge for its resection. But working around the outside of this using bimanual dissection allows us to sort of remove it essentially en bloc in one piece.

You can see the nice fine vasculature of the gland on the diaphragma and the very pale tumor, but some of these details that the endoscope working within the field really makes a difference. Another thing you'll notice because we are not using a fixe retraction or endoscopy, because we are using dynamic endoscopy we are able to constantly follow the movement of the instruments and get much closer and more detailed views than you would ever get if you just had a fixed holder holding the endoscopy outside or inside the nose. It really allows us to take full advantage of the endoscope by hiving that dynamic endoscopy while you are working. And people do this a lot of different ways, I'm curious to see how Mel has applied it in a more - in a setting outside of a university and I think there are a lot of different ways you can apply this but I think having two surgeons working there is really quite important.

Moving upward now to the trans-tuberculum or trans-planum approach, Juan described this anatomy really very nicely but this is the kind of wide view that you get with the endoscope that allows you to see all the way from the planum to the tuberculum down to the sella and then the clival recess. We can see a much wider view than a microscopy would allow all the way out to the carotid and the optic. There is the lateral opticocarotid recess which is the pneumatization of the optic strut and then what's been coined the term of a medial OCR and this is sort of more of a reference point than anything than a real recess, this is sort of like the keyhole for an endonasal craniotomy. And you know for a pterional craniotomy kind of to have this vague confluence of sutures that gives you the keyhole for a pterional craniotomy well here this gives you access if you remove this bone to the upper sella to the dural ring of the carotid, the optic and the suprasellar space. So it really is sort of

the keyhole structure. Here you see that corresponding area and this is a nice example because you can see here is a medial clinoid and here is that medial OCR up here and it's really what's giving you access to all of those critical anatomic structures. This is the kind of bony removal we see from above, this is a view from above of the planum and the sphenoid and you can see we want to remove all the way from optic to optic in a very wide exposure of the planum.

Here is a very simple case from several years ago, it's an epidermoid tumor but it sort of shows the technique very nicely. This is the suprasellar dura, the planum dura just being opened and the reason this is nice it kind of shows how you can work from the inside out. So Juan does this kind of wide exposure and this is kind of working inside out where you internally debulk the tumor, you have to have an image in your head of where these structures are and then you can work your way out, finally find the carotid and then of course you know just above the carotid you are going to have the optic nerve and if you follow the optic across the chiasm you can find the other optic nerve so ti's sort of an inside out kind of concept of tumor dissection. You'll see here that it really is microsurgical dissection being used. It's a bimanual dissection. The constant dynamic endoscopy allows us to keep this view. It also helps provide some of the 3-D because that constant movement gives you a sense of the depth. Here you can see they are using some countertraction with a suction, we'll use a blunt dissector and then finally scissors to dissect this free. So it's the wide exposure, it's the wide bone removal and then microsurgical dissection. As Juan pointed out the really critical structure is the superior hypophyseal arteries and these give supply to the optic nerve, to the chiasm and then down to the stock.

So a trans-planum approach really has the three major principles of this medial opticocarotid recess which is kind of the keyhole for the endonasal craniotomy. The superior hypophyseal artery perforators are very important, if you lose them on both sides you'll not only lose pituitary function but you'll harm an already ischemic optic nerve, so it's very important to recognize this and try to preserve them at all cost.

Here is an example of another nice tumor we can access, a craniopharyngioma. In retrospect you can see that arrow is pointing to the stalk off to the right side, we really didn't notice this, it was very difficult I think to find this on an MRI upfront but the endoscope gives you this view so immediately so see the stalk. So the first thing we see when we open dura is here is stalk, here is that superior hypophyseal and we can work next to the stalk in the cavity the tumor has created to preserve this. So it's just kind - at the endoscope introduced into the surgical field with this very wide exposure not only gives us the ability to move and work in that field but also allows me to see things I really wouldn't be able to see with a microscope or with another approach. Here is sort of the final view. And in this woman we were able to actually preserve her pituitary function, you can see the stalk there preserved and you can see just a slight amount of residual enhancement that's been stable over the years on the underside of the chiasm.

Another advantage that really no other approach provides you, here is the removal of that medial or middle clinoid. Again this is a very wide dural opening you'll see here, and in a craniopharyngioma this dural opening gives you good access but you can see if you open too superiorly you are going to see the optics well but for a craniopharyngioma everything is through the stalk or through the

hypothalamus which is of course retrochiasmatic. Now the idea of a prefixed chiasm etc. can impact the working room that you have but in many of these patients we are pretty aggressive with the gland itself, a lot of them lose pituitary function but even with a prefixed chiasm you can access this area. But no other approach will give you the view that we get with an endoscope coming from below this margin with the third ventricle and the hypothalamus.

So here we are able to - you can see the chiasm, we can see this margin with the hypothalamus and I think it allows us to really do a sharp dissection of tumor capsule from the walls of the hypothalamus. This is not a blind pulling of the tumor out but it's really a very careful dissection and we are able to get complete resections in many of these cases that we just wouldn't otherwise, and it's just an ability to actually see this margin. We are not doing anything surgically different than you would try to do with an open approach it's just we can actually see this margin to carefully dissect. So here we are looking up into the third ventricle from below the chiasm and we've carefully dissected off all the ways of the hypothalamus.

When we looked at this we were able to get gross total resection or near total resection in almost every patient, well not every, about 72% of patients again what we determine as maximal safe resection. The limitations, tumor location, extension, etc. did not limit this for craniopharyngiomas, they are really ideally suited for an endonasal approach. Greater rates at 100% of this maximal safe resection in children, I think partly that's a commentary on the planes in children but also a need to perhaps try to be a little more aggressive in children given it can be a more aggressive tumor.

Pituitary function we are able to leave it unchanged in almost half of patients who still had function and actually improved it or normalized it in a small handful of patients. Of course DI is a very high risk in craniopharyngioma but these are very favorable numbers when you compare this with open approaches. Even more favorable is visual outcome and we see this across different tumor types, and this just has to do with the fact that we don't have to retract the optic at all to get to these tumors. So 86% of patients had improved or normalized vision and no patient actually had permanent worsening of vision in this series.

This is always the trade-off for CSF leak, you see a patient with an active leak and we had about 23% of patients had a leak and this decreased significantly with the use of the vascularized nasal septal flap which has really been a savior for endonasal surgery. So I think this is a very natural corridor in line with the long access of craniopharyngiomas. You can allow for things like early stalk identification and has the potential for pituitary preservation. Many of these tumors themselves don't allow it based on their biology and how they've involved the stalk but in those few cases where you save a patient's function it really can be the difference - a huge difference for their life.

And then finally the hypothalamic margin is best visualized with an endoscope and with this endonasal perspective. That gives you again an opportunity to do a dissection in the area that oftentimes you might leave tumor, or if you do leave tumor at least it's a very conscious decision. But CSF leak remains a limitation and reconstruction is a critical part of applying this safely.

Meningiomas is an area that's a little more controversial and we'll talk about, a little bit about approach selection, you know eyebrow approach is a very nice approach also for planum or tuberculum meningioma, but we tend to base it really on the neural structures. So here you see a relatively large tumor, it even extends up over that right carotid there you see in the top view, a little bit extends over the right carotid artery but we are still able to access it. Again you'll see that very wide exposure so that first step the sphenoid and ethmoid has all been turned into one giant space that you can work in. So we've opened the posterior ethmoids, we've opened the sphenoid and then we do this very wide bony removal. So here is that medial opticocarotid recess being removed. Even as you peel the bone off we have some dural involvement here. One of the advantages of an endonasal approach for these tumors is it's inherently a Simpson Grade I resection. These are medially originating tumors. You can't access the tumor without resecting the dura that's involved. There is no other approach that can really even get you access to resect the tuberculum dura.

(Inaudible)

Right. Yeah, it's another very good point. The tumor has been completely devascularized, you've taken the dural branches that feed it, these basically never have any or rarely have an intracranial vascular supply so you can see how pale the tumor is at this point. These probably more than any other tumor except for maybe the hypothalamic margin with a craniopharyngioma require microsurgical technique. There are a lot of people who won't do these type of tumors if there is any vascular contact because of the fact that the microsurgical technique that's required endoscopically has its own learning curve and I think it's important to understand and respect that learning curve

because you can very easily get a vascular injury. And if you are more comfortable doing the vascular dissection from an open approach that's the right approach to use for that case. If you have a small tumor that's just causing some vision loss and you are not worried about vascularity, you think it has a nice arachnoid plane, that's an ideal case to really try endonasally.

So here we see just the final dural attachment here. If these tumors have a nice plane like this you can see that final dural attachment right on the medial optic canal. We'll resect all of that dura, get a true Simpson Grade I resection and here at the end we have a beautiful view of the optics going all the way out to canal. We have the A-comm complex and of course the stalk below. We always use a multilayer reconstruction for anything with CSF leak, a nice large flap after some sort of intradural inlay. You can use fascia lata. If you don't have a reasonable flap you can use a fascia lata also as an onlay, but multilayered reconstruction with vascularized reconstruction has really been key.

Here is the postop showing a complete resection. This patient does have a small cavernous meningioma as well that's just being observed and some improvement in vision. We looked at 75 patients over about a 9 year period that underwent this. This is over a whole team of surgeons over this period of time and most of these were primary tumors and the usual majority of women involved in this pathology. Here you see the involvement, about a quarter of tumors extending into the optic canals unilaterally in most of these, and bilaterally in a small percentage, and also into the pituitary fossa. It is important because I think these are the two of the toughest areas to access sometimes.

The most typical symptom in 80, over 80% of patients is vision loss. And you see the degree of resection. When we talk about gross total resection in this different than a lot of intracranial series we are talking about true Simpson Grade I resection, so all involved bone, all involved duras inherently removed in these cases. We were able to achieve this in 79% of cases and the remainder, the majority of the remainder had a near total resection.

So what about lateral extension? One of the early criticism of this, well you can't access the medial optic canal. Well you know ear, nose and throat surgeons have been accessing this for optic canal fractures and traumatic optic nerve injuries for many years, it's a really direct, very direct access through the sphenoethmoidal sinuses onto the medial optic canal really better than a transcranial approach.

Here is an example of on the right side drilling away the optic canal. You can see involved bone, you can see how the dura has been involved by this tumor. There is just no way to access this area through any other approach. So you can see how we can access really the optic canal all the way out to the orbital apex and even the globe of the orbit itself.

So optic canal invasion like we see in this tumor, here you can see again this left optic canal is very widely involved. Opening that falciform like Juan talked about we can then dissect tumor free from this optic canal. You can see how invaded this entire optic canal is. Perhaps from a contralateral transcranial approach you can get some view of this but not all the way out to the optic strut like you can with an endonasal approach from below. So we found that optic canal extension was not a

limitation in the least for gross total resection. We were able to get early devascularization and a low Simpson Grade resection because inherently we are accessing the tumor through its blood supply and through its bony and dural involvement.

So what factors did affect the degree of resection? Really tumor size, configuration and vascular encasement were the major significant factors that impacted it. And these are the same factors that impact a transcranial approach but it's important to understand these when you are approaching these tumors. Resection rates over time you'll notice them sort of slowly increasing over time despite a similar or increasing complexity and this just demonstrates our learning curve as well, we are now up to almost 90% complete resection of these tumors.

So what about vascular involvement? This is another key part in the learning curve. If you have a small tumor like this with a nice cortical cuff there is really very little concern about vascular injury or microsurgical dissection. If you start to get vascular adherence or contact you have to now be very comfortable with doing microsurgical dissection endonasally. And then finally if you have true encasement like this case you really have to be able to - you really have to be able to do a microsurgical dissection. Here is working with an angled endoscope, again early devascularization of the tumor. And then it's that microsurgical dissection that's very important, just protecting the optic nerves as soon as we see them with a neuro patty, internal debulking with two suctions, extracapsular dissection, all the same concepts you would do if you were doing this through an open approach.

Using this in the end we are able to dissect the tumor free, we're resecting the final anterior margin of the tumor and we're able to preserve that vasculature, here you can see the Acom complex that was previously invaded with tumor, you can see how the tumor has grown through the arachnoid here next to the artery Heubner, but it's that microsurgical technique that I think you'll see in the case that Wan's sharing on Friday, that really is critical. And here's the post op on that tumor.

But here's the issue with this, any time you have encasement there's a risk for injury. This is a very adherent vessel within the tumor, this is inherent to that tumor's biology and this is a patient where dissecting this we end up with an artery of Heubner injury and that ended up with a (inaudible) infarct. This is not a devastating infarct but it can have a major impact on that patient's cognitive function, word recall, those kinds of things and for this woman, made a significant disability for her an inability to perform the job that she normally did.

So we talked about that complication we had a very large plane of meningioma who developed multiple remote infarct for unclear reason. But we had no patient who had any post operative contusions like you might see with an open approach, no hemorrhages and no instance of seizure. We never treat these patients with prophylactics and we haven't had any of these patients have seizure with the one exception if they have a large amount of air you do have to be careful about that.

Symptom relief probably the biggest advantage of this is visual outcome. Again, 86% of patients have vision improvement, deterioration only in 2 patients, so a very small percentage. If you look at

comparable size modern craniotomy studies visual deteriorations are between 8 and 20% of patients so this compares very favorably. I think this is just purely a facet of the approach itself with no optic manipulation and an ability to see those superior (inaudible) branches. Again the trade off for this is CSF leak so there is a higher rate in these patients.

Recurrence, small rate of recurrence but as expected you would see some, much lower in patients with gross total resection. One patient was treated with repeat endonasal surgery, one underwent radiosurgery and the other 2 with very small recurrences are just being observed.

I think this is an excellent approach and it can be very comparable to craniotomy. We have improved visual outcomes, there's very wide decompression and access to optic canals, these are the advantages of it. The disadvantages are CSF leak and vascular dissection. You have to be comfortable doing that dissection to do this approach for tumors that have any vascular involvement.

We can access many other pathologies this way. This here is an example of a germinoma that's completely filling the hypothalamus, the stalk, and the entire suprasellar space. The epidermoid I showed you. Here's a pituicytoma in the suprasellar space, these are, tend to be very bloody tumors. By using this access again it puts you in line with the tumor. Here's a complete resection. Here's a very giant pituicytoma, there's really no other good approach. You could do a trans lamina terminalis but you would not really be able to access the lower pole of this tumor. Where as a transsphenoidal approach with a wide exposure can really get you in the middle of this tumor and get you very nice access to it. So again we see the sella we're doing this very wide bony decompression.

Here's that medial opticocarotid recess being removed. You can see that suprasellar dura already bulging and then once we enter the tumor as John said, you just work within the tumor. You can internally debulk the tumor and then work slowly from the inside out. And the tumor itself is providing this nice wide corridor into it, I'm not having to retract any optic nerve, I'm not having to deal with any vascularity except for what the tumor inherently has.

So at the end we see this, you can see us dissecting off the margin of the tumor and these are very vascular tumors, they can be relatively firm. And then we have this just absurd view up into the third ventricle you can see from the lateral horns all the way down to the aqueduct and this is just, the corridor of the tumor has created. We're taking advantage of this natural corridor through the tumor. And here's the post op naturally this patient needed a shunt, but we were able to get a complete resection and get the patient through post operative recovery.

So the lessons here really are that cortical cuff, if you have no cuff or vascular adherence you really should be aware of that and whether or not that's something you want to tackle endonasally. And vascular encasement is something even some very experienced surgeons won't tackle endonasally for fear of inability to manage this. And of course Wan talked about and we'll talk about more over the next couple of days, is don't cross the nerve. When it comes to approach selection, we're choosing tumors that are inherently medial to the nerve so I'm not having to work over the top of the nerve. And then microsurgical technique.

Probably even more controversial is transcribiform approaches so working more anteriorly. This can be used for large meningiomas like this where you have a fair amount of frontal lobe edema. Again you want to be careful with vascular involvement the same concepts as apply for tuberculum or suprasellar meningiomas.

One inherent advantage of this or conceptual is the fact that we're turning these olfactory groove meningiomas into a convexity meningioma. So if you work through the ethmoidal sinuses again that wide exposure removing all the ethmoidal sinuses we have direct access onto the base of the skull. We can do early devascularization by taking the ethmoidal arteries and we end up with a relatively devascularized tumor.

Finally removing the bone over the skull base and we really have a Simpson grade one resection of these olfactory groove meningiomas. What we'll do here is sacrifice the ethmoidal arteries first, you can remove lamina papyracea which has been done here in order to widen your access, so we can get really very wide access all the way out over the orbit and we'll show that a little better in the lab.

And here's removing the posterior cribriform and planum and we have access all the way from the frontal sinus, all the way back to the planum and now you can see the tumor is really just pulsing. It's really turned it into convexity tumor, we're widening our access over the lamina papyracea, and then finally removing the Christa Galli. That allows us then to sort of internally debulk the tumor. Here's a very nice case that would really fits all the criteria for a good endonasal approach. You can see there's some bony involvement so you want to get a good Simpson grade resection. There's a

nice little cortical cuff and the tumor is not too wide, it doesn't quite extend to the mid orbit. So it fits all the criteria that we would have for a good candidate for endonasal. It's really quite devascularized here we're using a laser. You have all the same toys and tools you would use from an open approach that are endonasal modifications for these that allow you to access it.

So here again we're internal debulking, extra capsular dissection, the same concepts that we use over and over again with open surgery and it gives us this really wide access. Now the one thing you'll notice and the one problem with this, is that since we've removed this entire skull base, reconstruction is an issue. We have this big hole that's been created by the tumor and then we have this very wide opening in the base of the skull. We used nasal septal flaps and this patient healed up very nicely. This can be used for tumors like esthesioneuroblastoma as well. You know this is an inherently nasal origin tumor. So it makes sense if you're going to do an endonasal approach to be able to do that anterior cranial facial resection endonsally as well.

Here's a case where the tumor clearly crossed across the olfactory for esthesioneuroblastomas if there's any skull base involvement you at least need a unilateral olfactory nerve resection you know that's the origin of this tumor. If you don't resect this olfactory tract you're potentially leaving microscopic disease behind. So a dural resection is an inherent part of treating in esthesioneuroblastoma.

But as Mel was pointing out, if you have this type of invasion you have to be comfortable with this intradural microsurgical dissection to do the resection of this tumor. The other really important

concept with this is that is preserving the oncologic principles. En bloc resection is not really possible for these tumors, it doesn't matter what approach you use, you cannot get an en bloc resection of these safely. So the margins then become important, getting negative margins is really critical. So we always check margins around the edge of every single one of these. But you'll see our anterior cranial facial resection is the same you would have from an open approach. We're going from one lamina papyracea to the other, we're going all the way from the anterior to the first olfactory filament all the way back to the planum sphenoidale so it's really the exact same margins we would have from an open approach.

One of the important steps after you've opened both sides of the dura is to transect the falx and this is something if we have time we'll do in the lab. But if you transect the falx that allows us to drop the entire dura down in order to bring it down in one piece en bloc. And then we tack margins on the olfactory nerves and here is an example of a patient immediately postop and then his scan with no evidence of disease 2 years postop. We are getting a larger series 5 years out that looks very favorable.

So transcribiform, the same concept as subpial invasion and vascular involvement and A2 dissection really applies here. Yeah?

(Inaudible)

That's a very good question. By using fascia lata versus allograft and really what you realize as you do these cases that reconstruction is as important as any other phase if not more important. You can do the most beautiful surgery and have your patient die if they don't have good reconstruction. We have gone to using partly I think largely because of Eric Wong's influence fascia lata on every single one of these. So even though we are using a vascularized reconstruction on top of it what I do is an intradural inlay of some sort of allograft whether it's DuraGen, something to replace that arachnoid layer. And then if you before you resect your dura if you do a wide epidural dissection so the dura is free epidurally you can then tuck in a piece of fascia lata as an onlay, so it's sort of tucked in and held in place in the epidural space. And then you can put your nasal septal flap or your pericranial flap or whatever it is over that and I think we've found that to be much more robust. There are some people like Roy Casiano in South Florida who only does fascia lata and does must multilayer and that works for him. It requires, you have to be absolutely meticulous with the reconstruction but we've gone to using fascia lata on far more of our patients but big anterior defects and also the big posterior fossa defects, but we use it on all of those, I think it heals a little better than any of the allografts. Fibrotic tumors we have the sort of same toys you would use through an endonasal through an open approach. And then that meridian of the orbit really is the width of your exposure.

Lateral extension, I said you can extend all the way out to the mid orbit just by removing the lamina papyracea that you see here and retracting it over we can remove that orbital roof and gain access to the tumor all the way out laterally. So really the mid orbit becomes your limitation. The orbit has a lot of fat in it so you can really retract it pretty liberally. You can even access tumors within the orbit which we'll talk about a bit later. So this really shows the limitations for the anterior cranial

base. Obviously if you have a malignancy growing through the skin it doesn't make sense, below that the anterior wall of the frontal sinus, meningiomas that grow up that anterior frontal wall they've done the brain retraction for you. That's very difficult to access endonasally and it's not going to require any frontal lobe access through a craniotomy so that makes more sense to do that through a craniotomy. and then finally orbital invasion or tumor that extends lateral to the optic nerve are really not things that are appropriate for an endonasal approach, at least not if you want to get a complete resection.

I'll sort of skip through of the olfactory groove data just in the interests of time, but we are able to get a complete resection in about 2/3 of patients. As I talked about it's that frontal sinus and the falx anteriorly that are difficult to get to and in a lot of ways doesn't make sense because a tumor like this that comes at the bottom here that comes up to the frontal sinus if you just do a low craniotomy through the frontal sinus you are not going to have to retract any frontal lobe because the tumor has done that for you. We have subtotal resection. This can be a nice indication for an old patient like this 80 something year old woman who just needed a debulking of her tumor.

Staging for very large tumors can allow you to resect some of these that you wouldn't think you could endonasally, but again very large tumors, very calcified tumors and tumors with vascular involvement. So you'll see this over and over again the larger a tumor the more involved it is the more difficult it is to get a complete resection. The residuals as I talked about, the falx and the anterior aspect of the frontal sinus and then of course over the orbit, these are just areas you can't

reach endonasally. Finally near total resection regardless of approach if it's too stuck to a vessel I'll leave tumor behind and not think twice about it.

Complications, the biggest issue with this is CSF leak, it's about 30%. It's gone down to just above 10% in more recent years but if you look at you know an anterior transbasal approach here at the bottom if you do a radical resection of the skull base it doesn't matter if you do it through an open or an endonasal approach they also have 30% leak rates. So this has to do with that wide resection. If you are really worried about that you have an obese patients, or you don't think you need a low Simpson Grade resection then maybe a craniotomy is a better option in that patient. Of course vascular injury remains a potential complication and a problem and this does again provide good visual outcomes.

Here you can see the degree of resection, as we got better at this both technically and anatomically we improved our rates of resection while decreasing our CSF leak rates. 'So these have a very large learning curve and I think remain controversial. Certainly large calcified tumors especially those that extend up to the frontal sinus really probably are better through a craniotomy approach, it's simpler, it's easier to reconstruct and that can make all the difference for that patient's recovery.

So why would you even bother with this for any patient? Well to make a long story short we compared open and endonasal olfactory groove meningiomas, paired the tumors exactly based on their size and the preoperative FLAIR change within the frontal lobes. This was done between us and the University of Toronto and when we compared endonasal and open looking at both the

FLAIR change you see postoperatively like here on the right after a craniotomy as well as the porencephalic cave so the encephalomalacia that's left after craniotomy versus endonasal and we found across the board endonasal had less FLAIR change in the long term scans, had less encephalomalacia and less overall change. And so what we found is that these radiographic changes were significantly different between endonasal and open. Now obviously I can't prove that there are any consequences to this but you have to imagine that some degree of frontal lobe manipulation does have an impact on the frontal lobes.

I think I'll sort of skip this although we have done - dealt with some aneurisms to make a long story short. Here is a ruptured ophthalmic artery aneurism that we are accessing endonasally by having access all the way out to - here is the cavernous sinus. The nice advantage of this with paraclinoid aneurisms is you actually have proximal control, you have true direct proximal control at the cavernous sinus. Even with an open approach if you have access through the neck you can have collaterals to still have back bleeding whereas here if I control the cavernous sinus I have true proximal control.

Here is opening distally. We can see the optic nerve and you start to see the dome of the aneurism, or the neck of the aneurism come into view there. There is putting our clip across the neck of the aneurism. Again the optic nerve is going to be up here, it's a medial pointing ophthalmic artery aneurism that's ruptured in this case. And there you see our final result. An extra clip. But here is our proximal control, we have distal control intradurally and we are able to treat a handful of aneurisms. The issue is that the clips sick out into the sinus which becomes an issues for

reconstruction. Here you see the fascia lata in this case I think we are using DURASIS and then finally the vascularized reconstruction on top of that. So there are some of these that you can't access but this is again I think something very controversial and I don't think we really know if this is something that should be done frankly. But every once in a while we are able to pull it off.

This is a recent book that we've published that really has the whole wide of skull based surgery involved in it, but this shows some nice cases, or nice approaches. I'd like to talk just briefly in the few minutes we have left about transclival approaches because I think these have become really an important part of endonasal surgery and have taken I think - they have taken on a large role for treating things like chordomas.

An infrasellar pathology, chordoma remains one of the primary ones. The transclival approaches, this is a very direct approach. Like a transalar approach to the pituitary if you just come directly through the nasopharynx you can land right onto the clivus. Tis can be used for intradural and extradural tumors. Here is a large chordoma, you can see significant compression of the brain stem, displacement of the basilar. This is a nice anatomic view. One of the things that you'll notice in here and in the lab is that if you come through the clivus you land directly on this very intense venus plexus and you do have to deal with that and pack that off, but once you deal with that and open intradurally we can have this beautiful access to the prepontine and basilar cistern.

Here is an example of a small neurenteric cyst causing some vertigo and sixth nerve palsy in a young man and of course we did a contralateral vascularized nasal septal flap, which is placed in the same

maxillary sinus on that same side and then simply exposing all of the clival bone by resecting the nasopharyngeal mucosa. You can resect this and it will heal through secondary intention just quite beautifully. It remucosalizes on it's own.

Here we are exposing the sella up above, you can see the paraclival carotids here and just removing the bone over the clivis. You'll see as soon as we open the dura here you've got some intense venous bleeding from that prebasilar plexus. That can be controlled with just SURGIFOAM or SURGIFLOW. You can pack it off quite freely without much consequence. And then we are opening directly over the cyst here through both layers of dura. You see some of the typical mucinous contents from the cyst. And then the dura is opened widely, a little more widely in this case, and we see a little bit of residual on the basilar itself. You can see the sixth nerve extending out towards Dorello's canal and again using careful bimanual dissection we are able to get the final remnants of the cyst well out.

Here is our final view looking out towards the 6th nerve, the 5th nerve and out towards the 7-8th nerve complex. Here is the postop on that patient. But this has really become a workhorse for tumors like chordomas where you can see intradural invasion here, you can see extension behind the carotid artery here which is always a challenging area and you see this again wide exposure all the way from the sphenoid, even posterior ethmoid all the way down to the nasopharynx, one large cavity after removing all of the involved bone. We can then work to this area behind the carotid artery using angled endoscopes just like with the transalar approach we've removed the bone over

the carotid so we can retract it over and gain access to the tumor that's growing up even behind the sella and behind the carotid artery.

Here is the final defect. We do a very wide bony and as wide as possible dura resection to try to avoid recurrence. If you leave even a small amount of microscopic recurrent tumor it will regrow so here is our basilar, there is the right 6th nerve so we do these very wide dural resections any time there is any dural involvement. And then of course a vascularized reconstruction. Here see the media postop, just some packing material but otherwise a complete resection.

We looked at 90 patients over a 10 year experience, treated about 2/3 of them are primary and the rest are recurrent. We were able to get complete resection in over 2/3 of these patients, even with some very large tumors. In primary tumors the gross total resection rates are much higher and recurrence much lower. This is sort of an inherent thing with these tumors, it can be very difficult to get complete resections in the setting of recurrence and also it's not necessarily always the goal of it.

Endonasal is not an approach for everything, about 10% of these required a combined approach. And you see the usual problem with spinal fluid leak remains quite high with chordoma, but the cranial neuropathy rates were really quite low. There were no perioperative mortalities, you can see the radiation treatments. Recurrence remains an issues for any chordoma. Here we see a nice resection but we had a bad recurrence in about a third of patients over 2 years. This is inevitable with any type of resection and most of these underwent repeat endonasal resection, of course most of these patients require radiation postoperatively.

We tried to look at where we got incomplete resection or recurrence and remember this is a direct midline approach to the upper and mid clivis so if you have low and lateral residual that's where you are going to leave tumor is out by the carotid artery. You don't have proximal control of that parapharyngeal carotid artery so perhaps another approach is better to try to get a complete resection and as you would imagine inferior and lateral is where we had recurrences.

We've gotten much better at understanding those areas for wider resection. Here is an example of a tumor that goes all the way out to the jugular bulb on either side and the inferior petrosal sinus. It goes quite low all the way down to the odontoid, so over time we got much more aggressive resections. You can see that medial jugular tubercle and inferior petrosal sinus there and as we drill into this medial jugular tubercle we can enter that inferior petrosal sinus. If you remember that's the medial aspect of the jugular foramen, so as soon as we enter that the nerves are going to be directly lateral to it and so we don't want to keep chasing that any further.

But by understanding this anatomy better we are able to get much wide resections of these tumors and so over time we improved our resection rates in chordoma as well and this is very intent anatomy and also provides some technical challenges that have an inherent learning curve to them. If you compare this to the literature it compares very favorably really in every aspect. Lower cranial nerve palsies and a similar CSF leak rate to even any open approach. So I think as a result it's become really a very competitive approach for chordomas.

I'm going to skip through some of this just in the interests of time and get to sort of the final point which is what is our lowest access that we can get to? You know what's really the most inferior access or how low can you go with endonasal approaches? And the answer is odontoids. I think for a general neurosurgical practice that we do have to deal with this from time to time and this is a fantastic approach. It's a little more challenging than a transoral approach but it provides such better recovery for the patient. If you draw this line between the bony nasal septum and the hard palate and extend it into the depth it gives you an approximation of how low you can get. Usually we are about a centimeter above that and there is some limitation from soft tissue and some limitation about how much you have to access but you really are able to get quite low down to the odontoid.

Here is an a example of a patient with irreducible bony compression that was done. This was a child who had recurrent compression after a posterior fixation and so all of these were cases where we were able to get a nice endonasal resection directly through the nasopharynx. We are fortunate to have an intraoperative CT scanner, something Dr. Lundsford instituted really when I was in I don't know kindergarten or something. But you can see the access directly through the nasopharynx.

Here is a case that we did, so between the eustachian tubes just resecting the nasopharyngeal mucosa gives us direct access onto the odontoid. The rest of the technique is frankly exactly the same as you would do through a transoral approach. You resect the anterior ring of C1, expose the odontoid and then drill the odontoid from the top down. You don't want to disconnect the neck of the odontoid, you have this free floating tip of the odontoid with all of the adherences to the ligaments etc. So you want to drill from the top down and then remove any ligaments as manus until you get to this nice

pulsatile tectorial membrane. I don't ever resect the tectorial membrane because it's not necessary , you know if you are doing this for the right indications usually your bony decompression is all that you need.

Here is our intraoperative CT showing a nice wide decompression and then for reconstruction as long as there is no leak all you need is TISSEAL, some fiber glue and it remucosalizes on its own very nicely. It's actually quite remarkable, but patients can be fed immediately unlike a transoral approach and here you see kind of not a great picture but this is the kind of healing that we get in the nasopharynx.