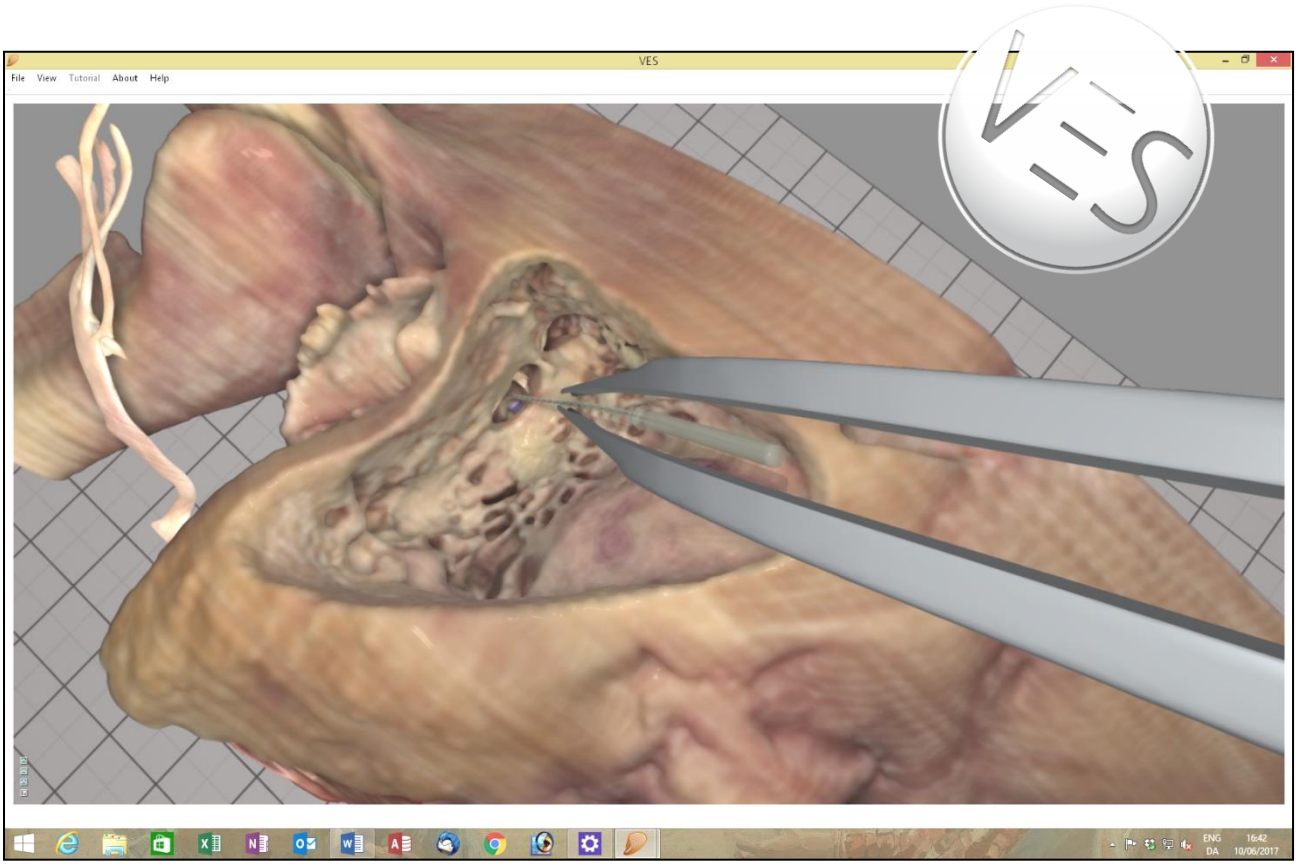
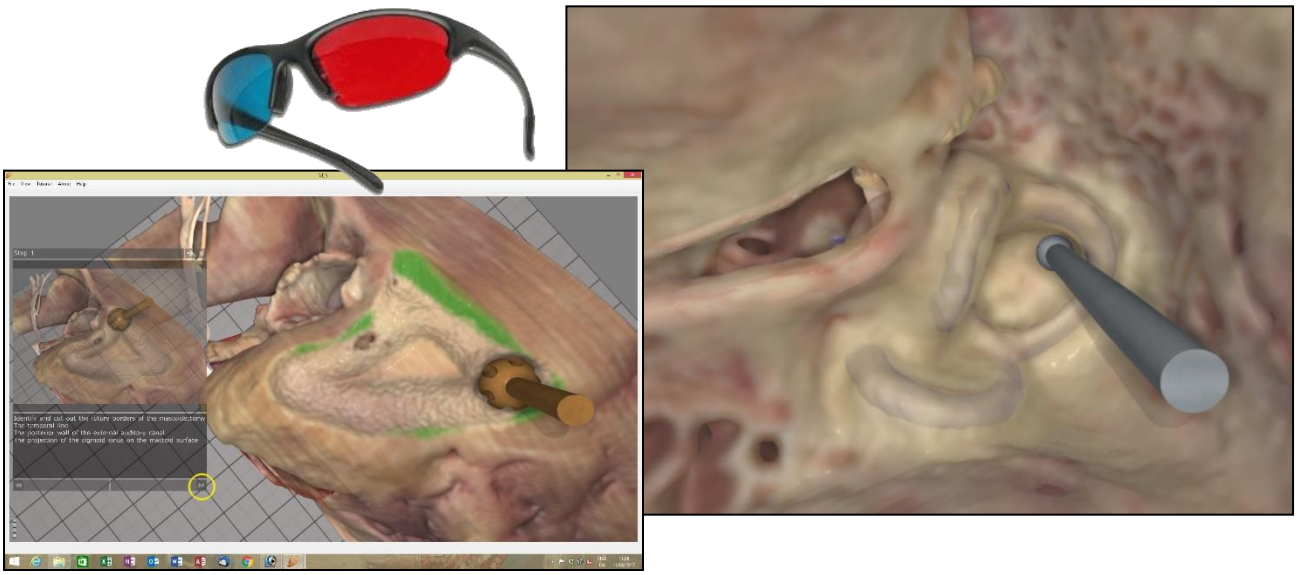
# The Visible Ear Simulator Dissection Manual.




Stereoscopic Tutorialized Version 3.1, August 2017



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Mads Sølvsten Sørensen & Steven Andersen, ENT Department, Rigshospitalet, Copenhagen, Denmark

http://ves.alexandra.dk/

## Preface

This step by step manual was designed for use with the VES freeware, Visible Ear Simulator 3.0 (http://ves.alexandra.dk/) developed by Peter Trier Mikkelsen, The Alexandra Institute A/S, Aarhus, Denmark; Steven Arild Wuyts Andersen, Copenhagen Academy for Medical Education and Simulation and Mads Sølvsten Sørensen, ENT department, Rigshospitalet, University of Copenhagen, Denmark.

The first section **Installation** provides information on hardware requirements, computer configuration and software installation.
Next the **Check out your tools** section shows how to set up and operate the virtual tools for drilling and control of visual settings.
The **Get to know your bone** section demonstrates several anatomical reference points for navigation.
Finally, in the **Drill your bone from A-Z** paragraph you are guided through a complete anatomical resection of the mastoid step by step.
The mastoidectomy procedures are 'temporal bone course' routines, which aim to demonstrate the surgical landmarks and boundaries. They remove more bone than the average surgical mastoidectomy, but the fundamental approach is similar. The integrated CI tutorial presents a more realistic surgical procedure with facial recess access to the round window niche. A labyrinthectomy tutorial was recently added.

In each step of **Drill your bone from A-Z** you may click the video tag and view the corresponding surgical animation at: **(VES-3D).** Check the stereo intro at: **(VES-Tutor)**

Some of the 2-D images are presented in stereoscopic 3-D as well. Stereo images appear fuzzy in plain sight – they must be viewed through red/blue anaglyph 3D glasses, which are easily obtained online at eg. http://www.rainbowsymphony.com/freestuff.html

A **tutorial** is integrated in the VES application to provide intuitive visual guidance while you are drilling. We will extend the manual and the tutor library to cover other temporal bones and procedures. The **censor** function can evaluate your drilling automatically and the evaluations may be saved to monitor your progress.

Check the VES homepage/blog http://ves.alexandra.dk/ for updates and remember to leave your email to receive future reminders on updates. Your comments and suggestions for future improvements are all appreciated at the blog.

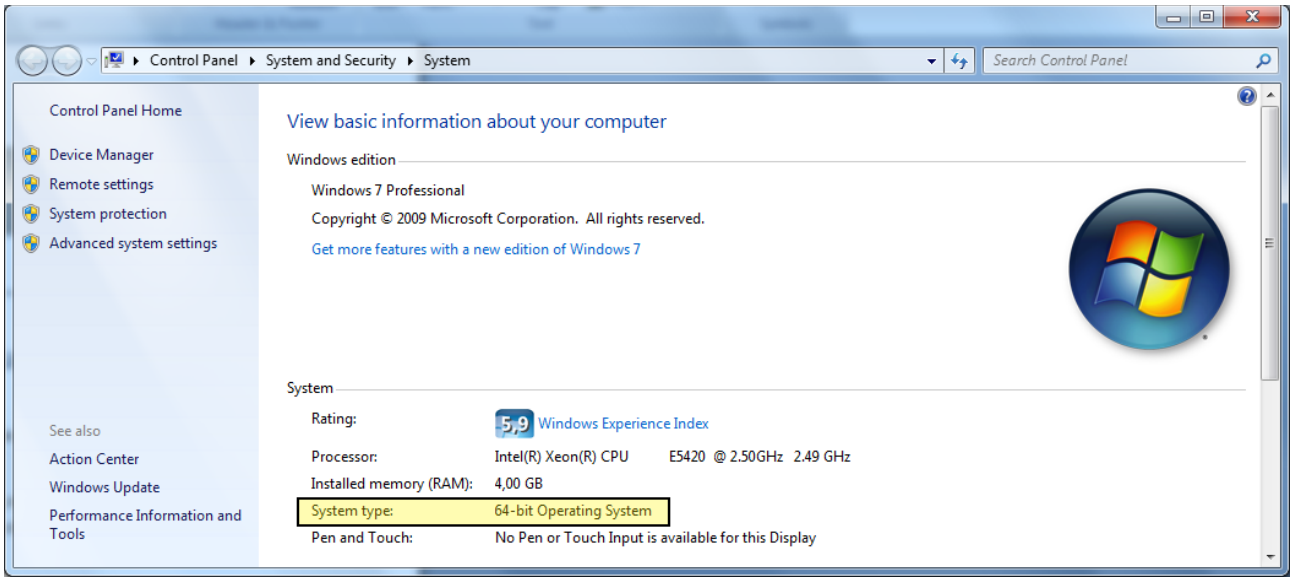
The VES is an academic freeware project supported by the Oticon Foundation, Oticon Medical and MED-EL. You need to buy your own PC and haptic device but the software is free!

PTM, SA & MSS August 2017

## Installation

First it is important to know if your computer meets certain requirements to be able to run the simulator. You need a Windows PC and an Nvidia GeForce GTX graphics card. A Phantom Omni© (now Geomagic Touch©) haptic device is needed for drilling but you may install and view the VES even without a haptic device connected. NB! The old Phantom device requires a FireWire IEEE-1394 port but the current version of the Geomagic Touch device connects to your PC via the USB port.

If you have the necessary computer hardware make sure your Windows installation is a 64-bit version. To check out the type (32-bit or 64-bit) of your Operating System, press the ”Windows” button and the “Break” button on your keyboard simultaneously. This will display the Windows system information.

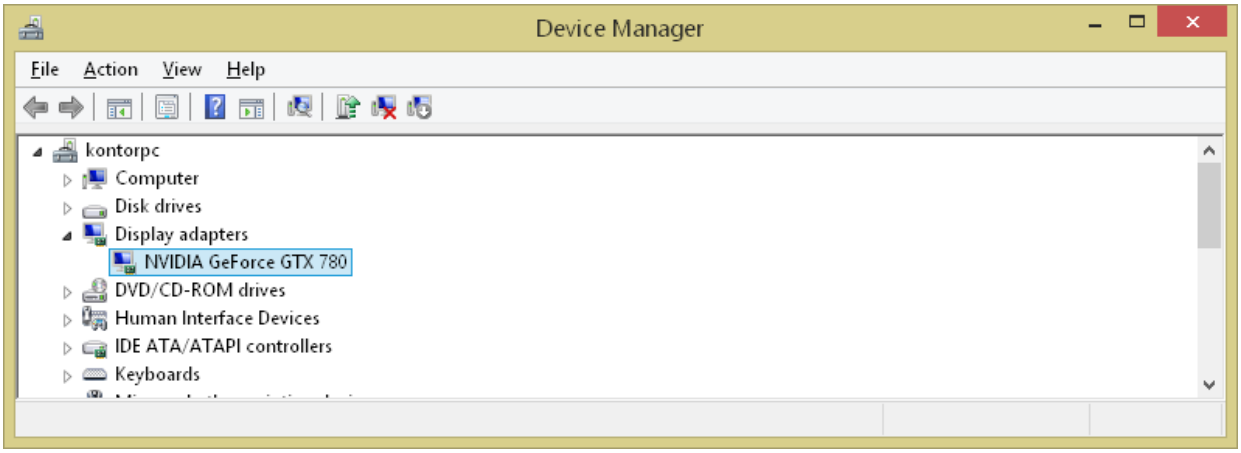



In this case the highlighted text shows that there is a 64bit Windows 7 installed.

The simulator currently supports the Operating Systems Windows XP, Windows Vista, and Windows 7-10. Before you run the VES3: Go to “PC Settings”, select “Update and recovery” and then download and install any updates as suggested by Windows Update.

The current simulator version supports only Nvidia GeForce GTX graphics cards. We recommend Nvidia GeForce GTX 1070 or better. However, the simulator will also run on older cards.
To check what kind of graphics card you have, press “Windows + Break”, open the “Device Manager” and click on “Display adaptors” as highlighted in the image below. This will display the type of graphics card you have, and it must have an “NVIDIA” in the description.

In the image below, the graphics card is an “NVIDIA Geforce GTX 780” which is a few years old but still fine.

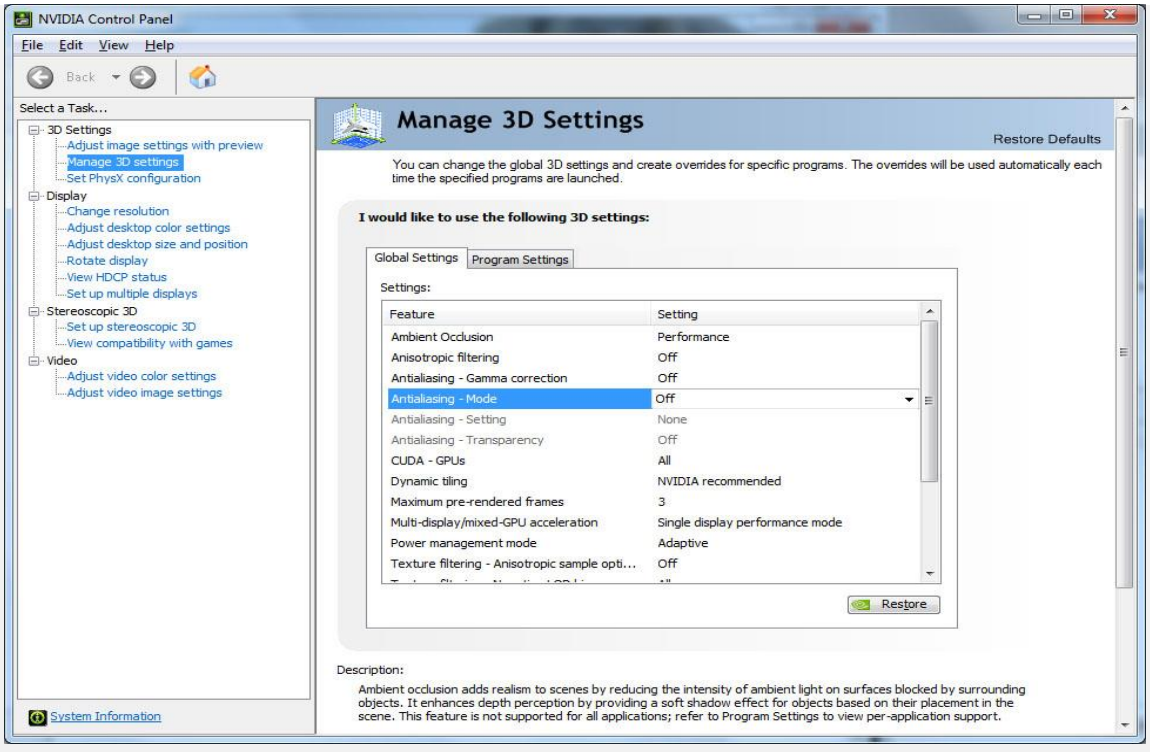



The reason for these relatively high requirements is that visualization is based on a voxel rendering technique, which is very hardware-demanding to provide the high visual quality, which we suggest is important in the training process.

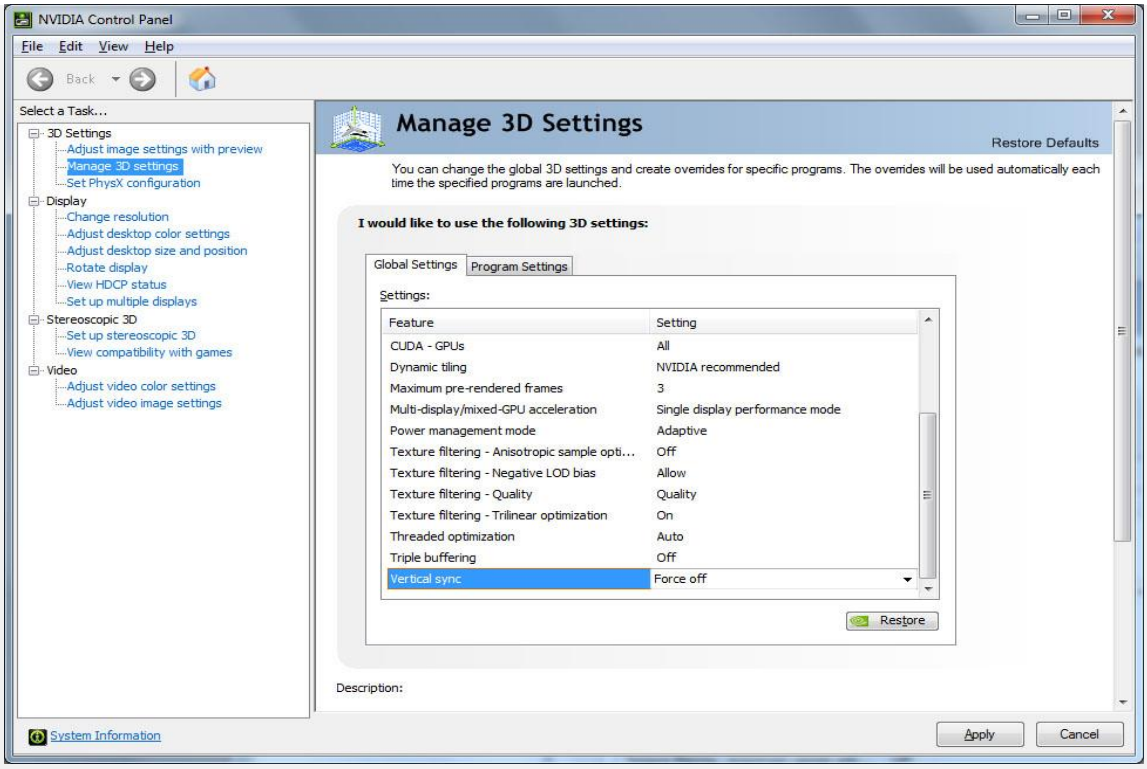
It is crucial to have a high resolution and frame rate on the PC screen. This increases the image fidelity during navigation and it also improves the haptic response.

Go to the NVIDIA GeForce homepage [http://www.geforce.com/drivers](http://www.geforce.com/drivers) to update your graphics driver:

When the latest driver issue for your card has been installed, optimize your Nvidia graphics settings: Open the Nvidia control panel by right clicking a blank space on the Windows desktop, then select the “Nvidia Control Panel” option and make the selections as indicated in the screenshots below.




Turn Antialiasing mode off.

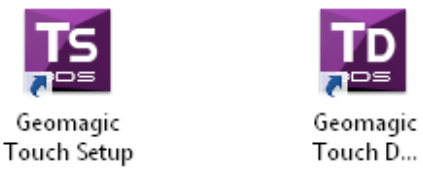



Turn off vertical sync, to enable high frame rates.

You need a [Phantom Omni/ Geomagic Touch haptic device] to move the virtual drill in 3-D and to experience a force feedback simulation of the vibrations and bony contact and resistance during drilling. Visit [http://geomagic.com/en/how-to-buy/find-a-distributor] to find a reseller.

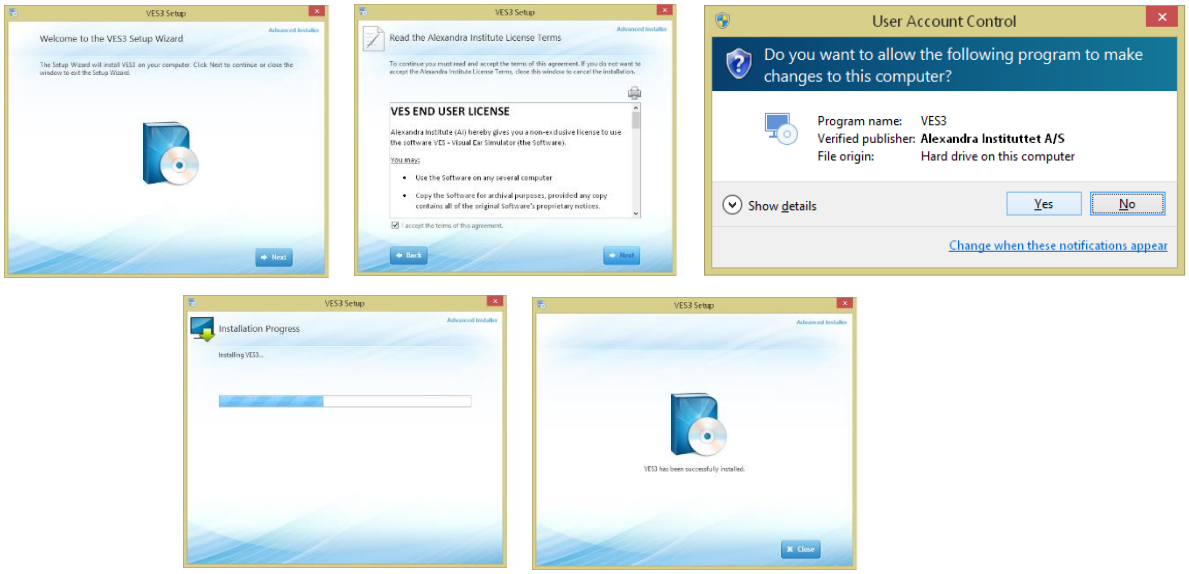

Notice, if you do not own a Phantom Omni device, you can still install and preview the simulator and drill with your PC mouse. The drilling experience will be lousy, but all the other features are still available.

For the older Phantom Omni device, you need an IEEE-1394 Fire Wire port (6 pins, or 4 pins on laptops) for connecting to the PC. New product versions come with a USB interface. Before you connect the Phantom, be sure to install the Phantom device drivers that come with your device. Shortcuts for the Geomagic Touch Setup utility and for the Geomagic Touch Diagnostic (calibration) utility will appear on your desktop.



For Visible Ear Simulator software installation visit the VES download page at [http://ves.alexandra.dk/](http://ves.alexandra.dk/)

After downloading the VES3 zipped folder, unzip it by right clicking the downloaded file and select the “Extract Here” option. Go to the “Setup Files” folder, double click the “VesSetup.exe” file and follow the instructions.




The installation procedure should install both the sound driver (oalinst.exe) and the Microsoft Visual C++ redistributable 2013 (vcredist_x64.exe) automatically. If not, open the Prerequisites directory in the installation folder and double click the vcredist_x64.exe and oalinst.exe file to install this prerequisite manually.

Now the VES shortcuts will appear on your computer desktop.

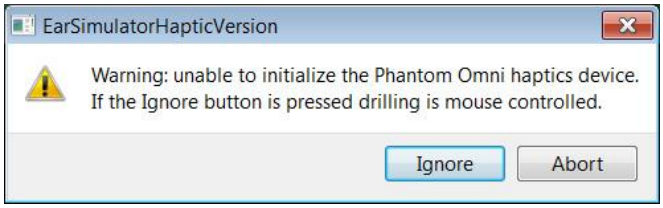

Before you start the simulator, it is recommended to calibrate your Phantom Omni/ Geomagic Touch. This ensures that your PC can recognize the haptic device and that the drilling tools will be properly aligned in the virtual workspace.

To connect the haptic device, run the “Geomagic Touch Setup” program.
To calibrate forces, alignment and refresh ratio run the “Geomagic Touch Diagnostic” program.


This calibration is normally only necessary the first time you run the simulator after a computer restart. However, should you at any time experience trouble with the haptic functions of the simulator, save your action, close the VES3 and re-calibrate.

With the Phantom Omni calibrated, then double click the VES icon and start the simulator.


If no Phantom Omni device is installed when the VES is starting up a message will appear on the display:



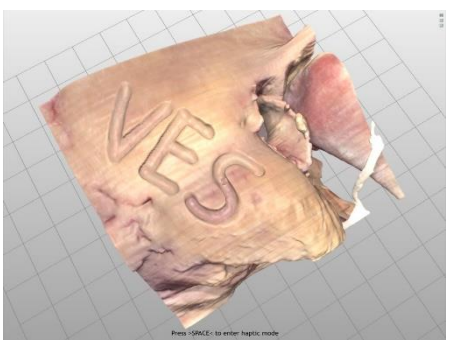

Click “Ignore” and use the PC mouse to control the drill. This option is intended to provide a first impression of what the simulator offers before you go ahead and purchase the (relatively costly) Phantom Omni device.

If the simulator fails to start, please first make sure the sound system is installed as mentioned earlier by running the “oalinst.exe”. Next check for system updates at Windows Update and make sure you have the latest graphic drivers from: http://www.geforce.com/drivers

If the action is slow or erratic remember to turn your user access control off. *(Please note: Any background CPU activity such as Skype, automatic maintenance programs, a wireless LAN or FRAPS type video streamers may exhaust your CPU capacity and slow down the haptic update frame rate. This may slow down performance and interfere with real-time interaction and haptic “smoothness”.*
*Turn off such resident programs if you experience this type of problem.*

If nothing works you are welcome to send us an email where you can attach the simulator log file, which will be in your:
“C:\Program Files\Alexandra Institute\VES3\Veslog.txt”
Please include some information about your computer and the nature of the error.
Send this to peter.trier@alexandra.dk and we will try to help you out. Other issues might already be described on the VES3 blog.

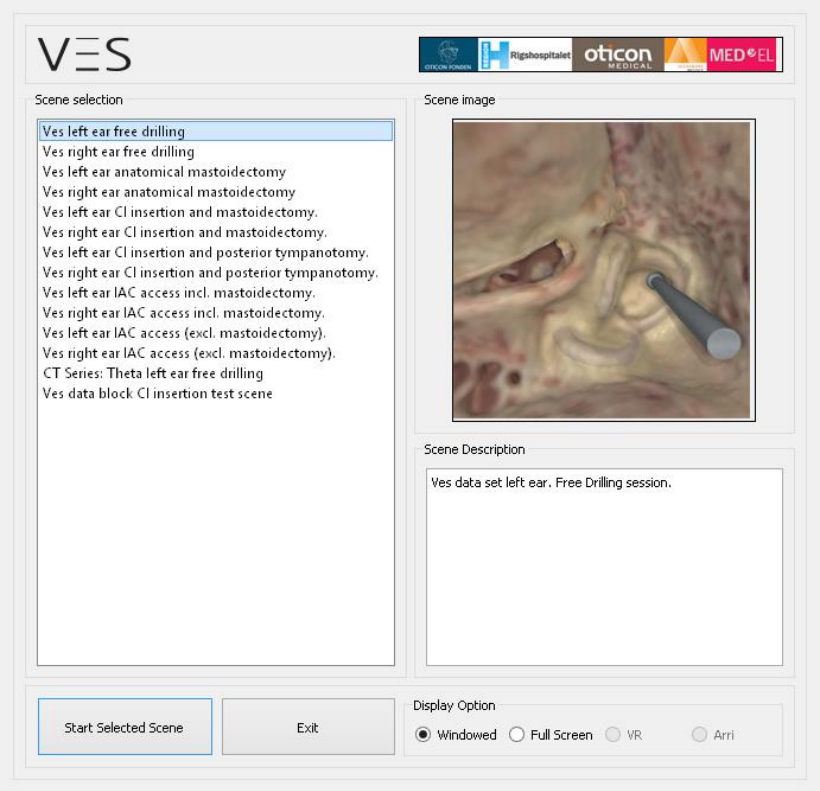
We encourage you to report bugs and to enter comments on our blog, where you can share your Visible Ear Simulator work and experience with other users and even contribute new tutorials.



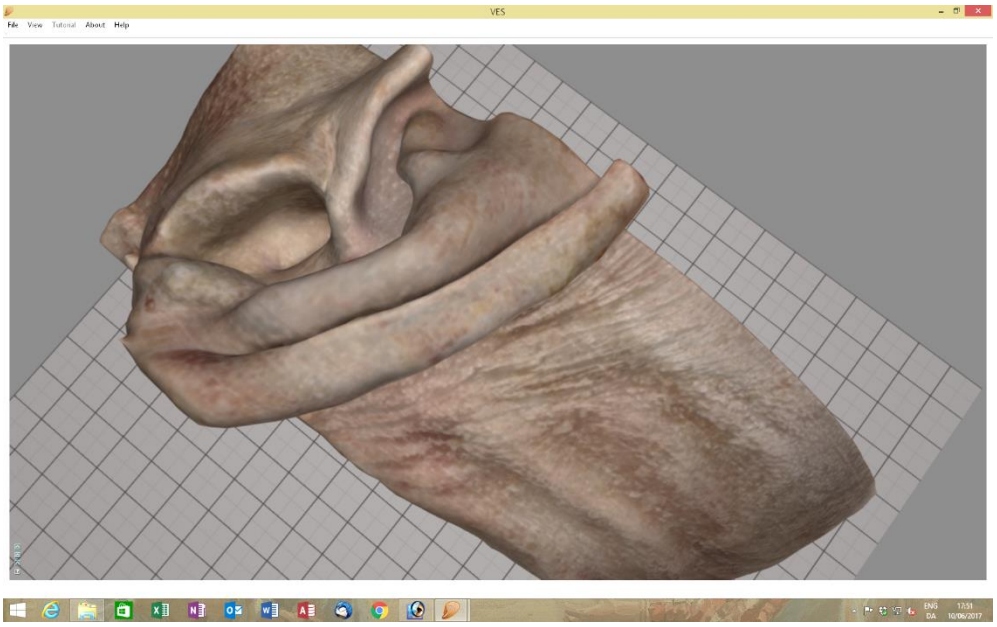
**Check out your tools.**

Click the VES icon and start the simulator.

From the scene selection screen select “VES left ear free drilling” and press “Start Selected Scene”.

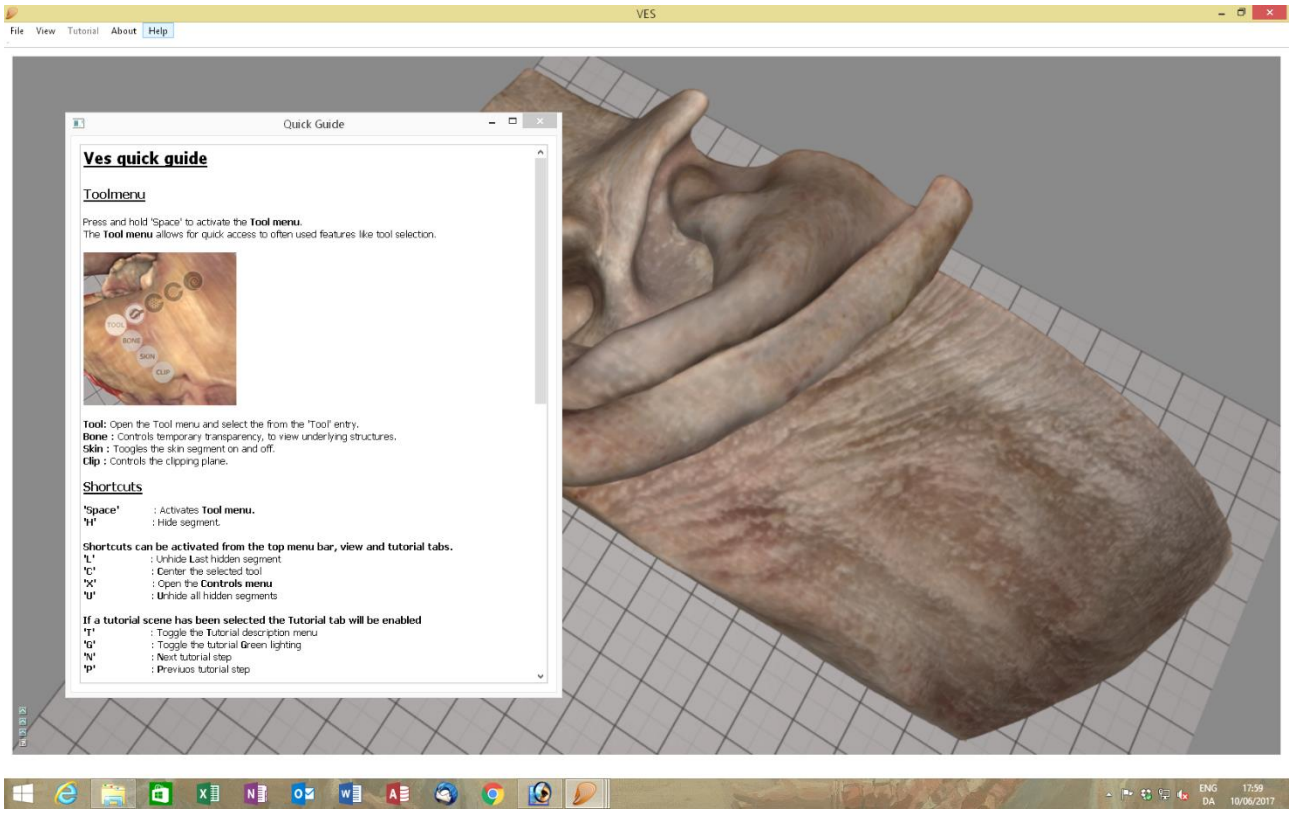



A temporal bone appears in your workspace

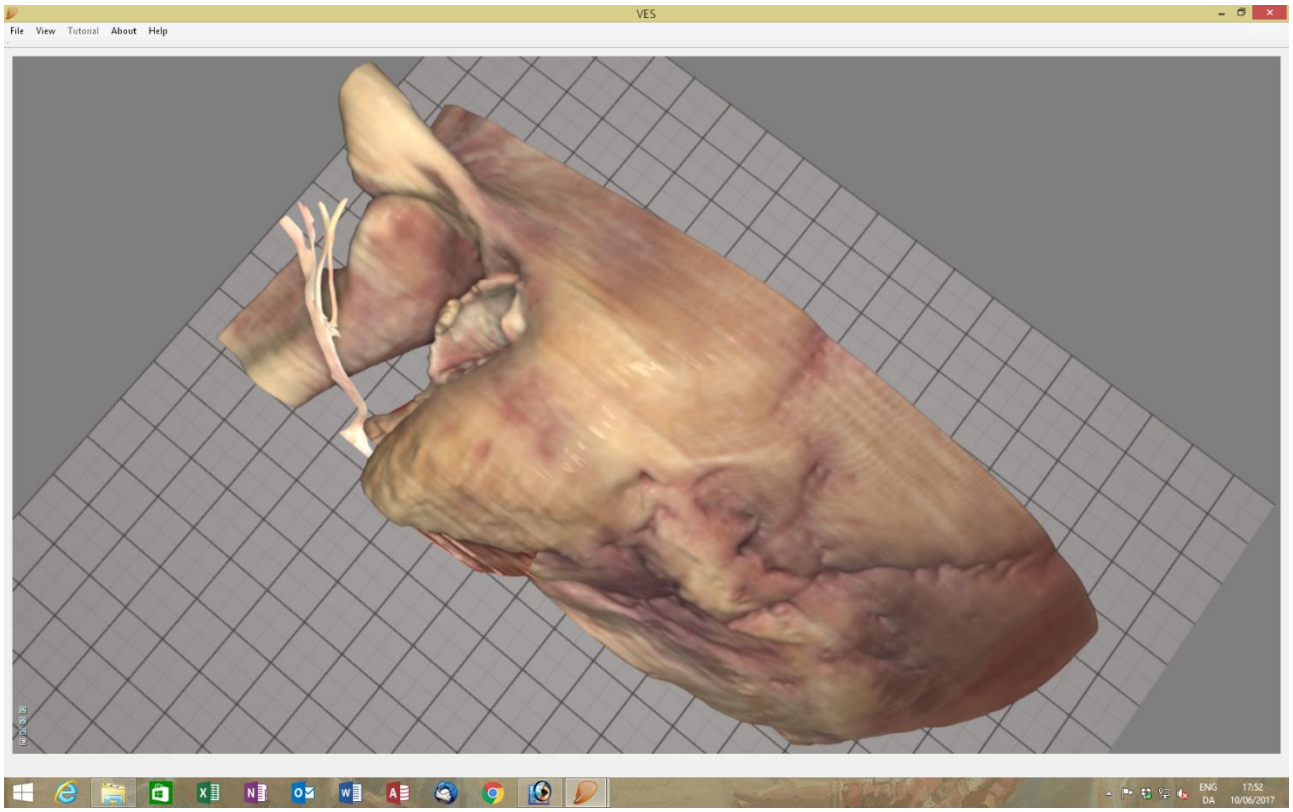



If you select “Help” from the menu bar on top or press “F1” the VES quick guide appears.

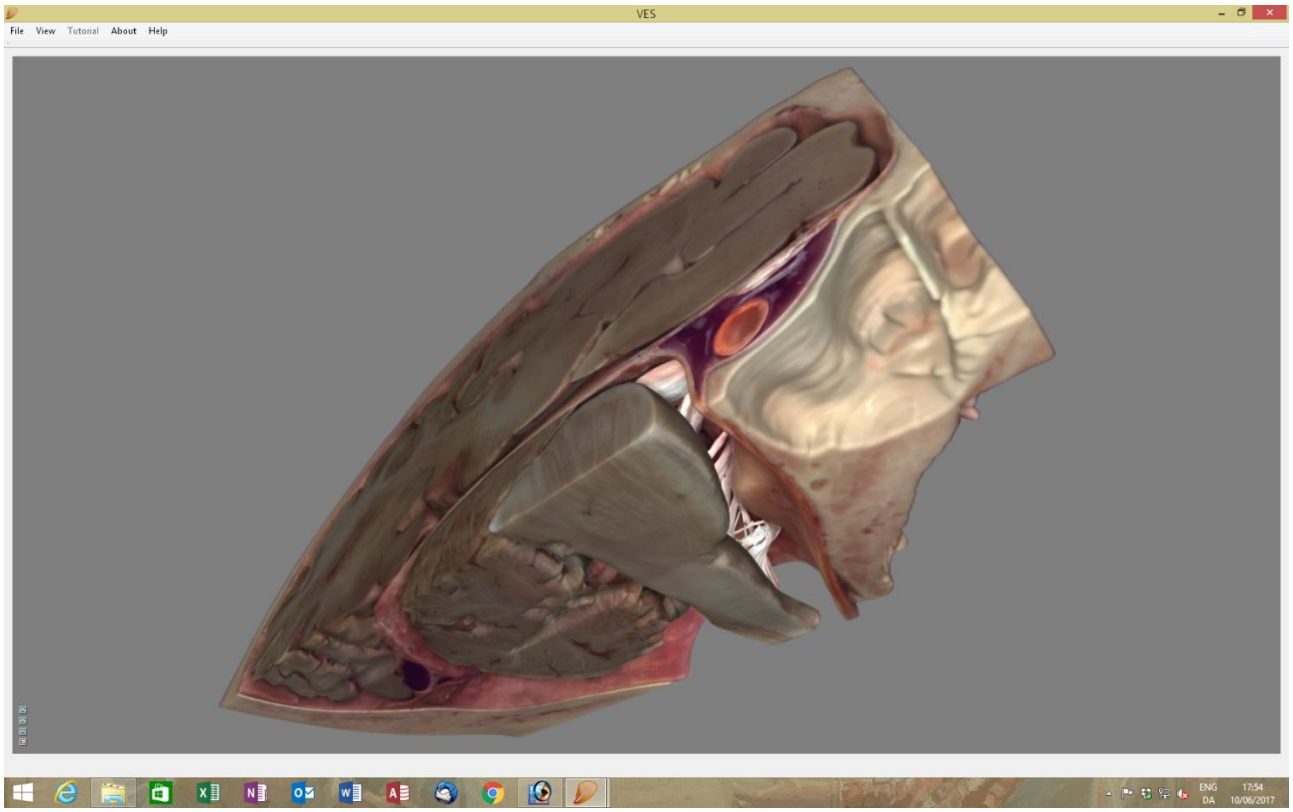
You can click it and drag it around in the workspace, re-size it and keep it on top while working with the simulator or close it at the “X” in the corner. The quick guide shows the most common keyboard commands and shortcuts.



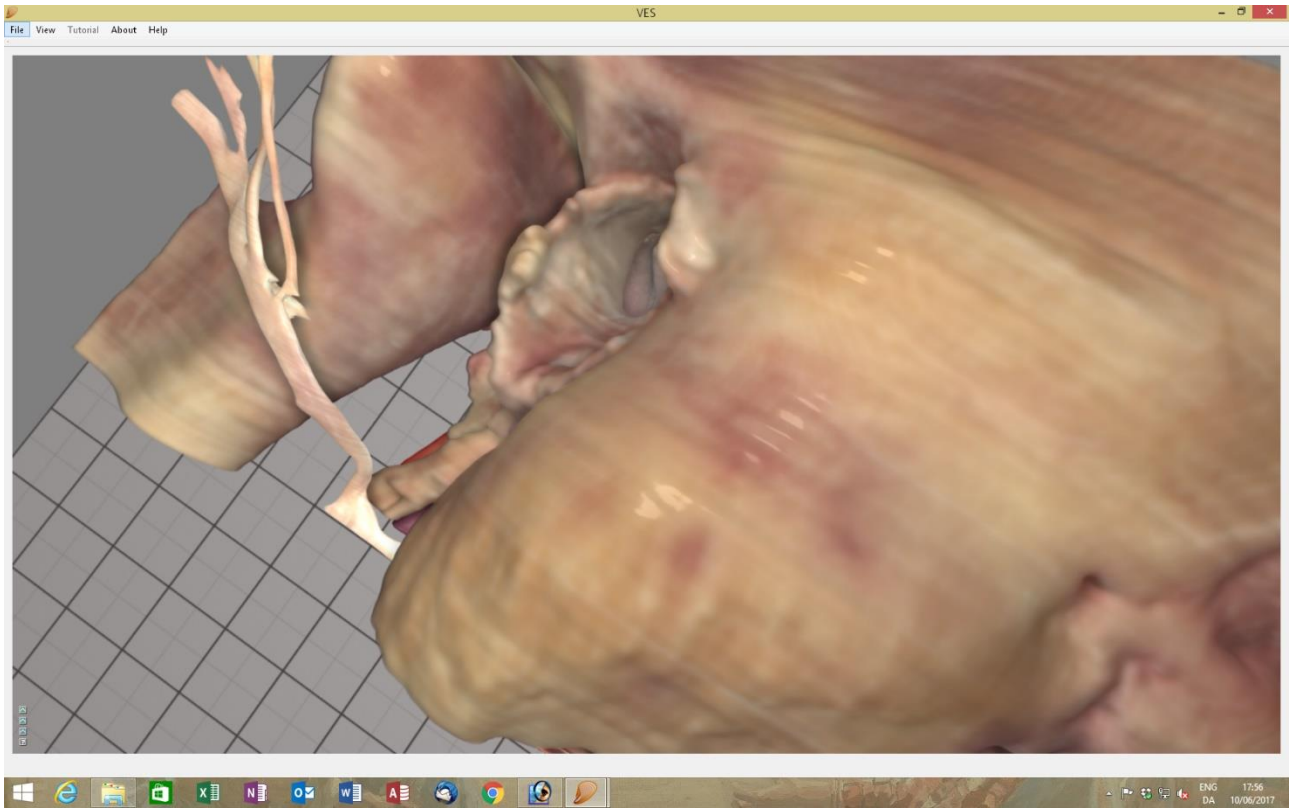

Double right click on the skin to hide it. You can press “L” to unhide it again, “U” to unhide all.




Left click and drag to rotate the model. Left double click any spot to select this as a new pivot point for the rotation.

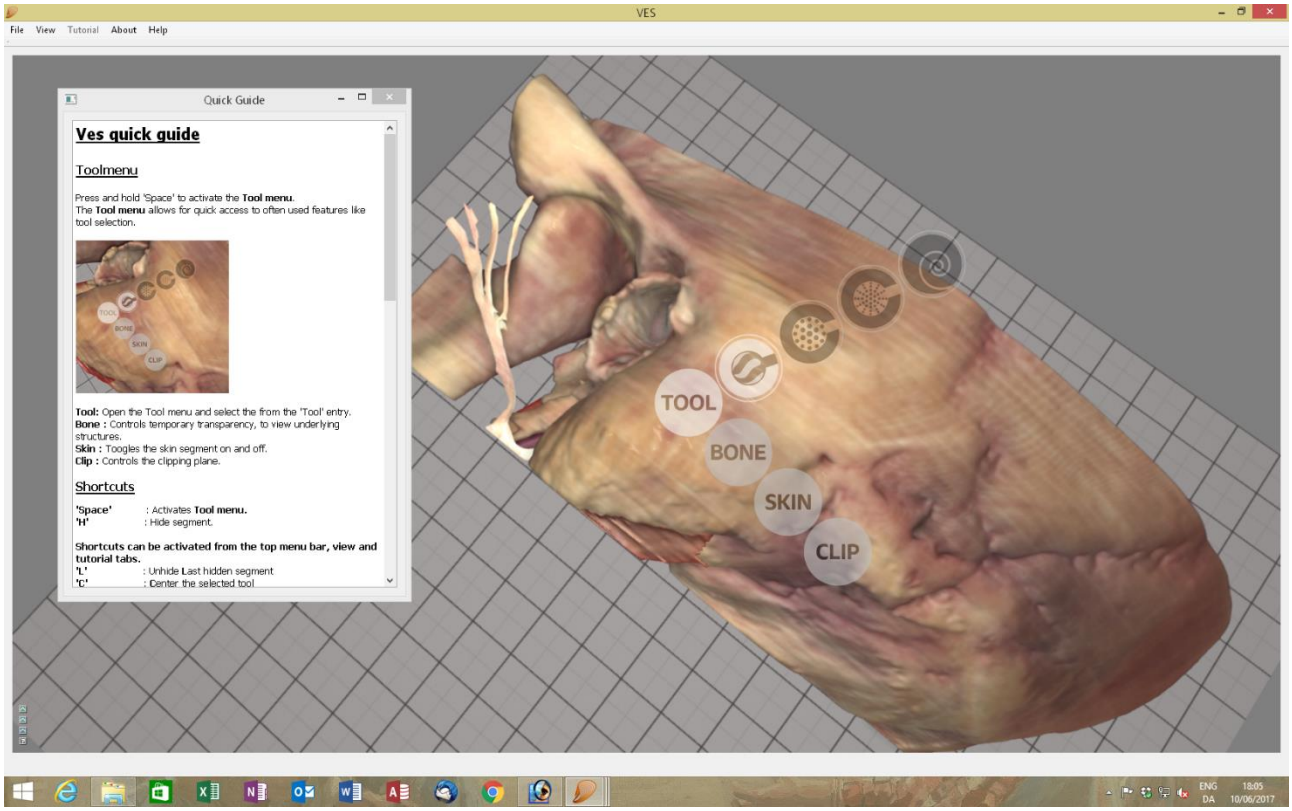



Right click and drag to pan (slide) the model.
Use the mouse wheel to zoom in or out.

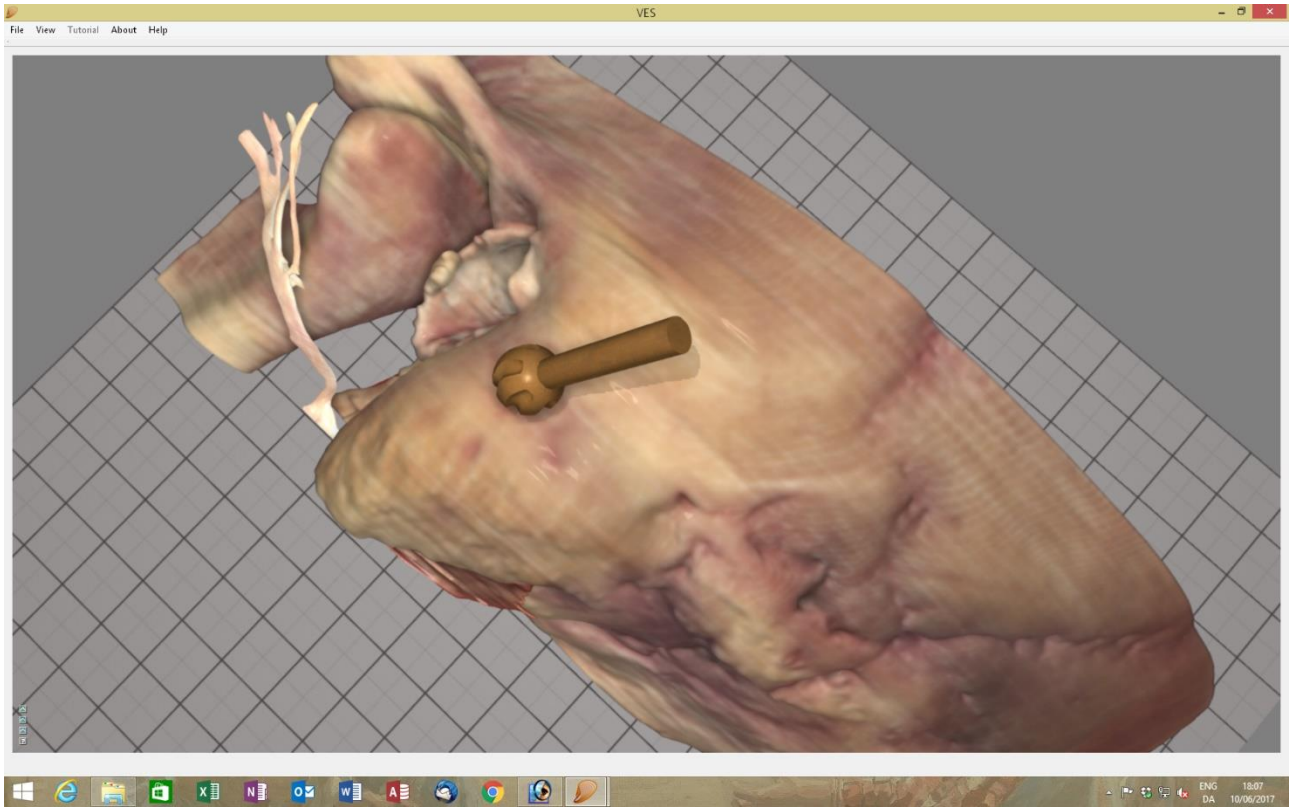



Press and hold the “Space bar” to select a sharp drill, coarse diamond or fine diamond drill or forceps. Bone transparency, clipping plane and skin toggle can also be reached here.

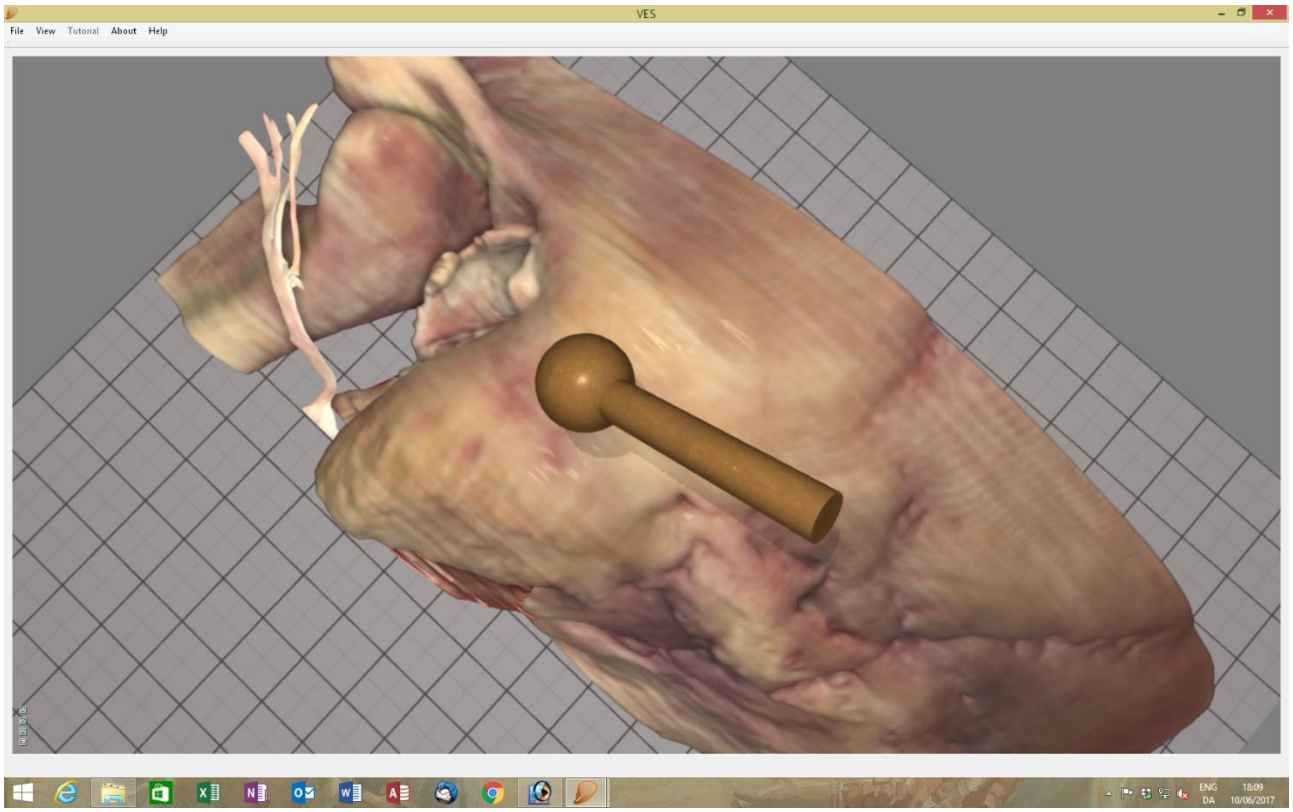
Make you selection with the mouse arrow and execute it by releasing the “Space bar”



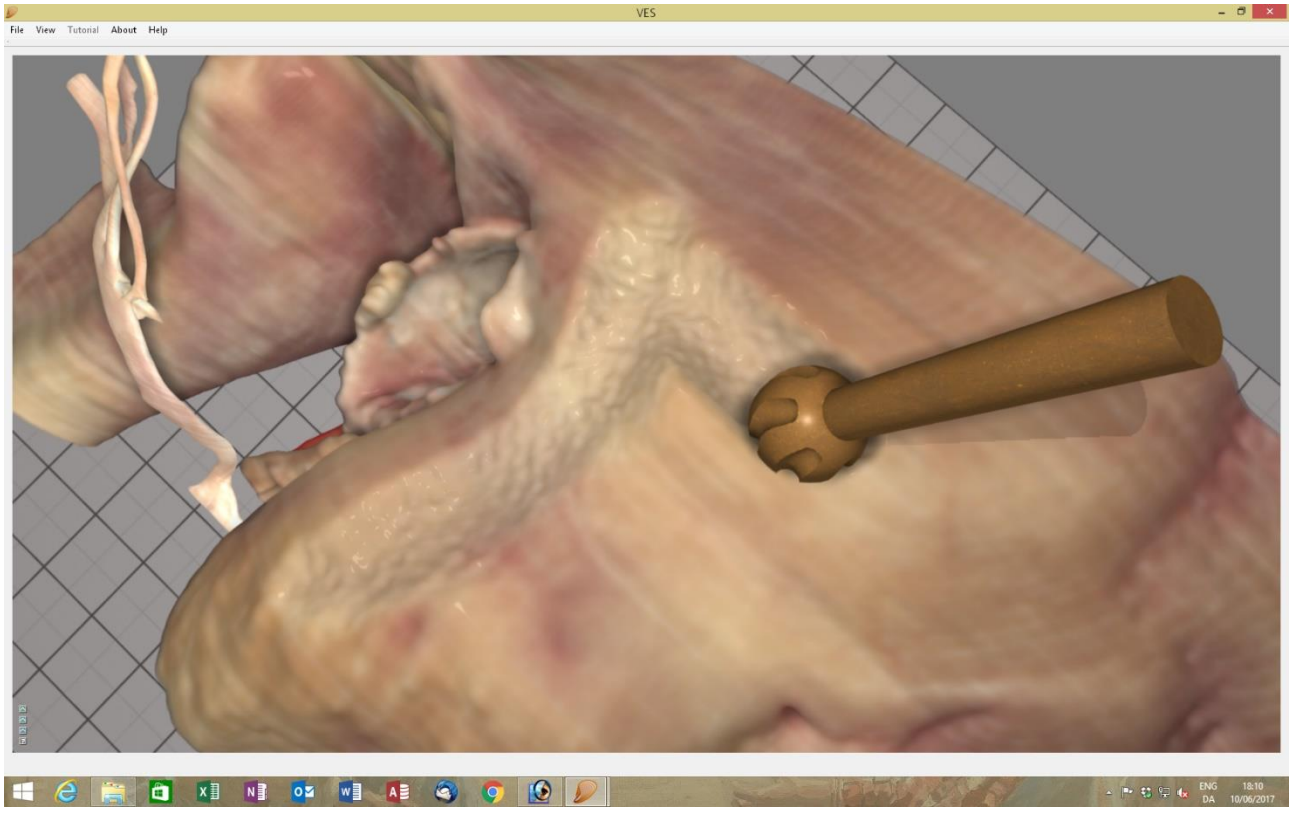

Select a sharp drill and watch it settle on the bone surface. Grab the stylus of the haptic device, move the drill around and feel the bony surface of the model and the weight of the hand piece.



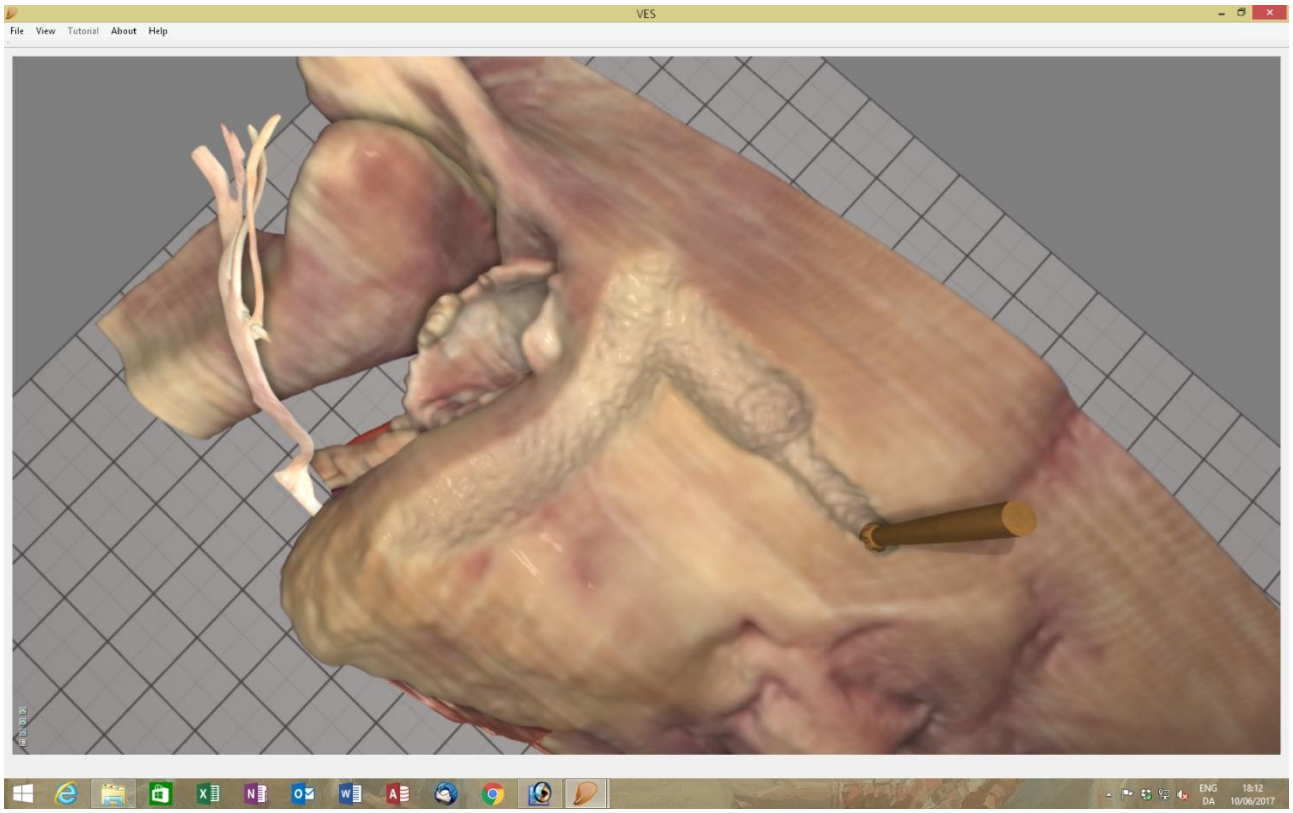
Hold the stylus like a pencil and press and hold the front button with your index finger to start the drill rotation and feel the vibration.




Put the drill to the bone gently and move it along the surface to drill.



The default drill size is 5-mm. Use the up arrow or down arrow to change the size from 7-mm to 6-5-4-3-2-1-½-mm. The drill size is shown in the upper right corner.



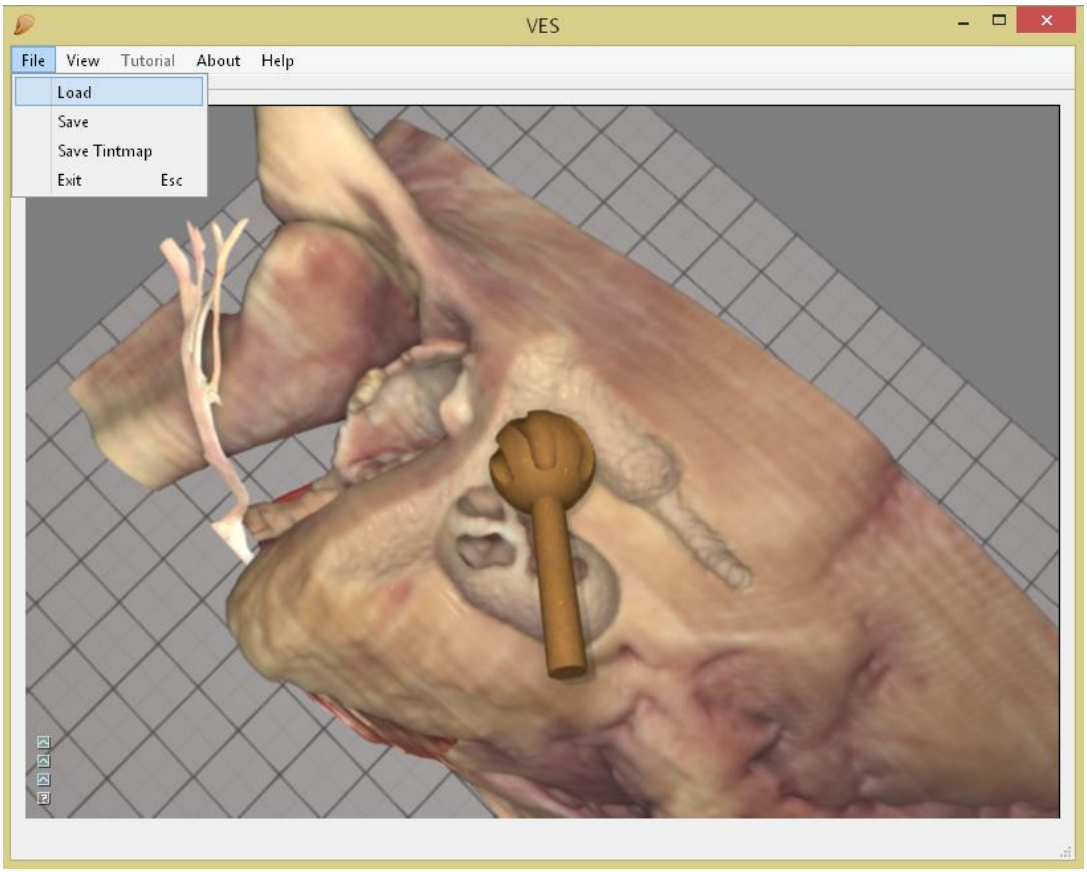

The model can be rotated, panned and zoomed using the haptic device: Press and hold the front button to rotate, press and hold the back button to pan, press and hold the back and front buttons simultaneously to zoom, rotate and pan in one combined movement.

If sometimes the haptic stylus comes out of range when you drill you may easily calibrate your working position by placing the drill as close as possible to where you want to drill and then press and hold the back button. Feel the pen device disconnect from the virtual drill, move the pen to a comfortable position inside the working range of the device, release the back button and feel the pen re-engaging the drill.

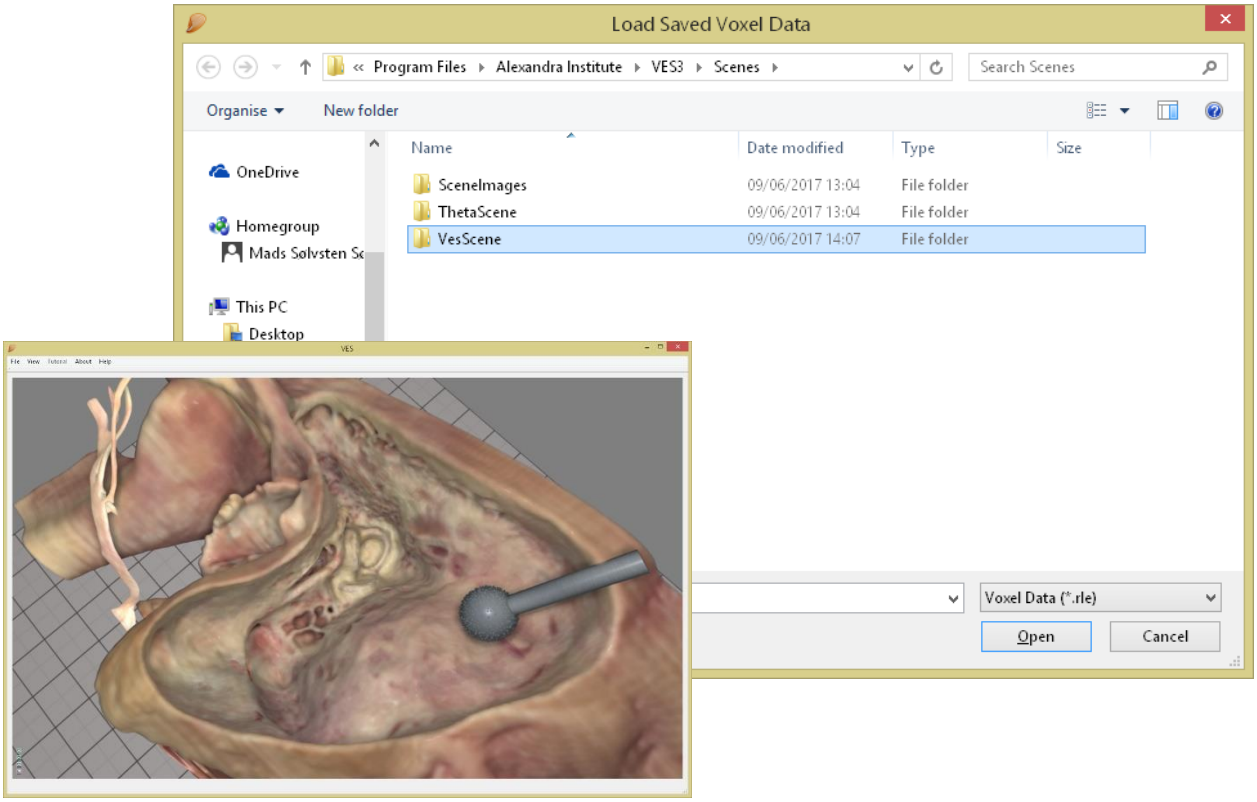
To align the stylus pen of the haptic device and the shaft of the virtual drill press and hold keyboard “Left Ctrl” and stylus’ back button simultaneously and turn the stylus until it is parallel to the drill shaft, then release the buttons.

If sometimes you cannot find the drill you just selected on the screen, press “c” to centre the virtual drill in the workspace.

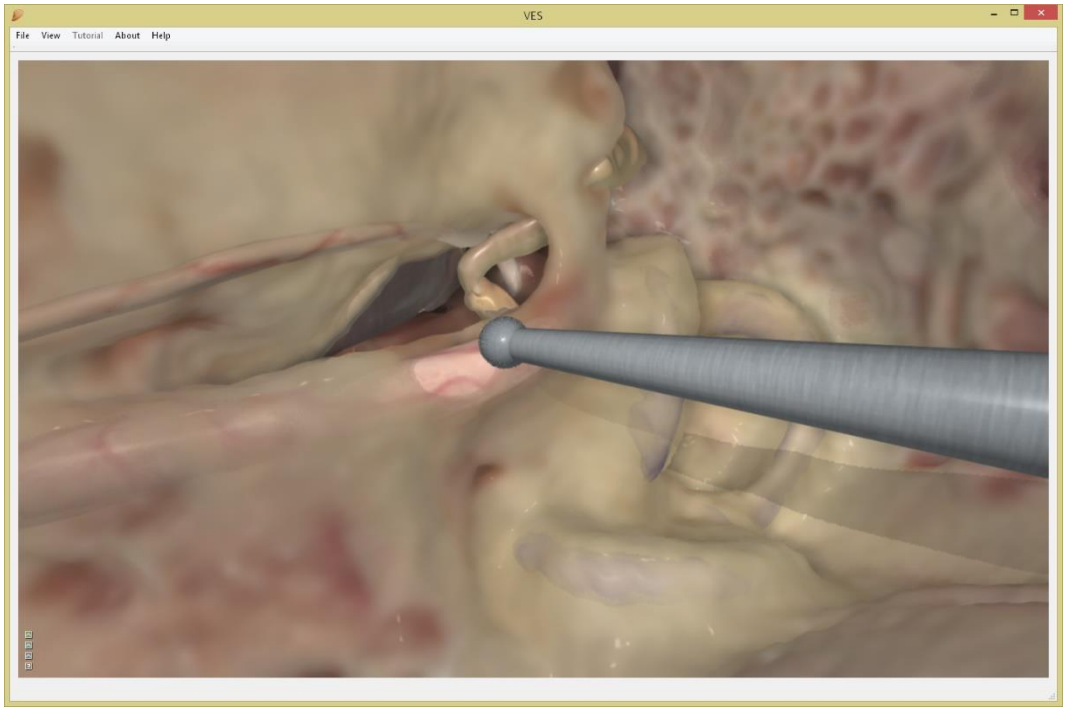
To load a previously saved exercise/scene use “File/Load”
Use the same menu to save (“File/Save”) your work when needed.



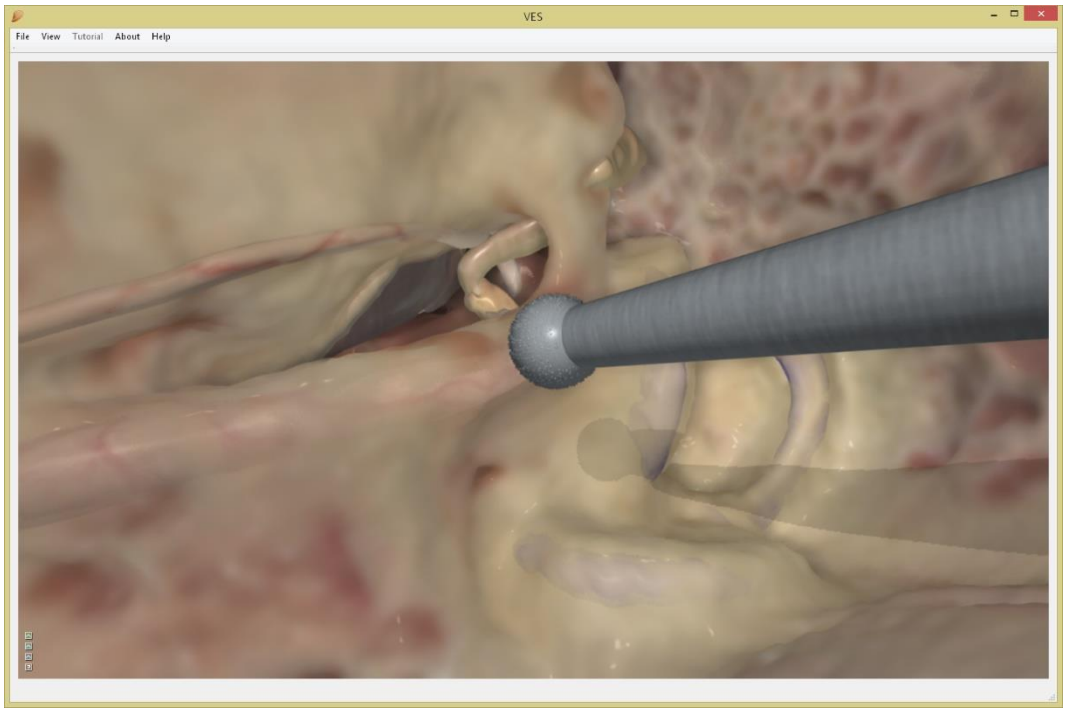

Select the scene you need for the exercise at hand.



If you make a mistake …



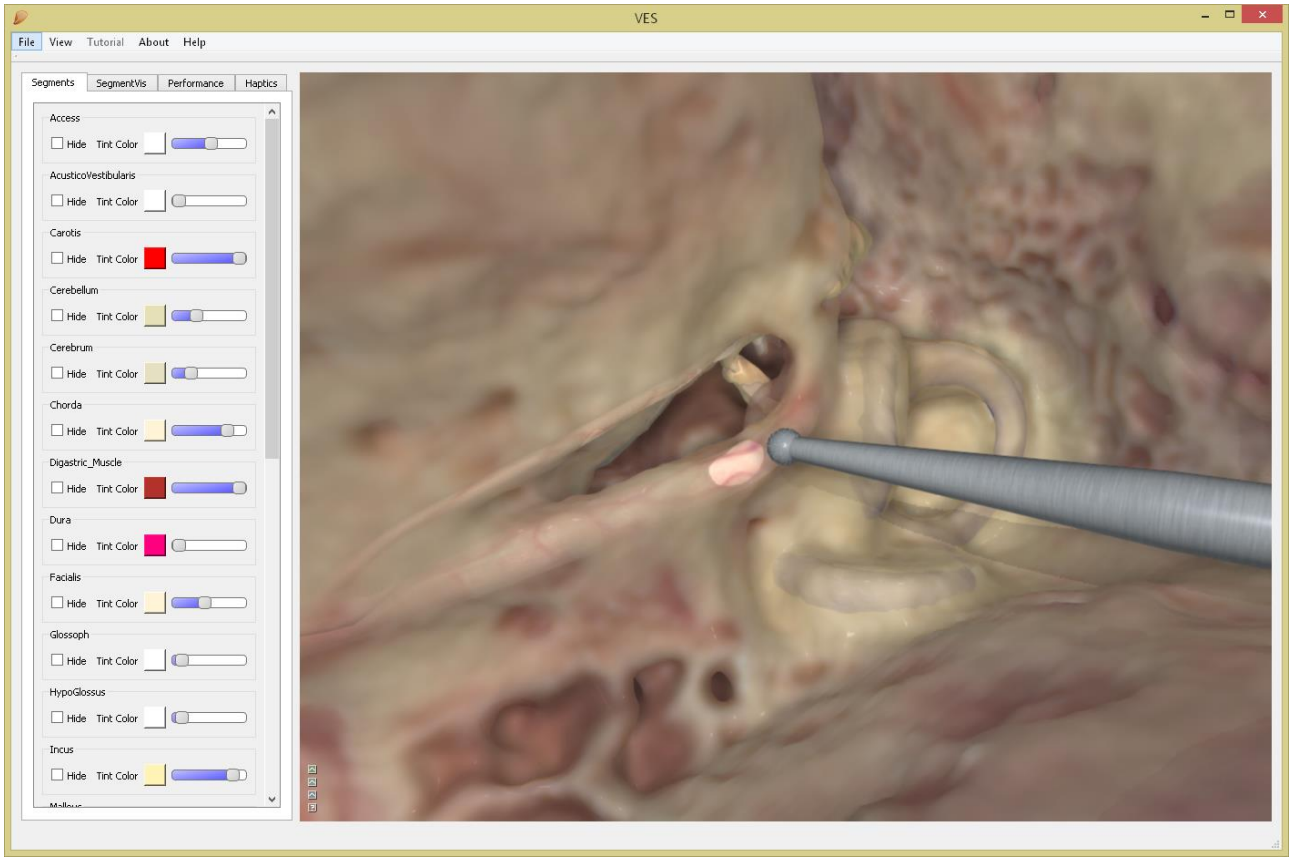

… press “z” to undo and roll back your action one second, or more by pressing “z” repeatedly.



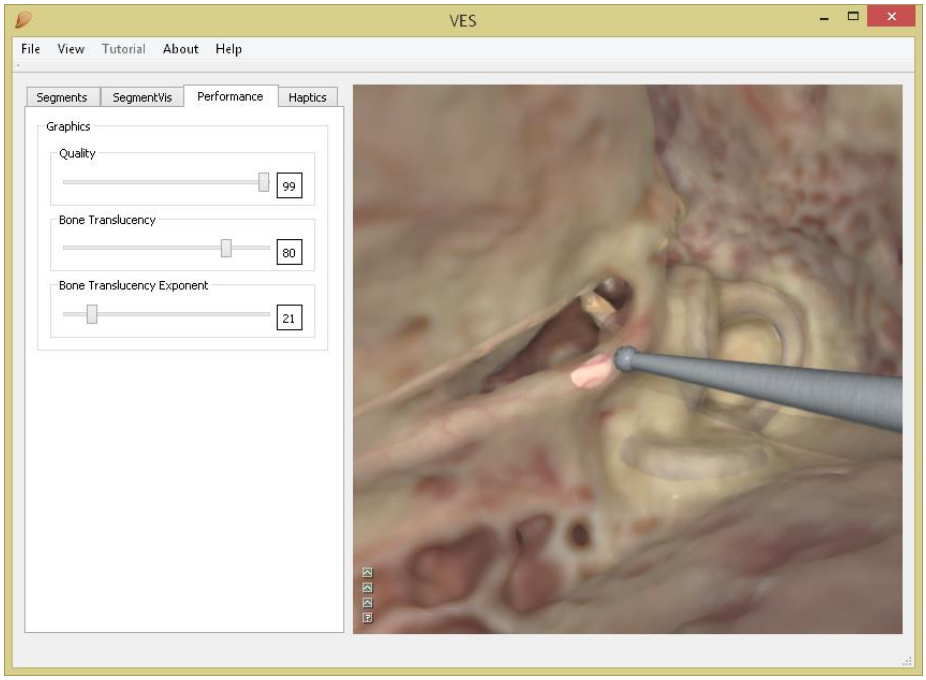

This is not a “cheat” function intended for covering up poor surgery. However, it will allow you to learn how to go closer to the limit because you may easily explore the consequences of further drilling without having to start all over with a fresh session each time you went too far and learned a new lesson.

Press “x” to access the graphic and haptic calibration menu.

In “Segments” you may hide/unhide any segment (structure) or tint it with a colour and intensity of your preference.

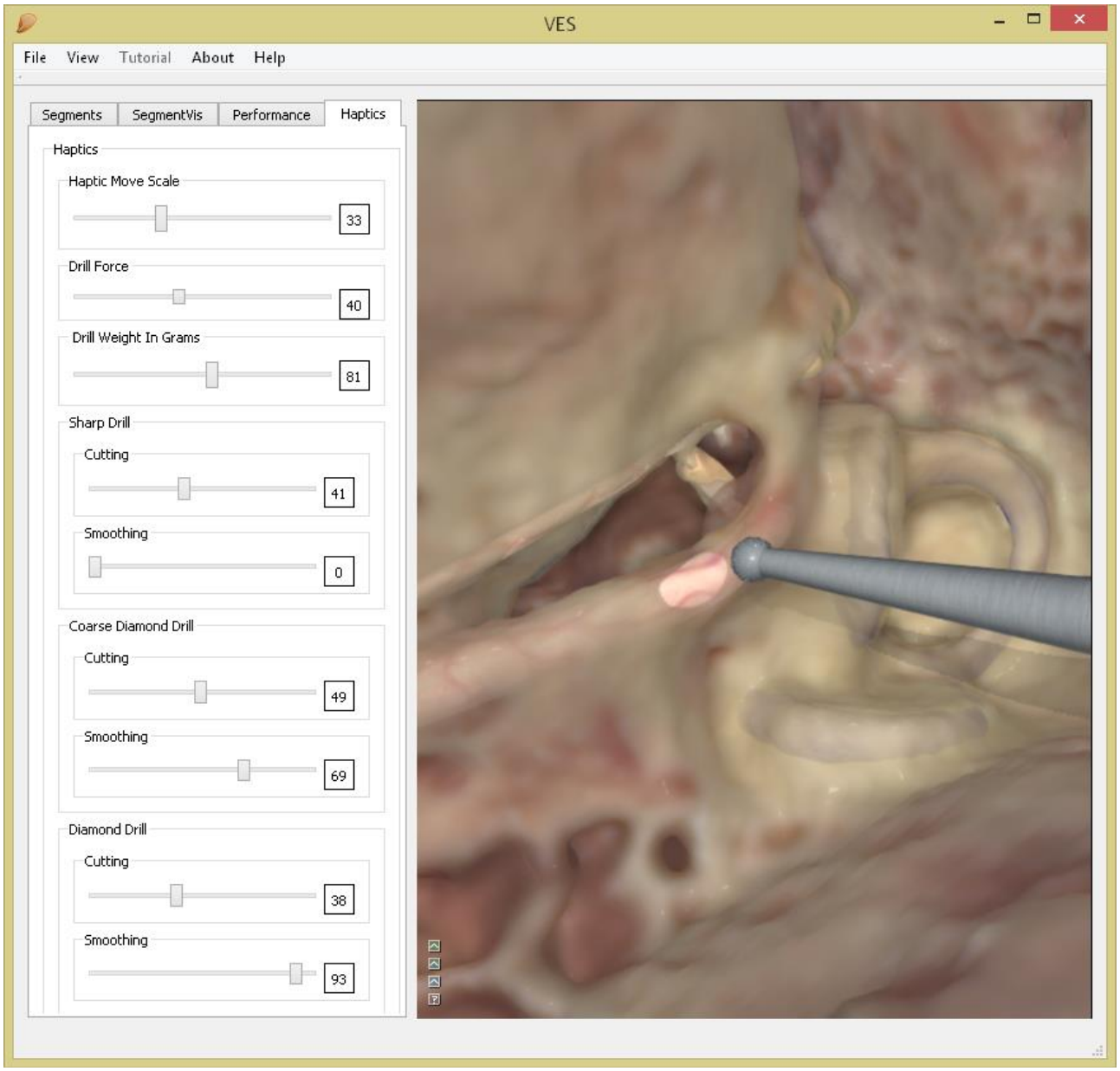



In “Performance” you can trim the overall graphic performance to match the power of your graphics card.
“Bone Translucency” calibrates the transparency through the entire model.
“Bone Translucency Exponent” increases transparency only in the most superficial bone.



In “Haptics” you can calibrate the translation function from hand movement to drill movement at “Haptic Move Scale”.
“Drill Force” determines the degree of haptic feedback during drilling – too little feels dull, too much makes your drill jumpy and hard to control.
Too much “Drill Weight” will make you tired.
For any of the 3 drill types, cutting- and smoothing effect can be tuned.

The haptic calibration is depending on the type and speed of your PCs CPU – no setting is right for every PC, so this is a calibration you will most likely have to go through.

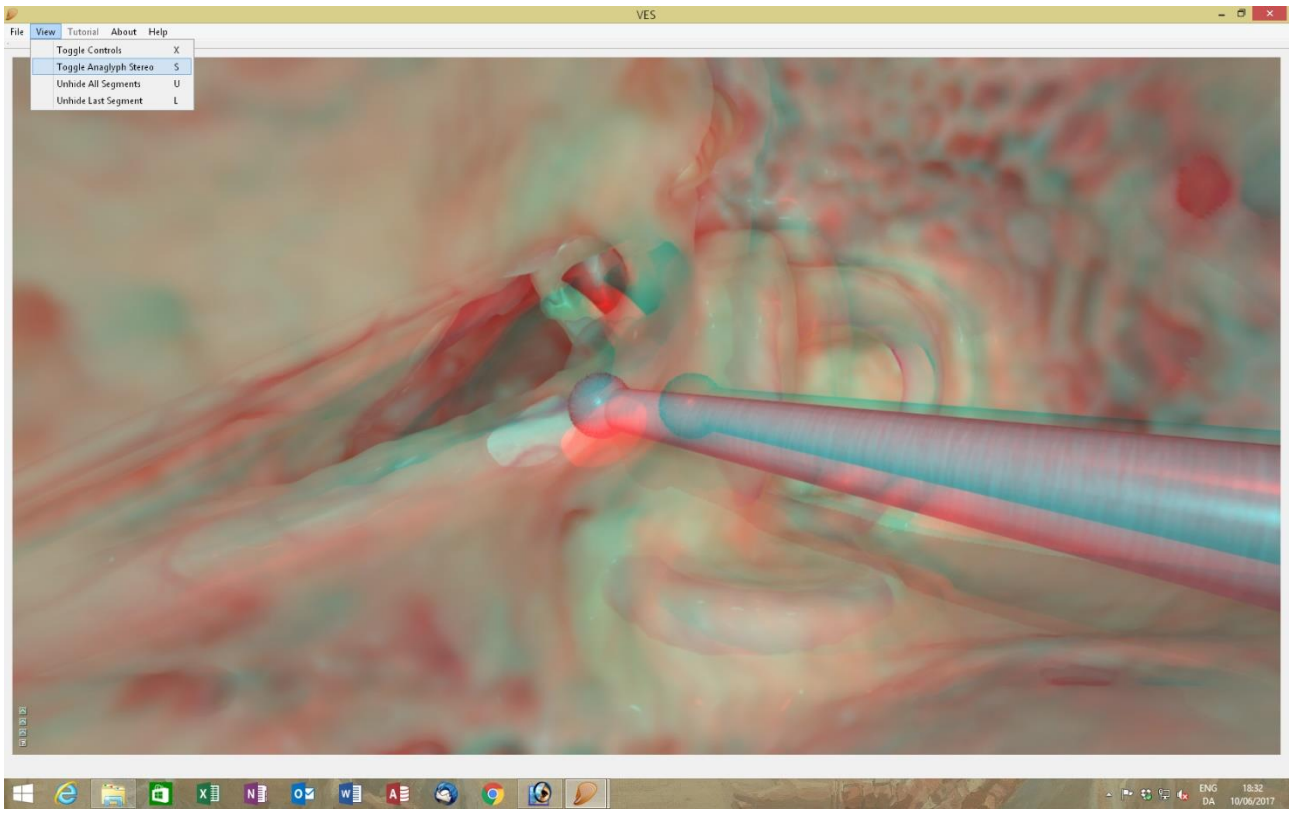


You may want to drill in 2D, but if a stereoscopic view is needed press “View/ Toggle Anaglyph Stereo” or keyboard “S” and put on a pair of red/blue anaglyph glasses. Without such glasses, you will only see a double red/blue image on the screen.

The image below will appear in stereo whether on the pc screen or in colour print.

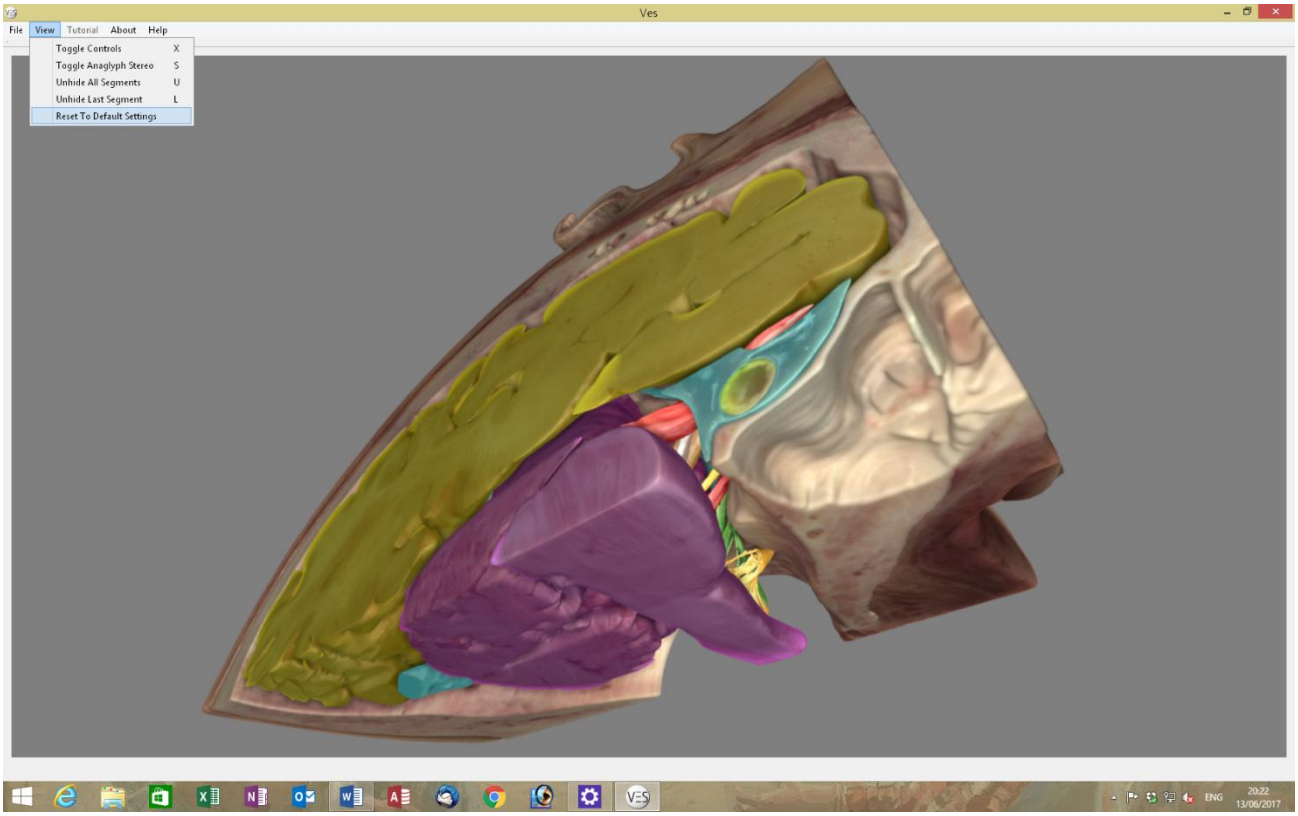
Some colour information is lost, but this stereo mode is opensource code, which helps to keep the VES3 simulator free.

Whenever you wish to return to 2D press “S” or “View/ Toggle Anaglyph Stereo” again.



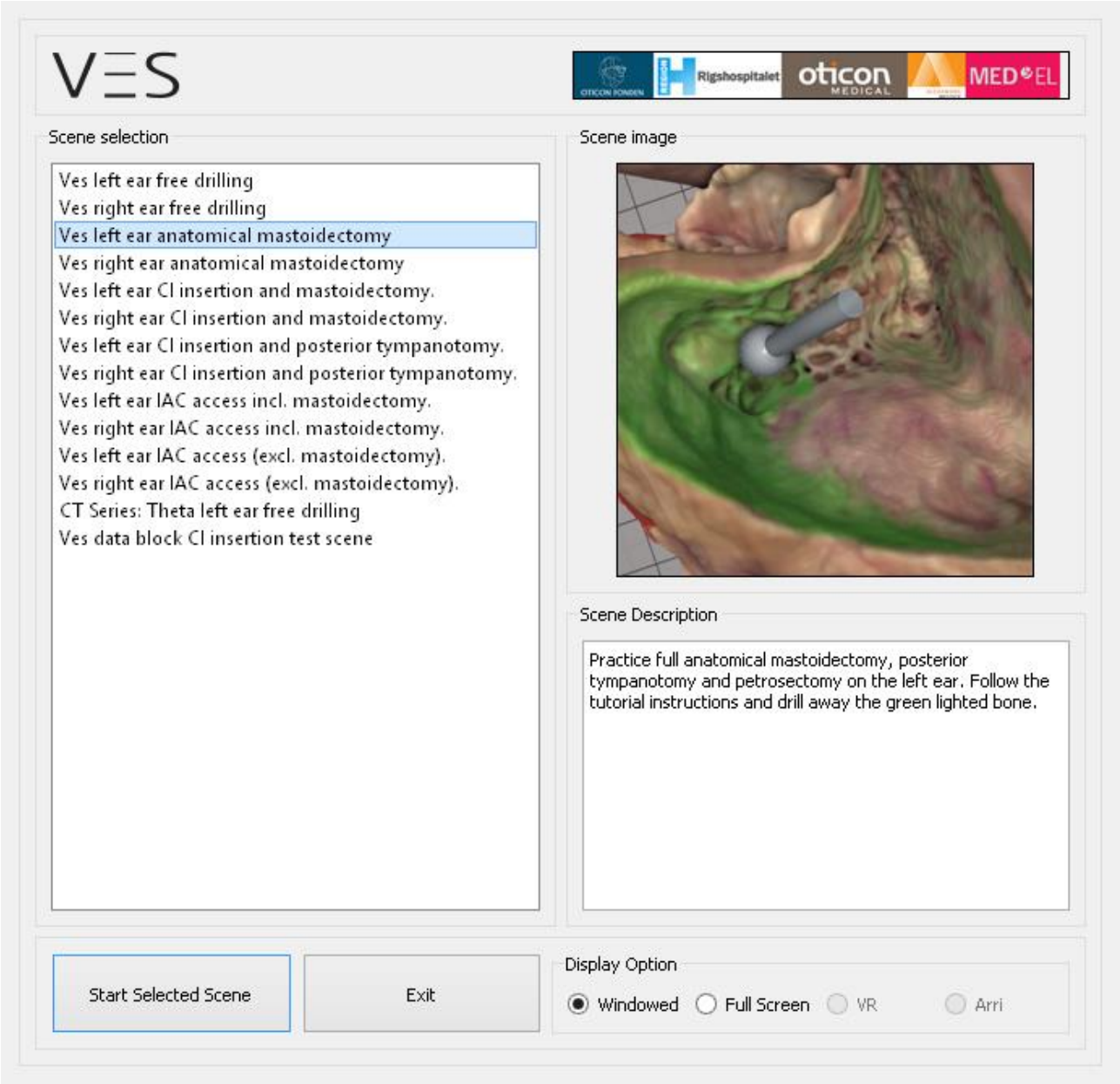

Stereo output for a polarizing screen, Oculus Rift VR or the Arriscope® digital surgical microscope as optional in VES2 will become available for VES3 soon (as it is for VES2).

If you played around with every calibration of graphics and haptics and got lost in the process use the “View/Reset to Default Settings” to return to a realistic set up.



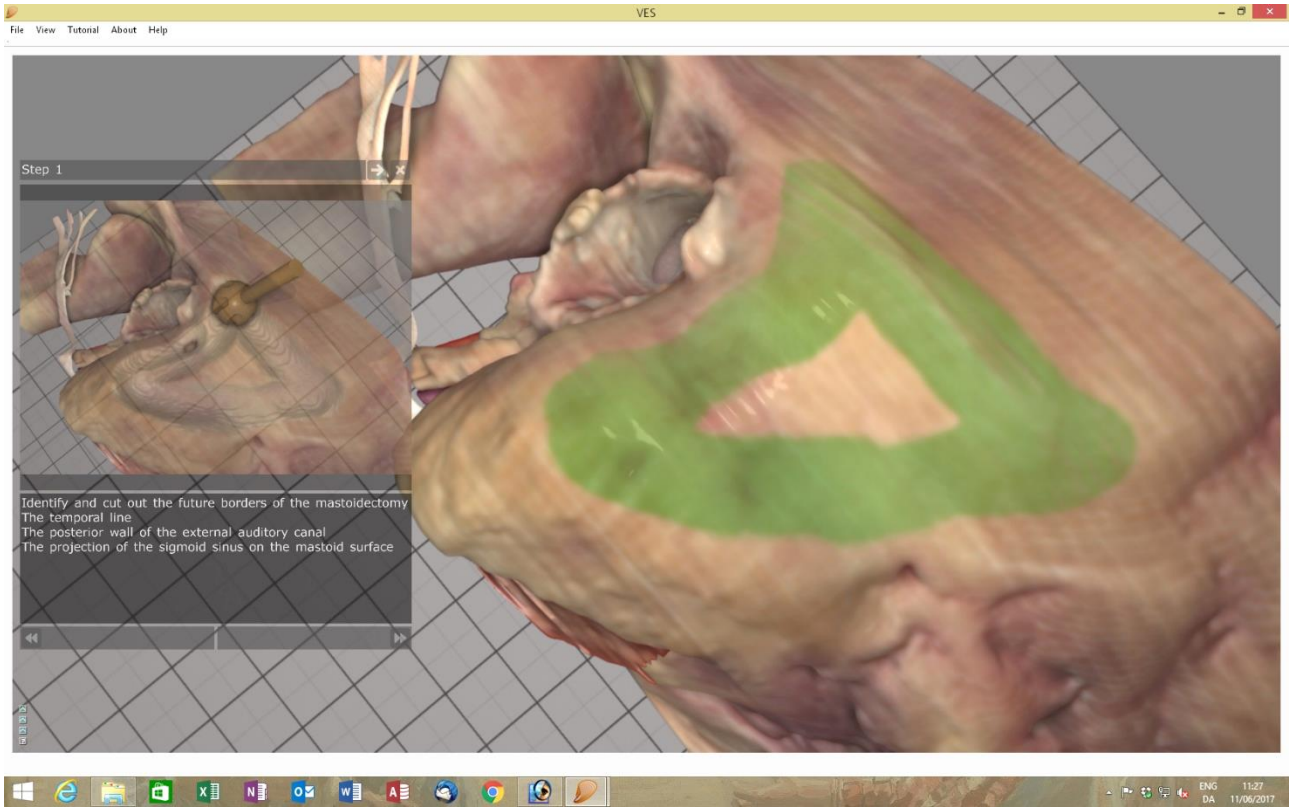
Press “File/Exit” to return to the scene selection screen.

Drill a complete anatomical mastoidectomy assisted by the integrated tutor function by selecting “VES left ear mastoidectomy tutorial” and pressing “Start Selected Scene”

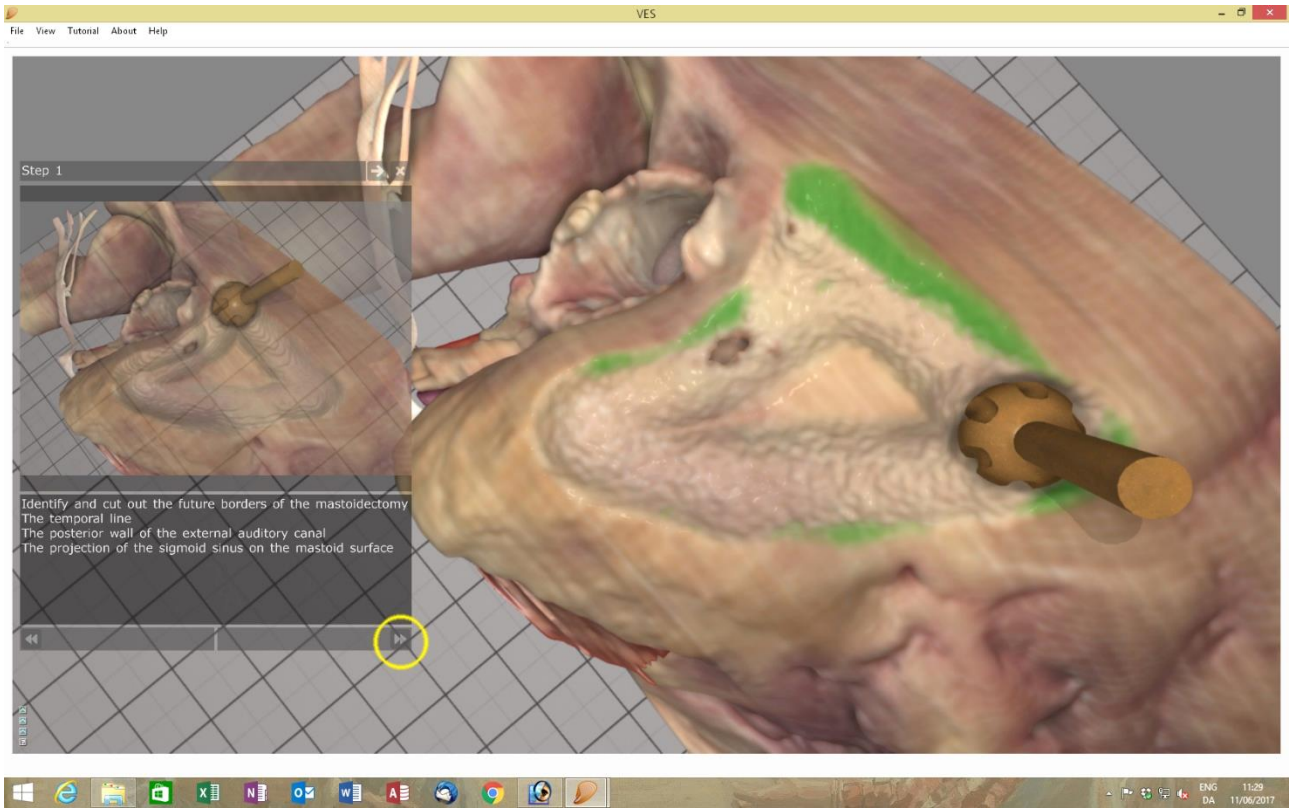


The VES3 presents a new bone with an overlay of stepwise instructions, which can be pushed aside by clicking the arrow. You can toggle the instruction On/Off with “t”.

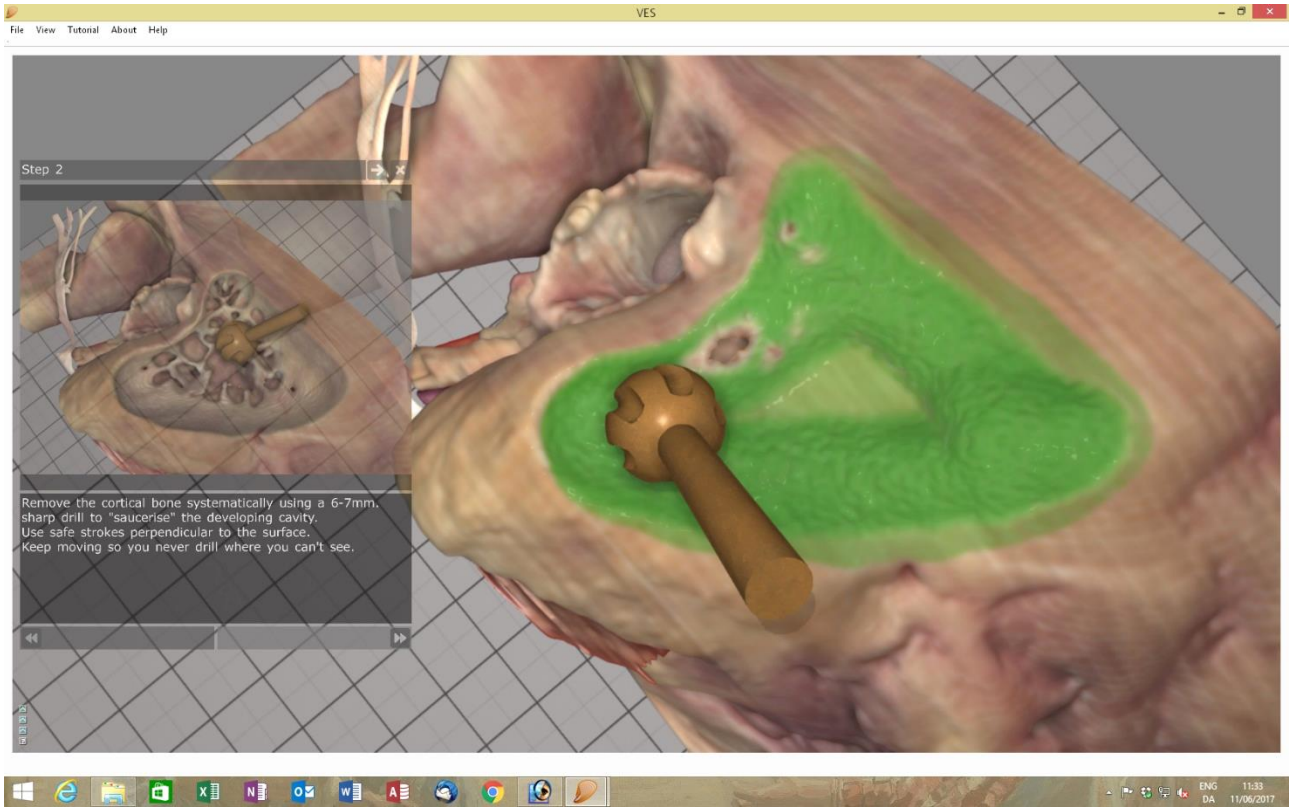

The volume of bone that you are prompted to remove is greenlighted in the voxel model, so all you really need to do for a start is to remove the green bone.



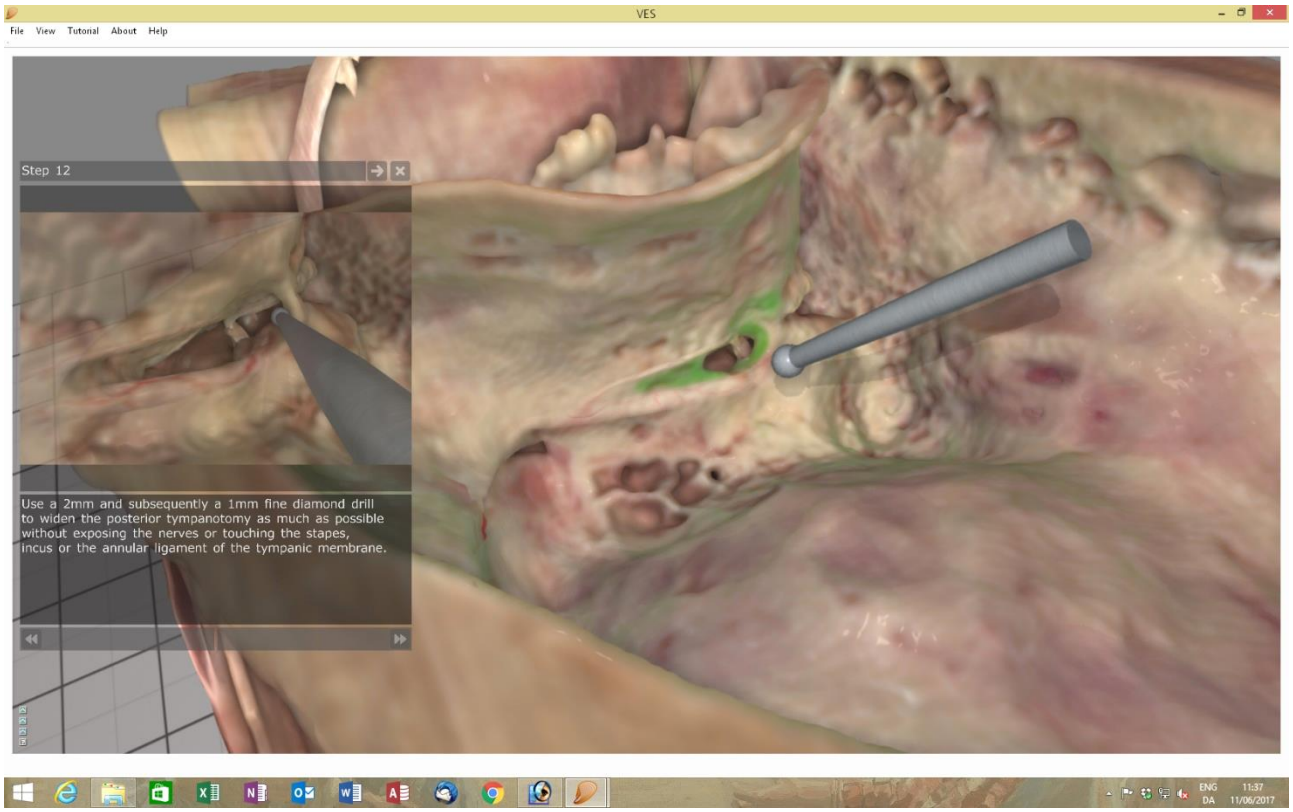
When the green bone is gone, go to the next step by clicking the arrows (bottom left)



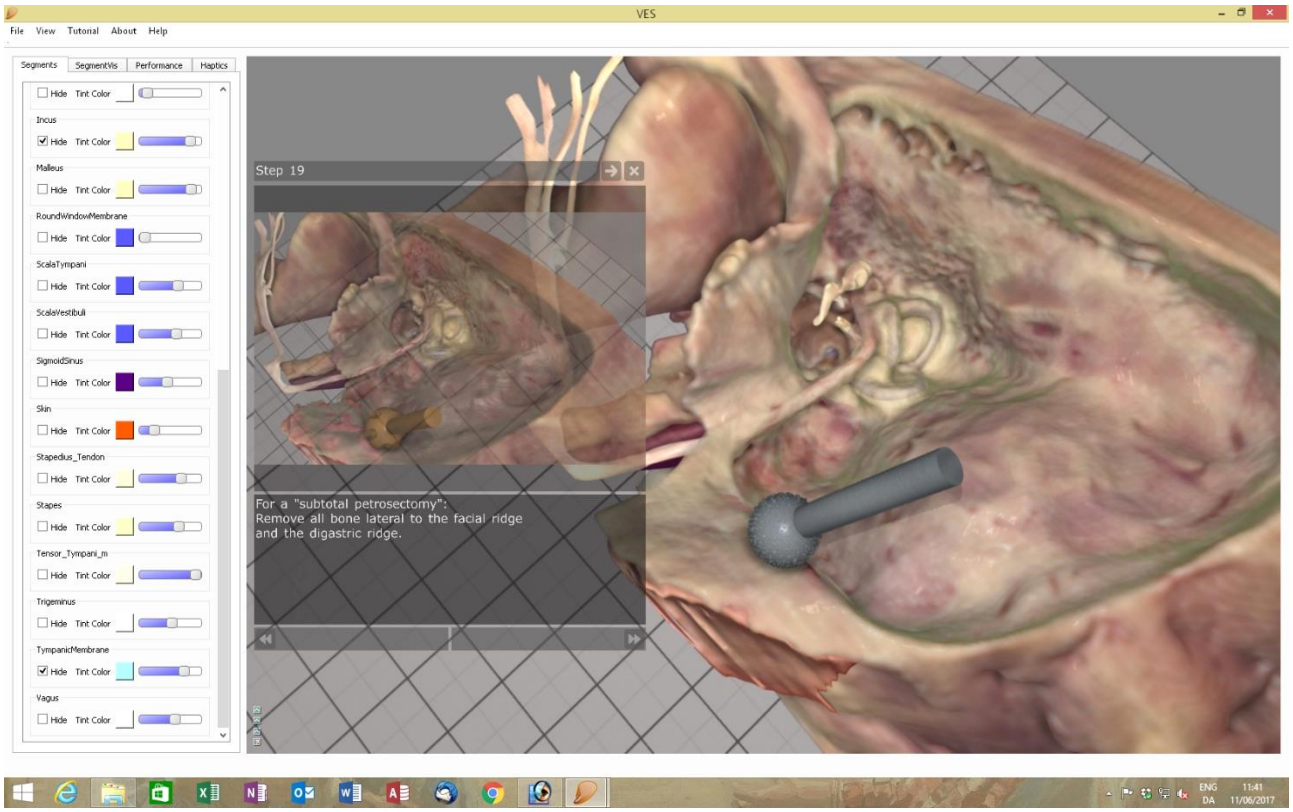

Complete the next step and so on…



Even the more complex steps can be intuitively demonstrated

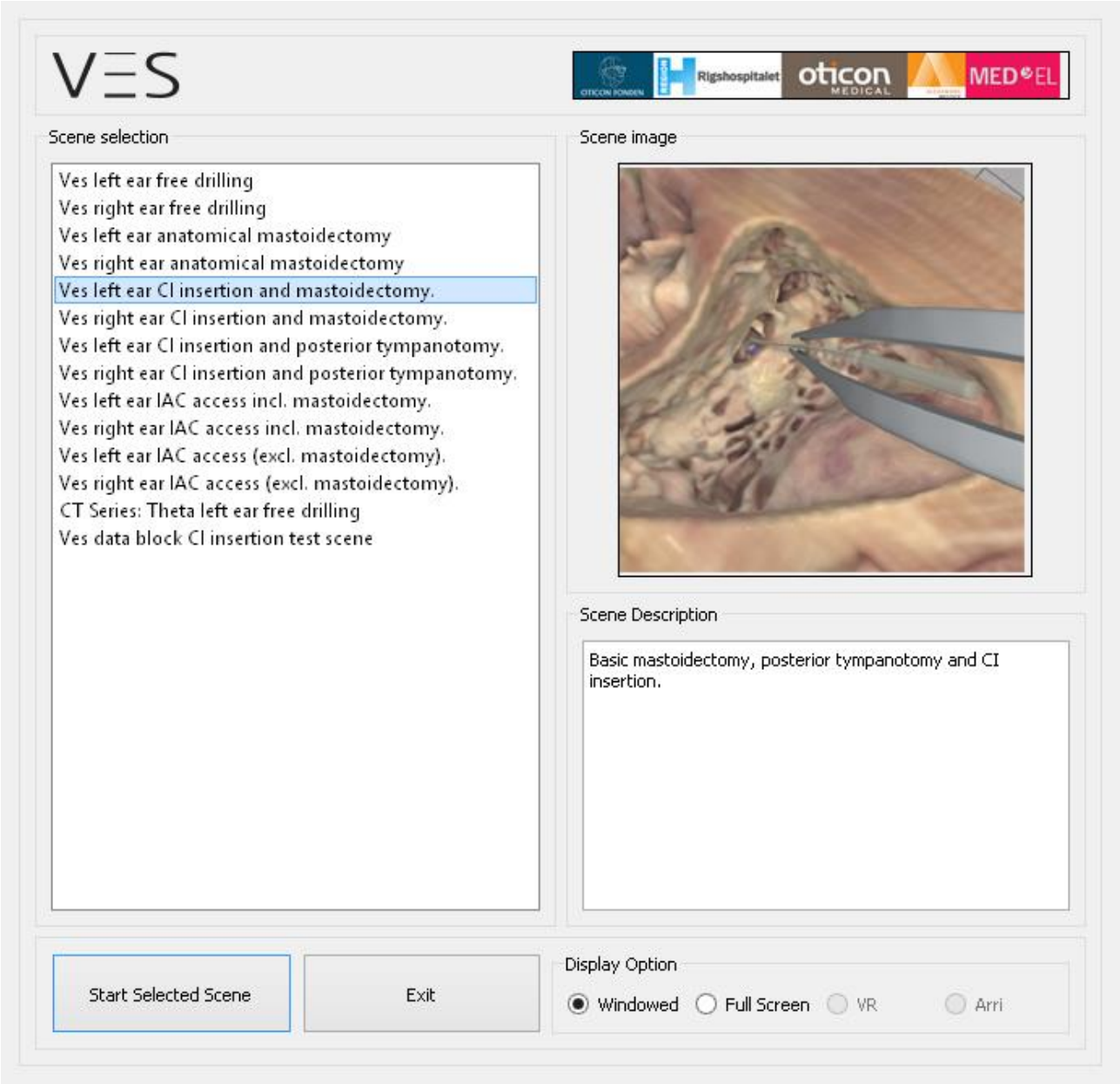



All the way to a Petrosectomy.

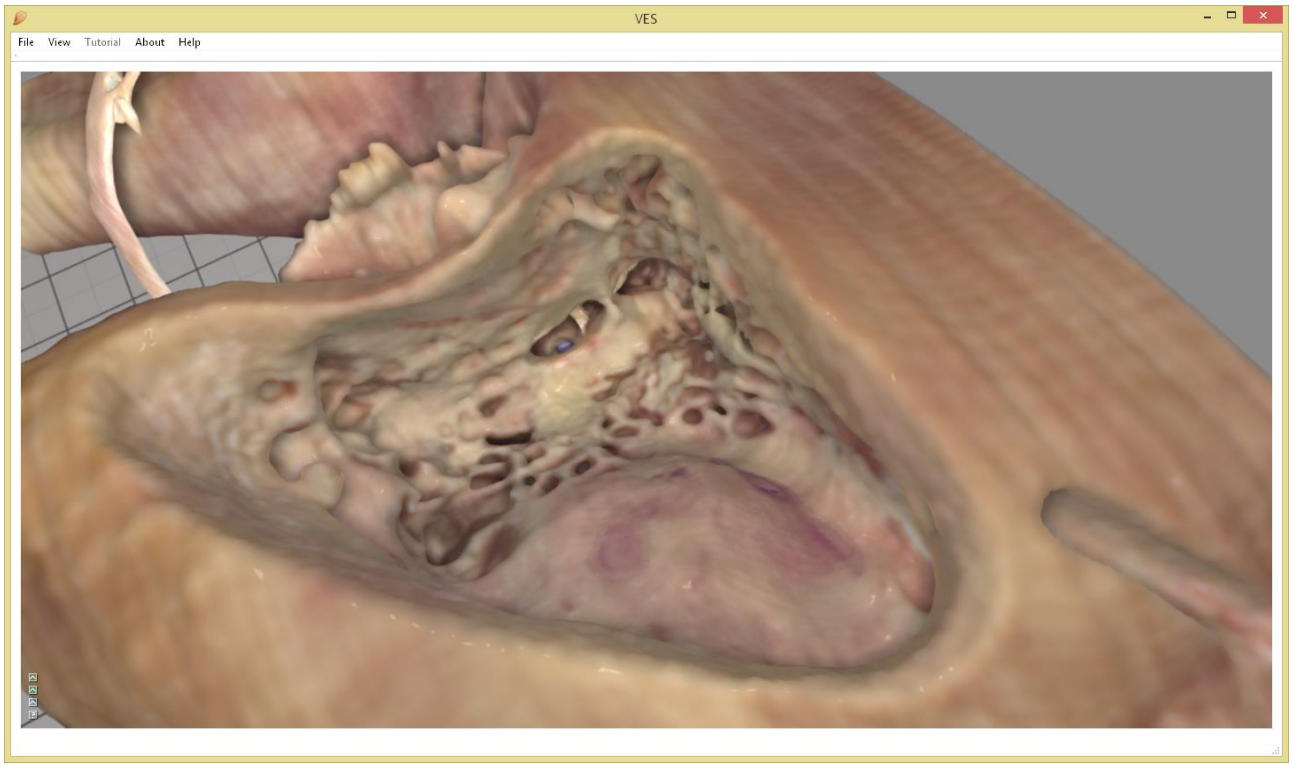


Press “File/Exit” to return to the scene selection screen.

Select “VES Left CI Tutorial” and press “Start Selected Scene”

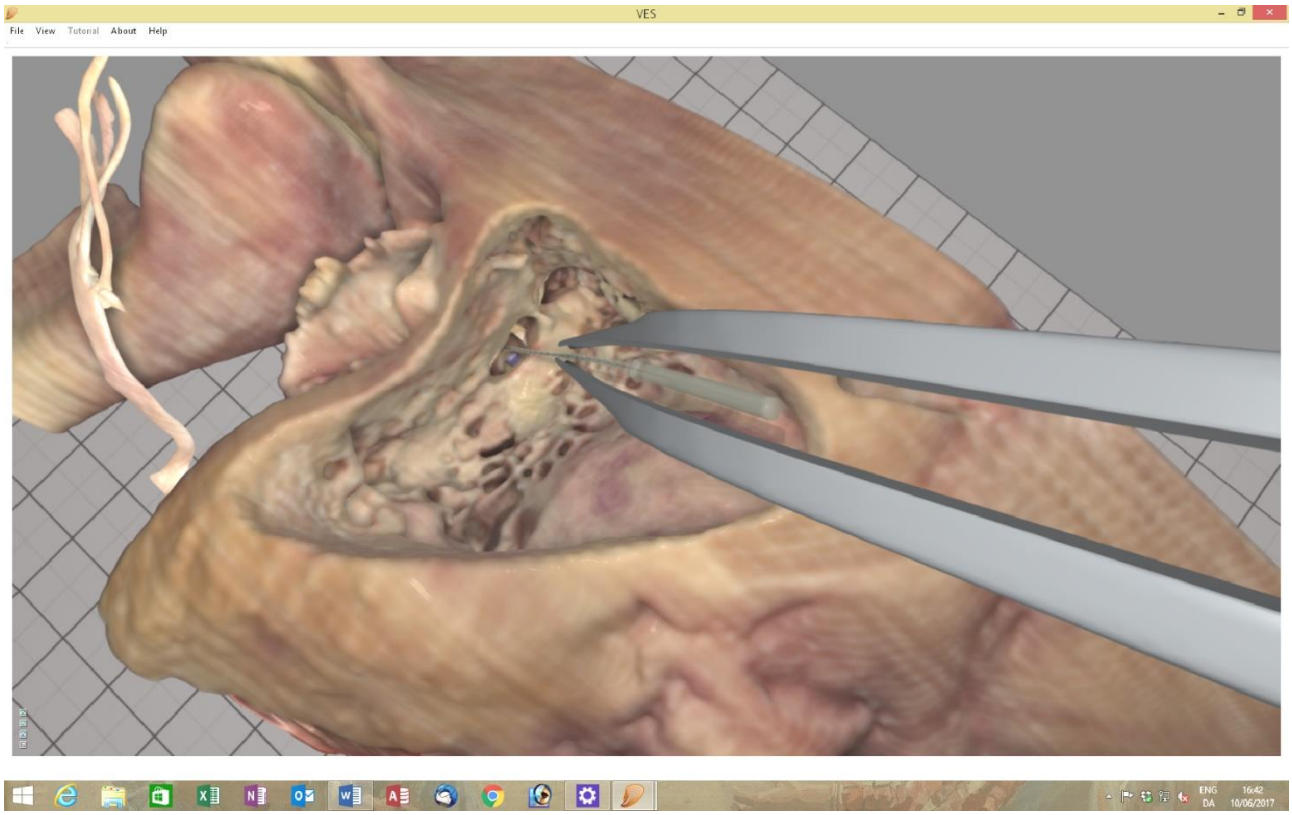


In this CI procedure the mastoidectomy is less comprehensive and more clinical compared to the anatomical mastoidectomy.




It removes bone necessary to expose the round window membrane for electrode insertion.

Select the forceps tool and press “I” to retrieve a CI electrode.



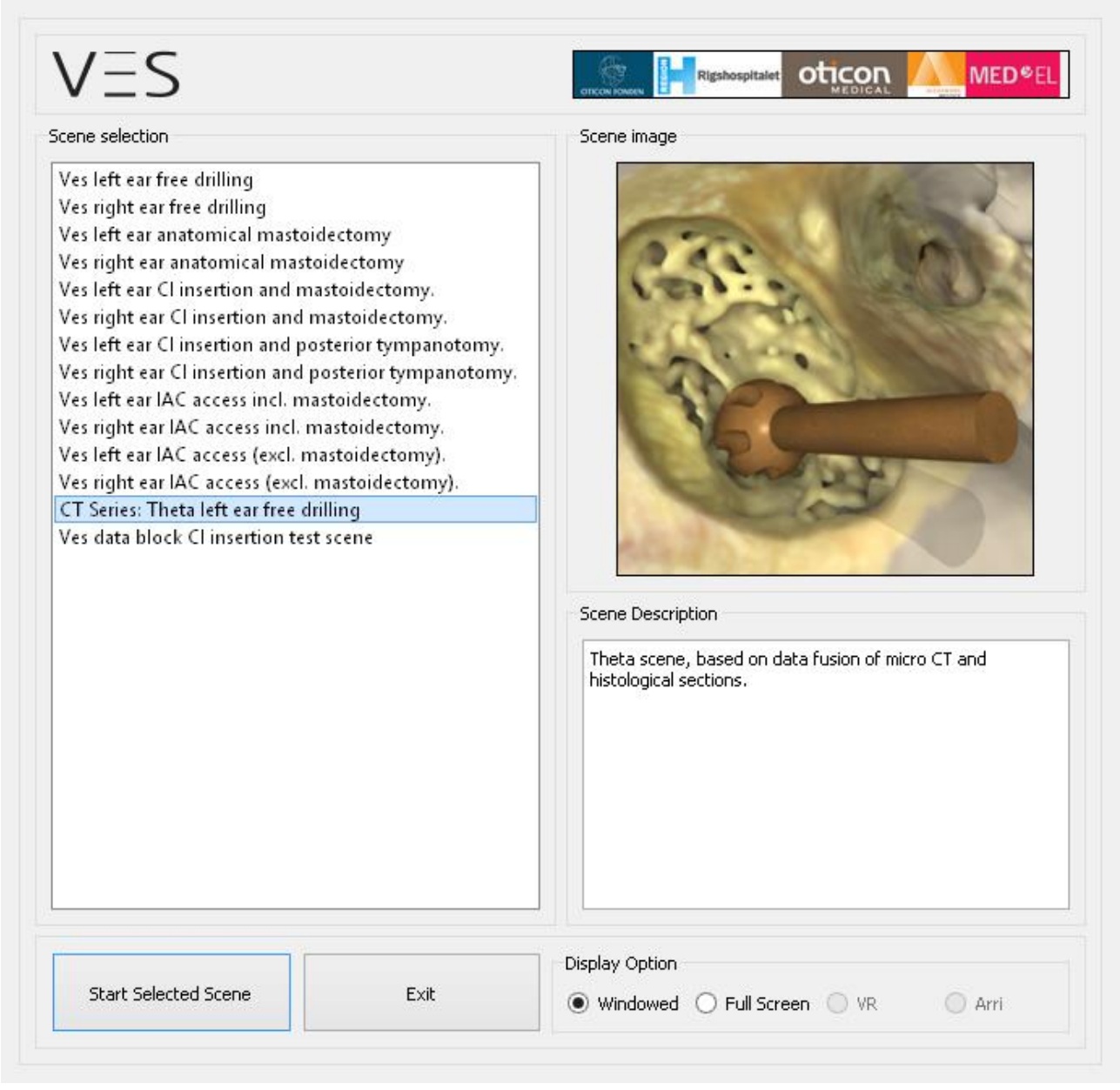

Use the front button to release and grab the electrode and insert it gently and slowly through the posterior tympanotomy.

It’s not easy – just like in real surgery. We are working hard to make it “not easy” in the exact right way, so check the VES homepage for updates.

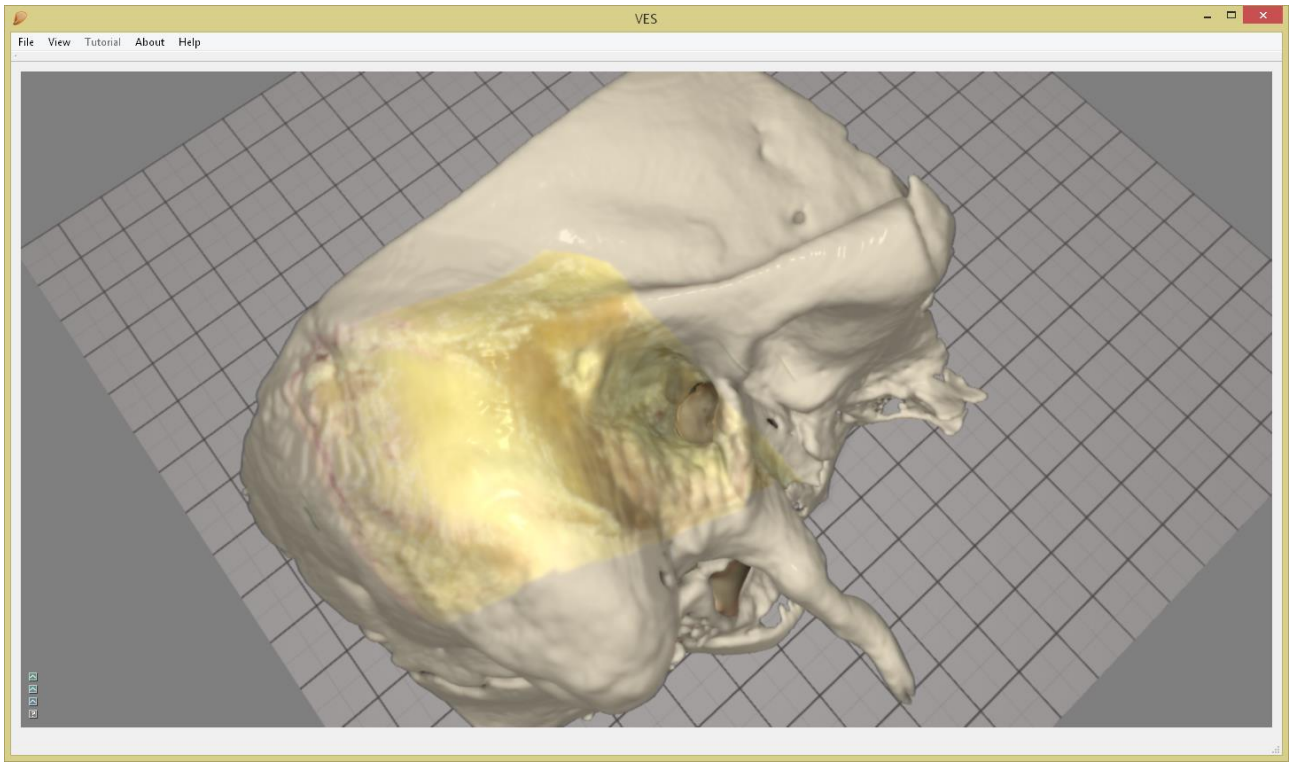
Press “File/Exit” to return to the scene selection screen.

Select “CT series: Theta left ear scene” and press “Start selected Scene”.

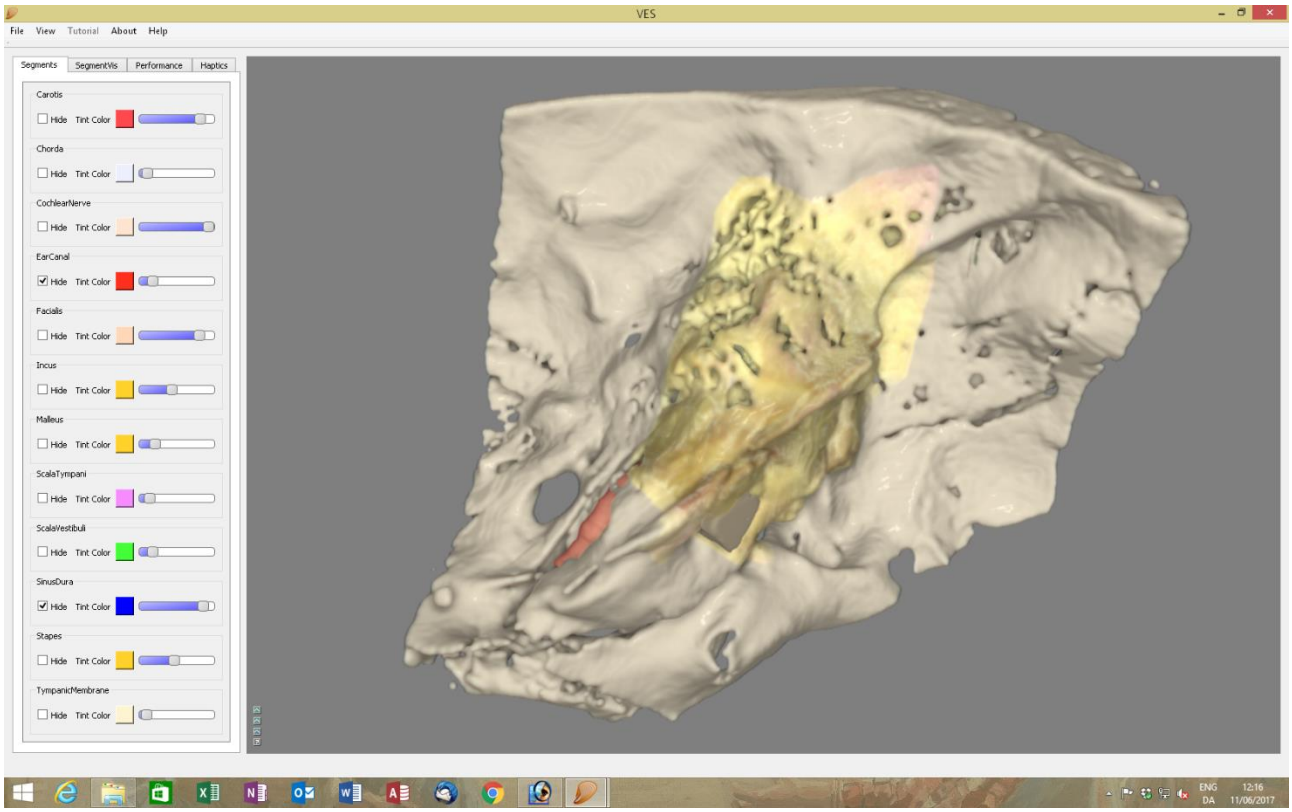
This bone is an early prototype kindly provided by Daniel Sieber of MED-EL, based on micro CT and some manual post-processing for the VES3.



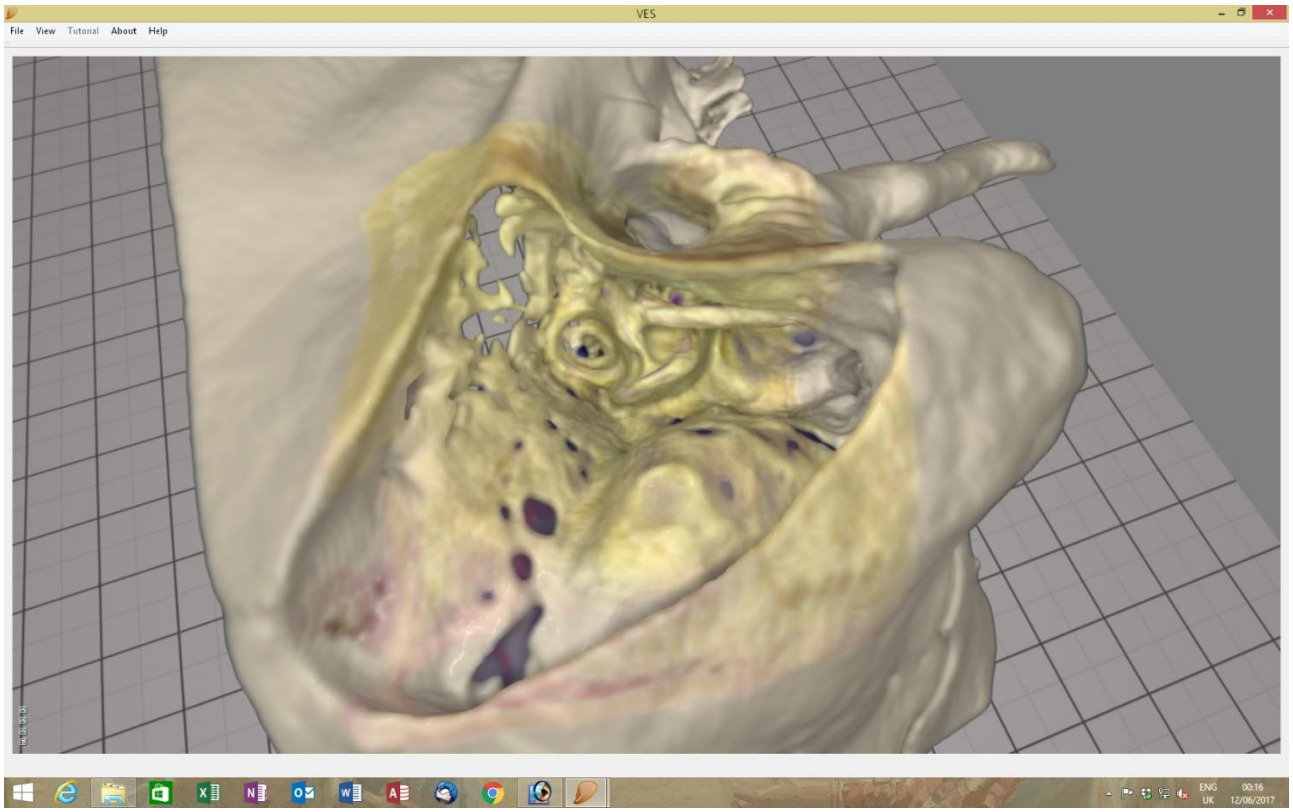
The central, slightly yellow bone is a fusion of CT and histological information.

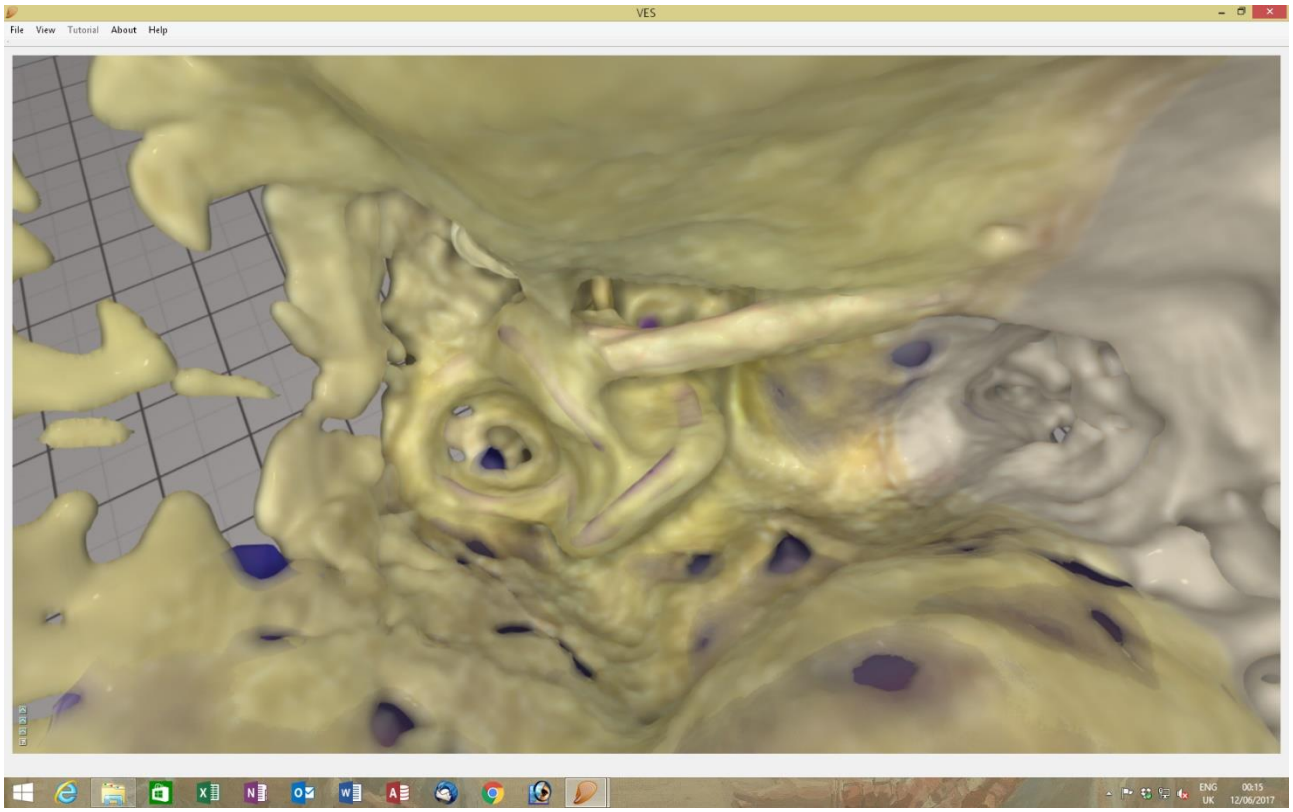



There are some artefacts most visible at the outer limits of the temporal bone…



…but the specimen can never the less be drilled

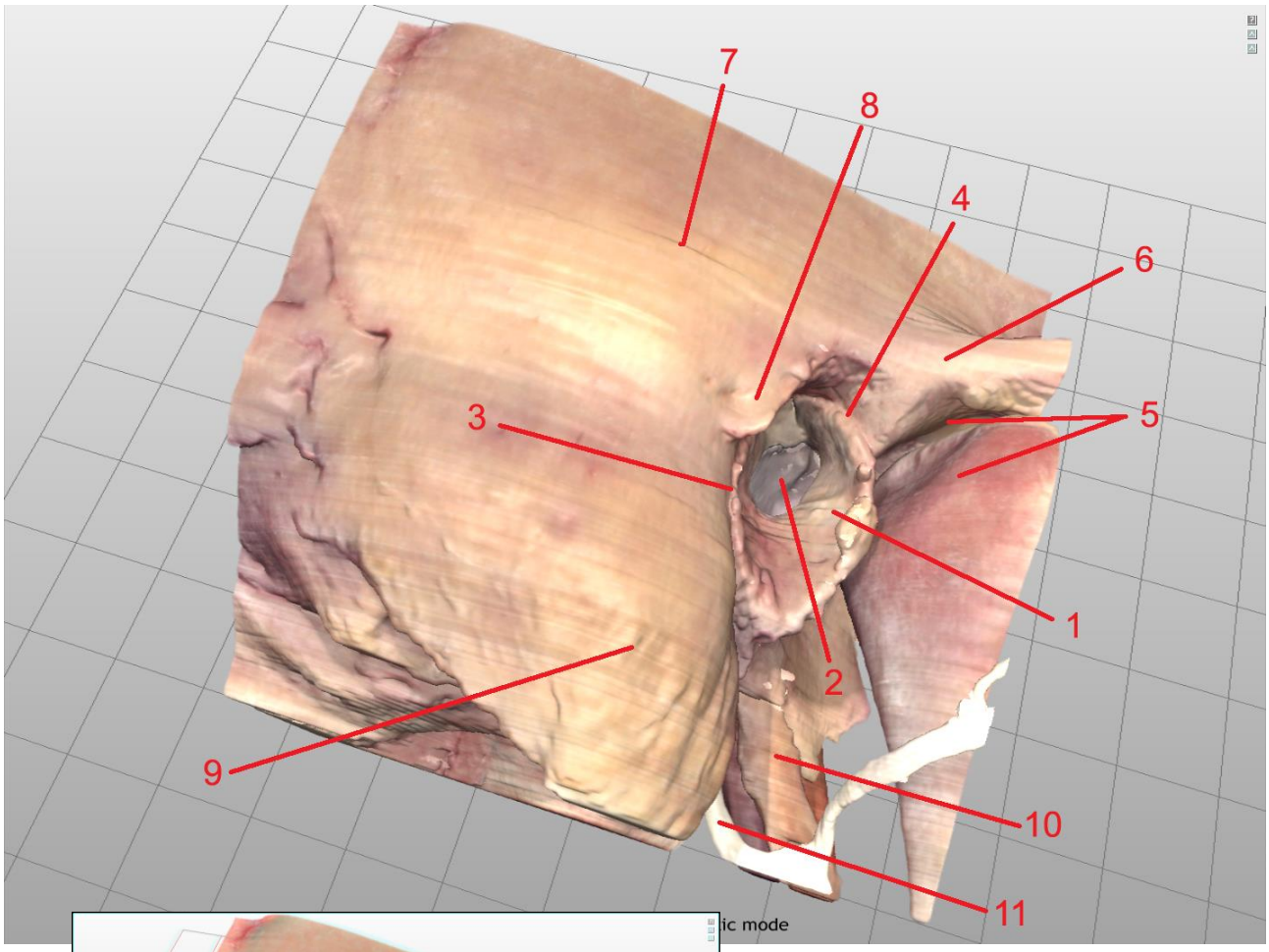


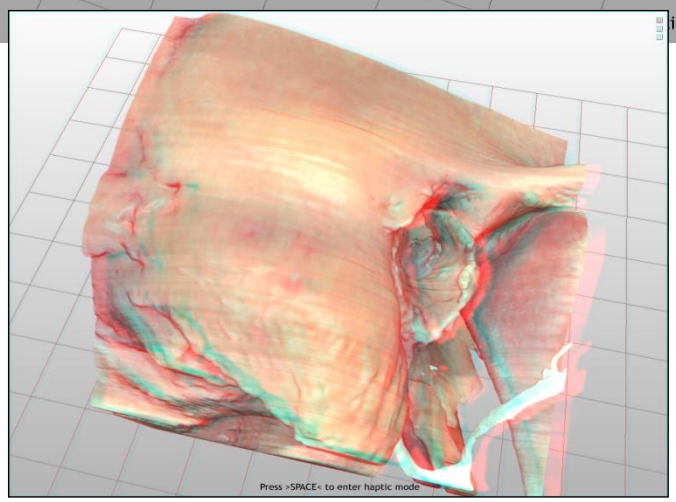




Press “Esc” or “File/Exit” to leave the Theta scene.

**Get to know your bone.** Identify the:

1. External auditory meatus
2. Tympanic membrane
3. Tympano-mastoidal suture
4. Tympano-squamous suture
5. Mandibular condyle/ -fossa
6. Root of the zygomatic arch
7. Temporal line/ suprameatal ridge (posterior extension of 6.)
8. Henle´s spine
9. Mastoid process
10. Styloid process
11. Facial nerve

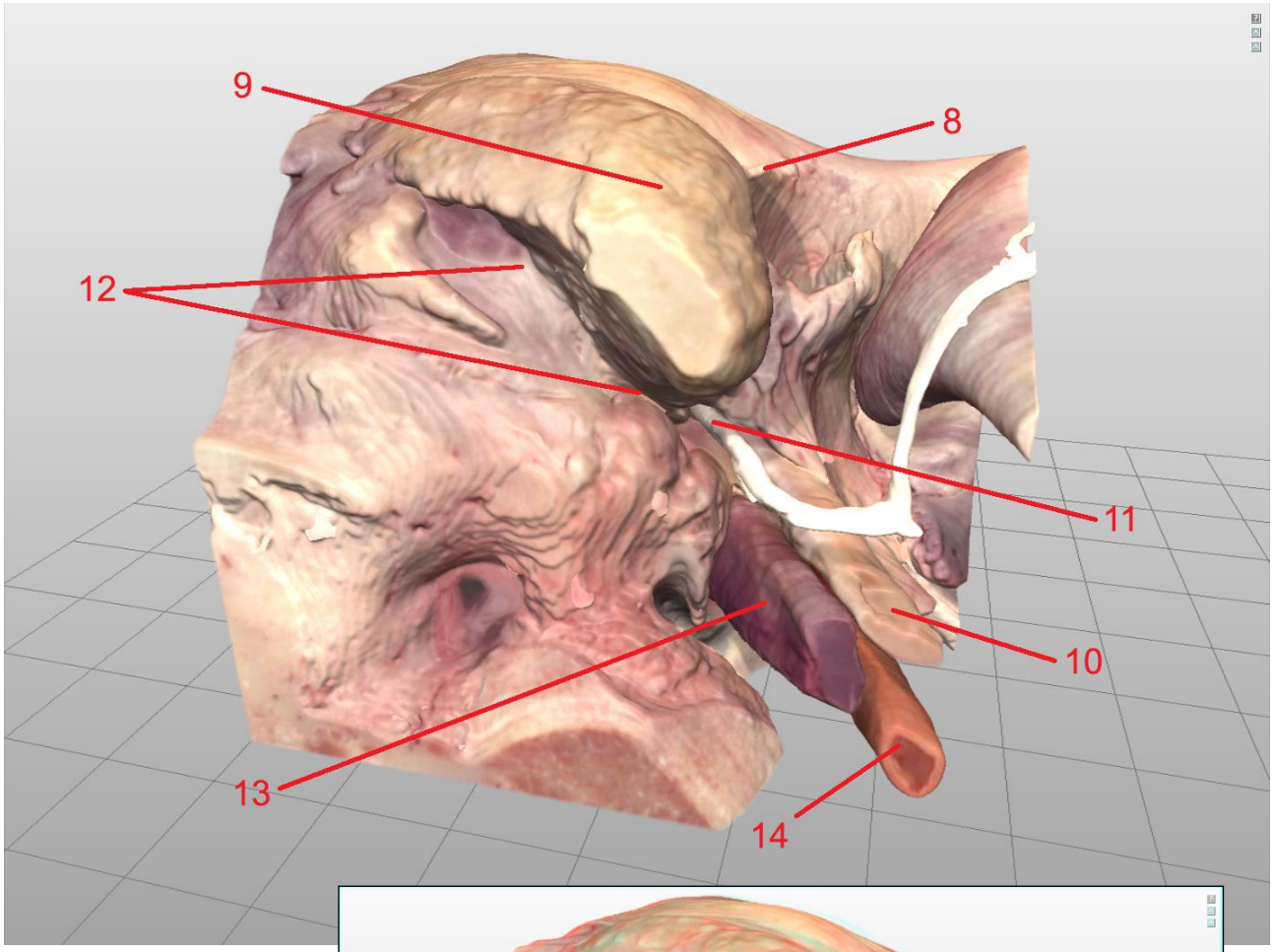


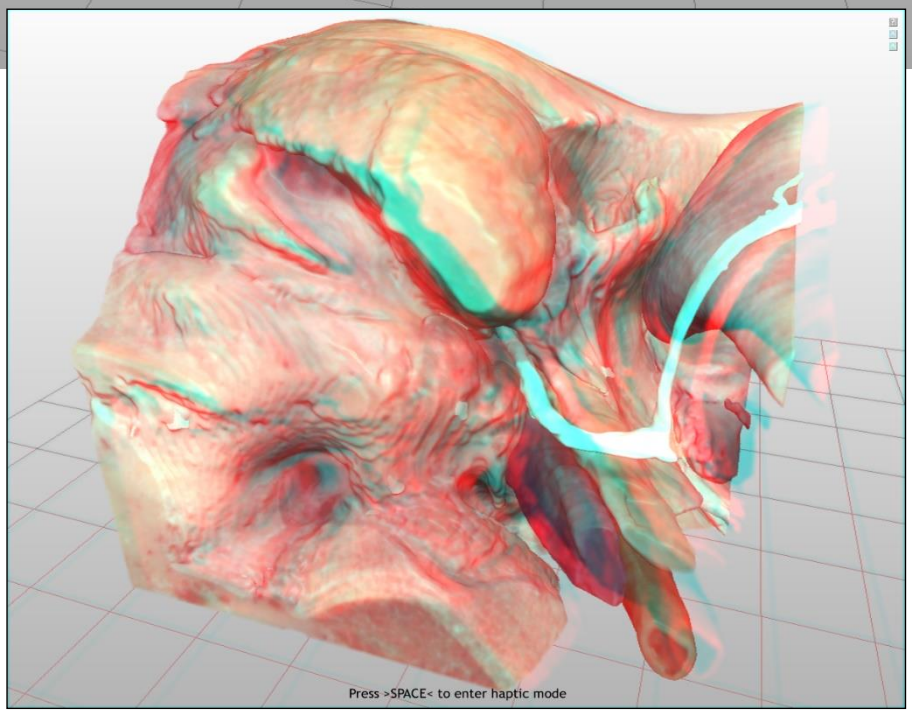

(VES 1.3 images)

Turn your bone upside down to identify the:

8. Henle´s spine
9. Mastoid process
10. Styloid process
11. Facial nerve exiting the stylomastoid foramen
12 Digastric groove (picture the corresponding digastric ridge inside mastoid)
13. Jugular vein
14. Carotid artery



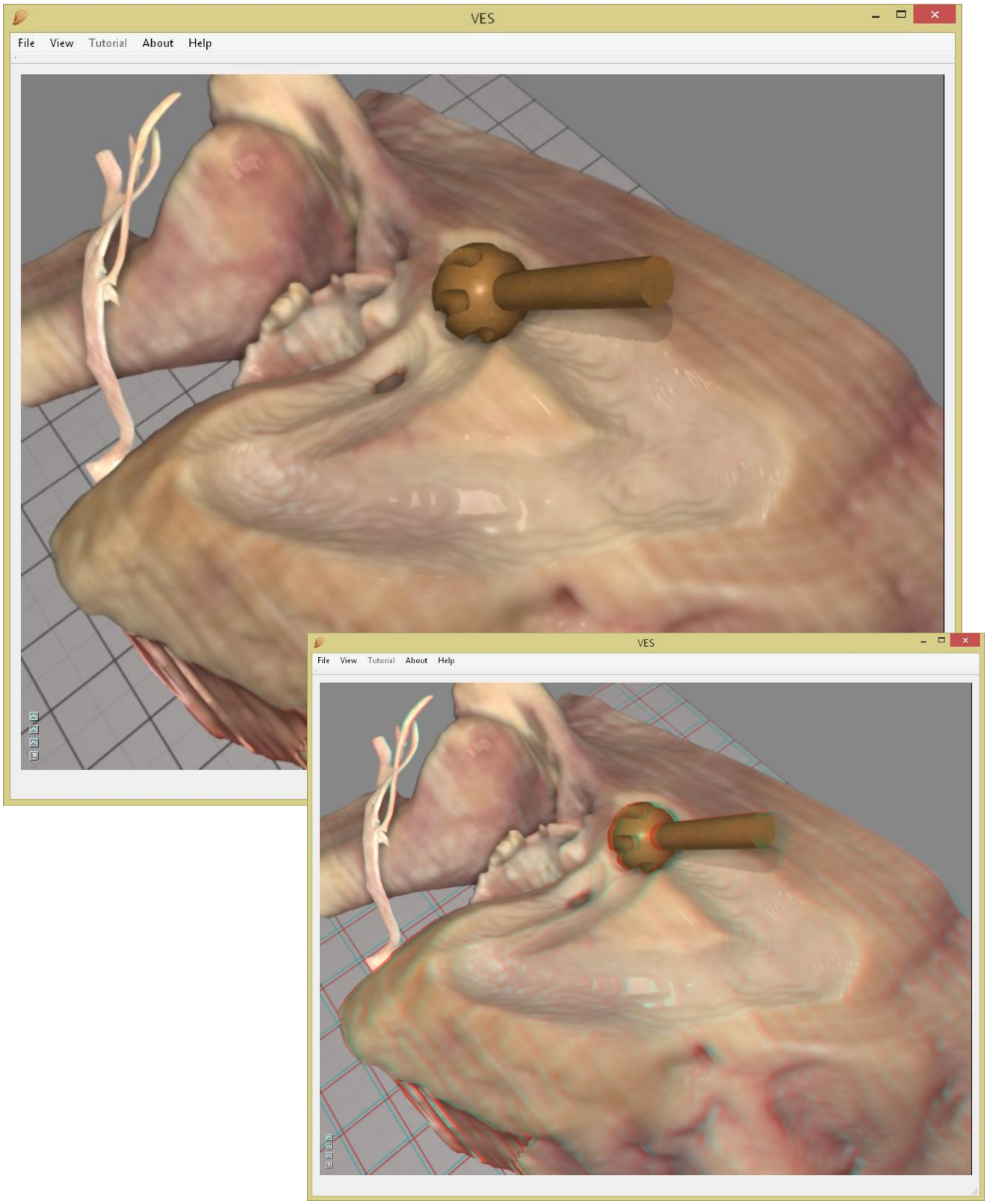

(VES 1.3 images)



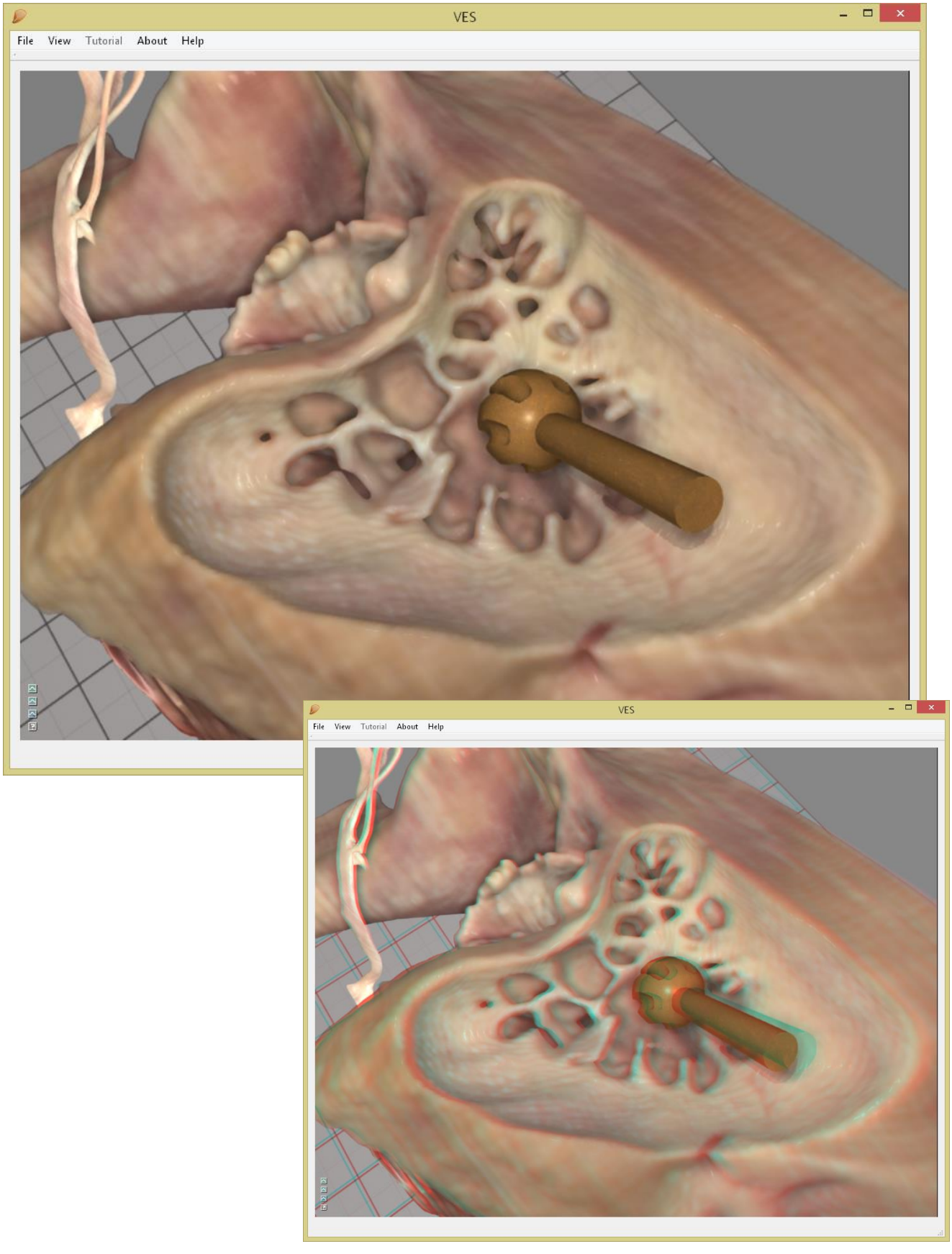
**Drill your bone from A-Z (an anatomical mastoidectomy procedure)**

Identify and cut out the future borders of the mastoidectomy: **(VES-A)**

The posterior wall of the external auditory canal.
The temporal line, extending posteriorly from the zygomatic root.
The projection of the sigmoid sinus on the mastoid surface.

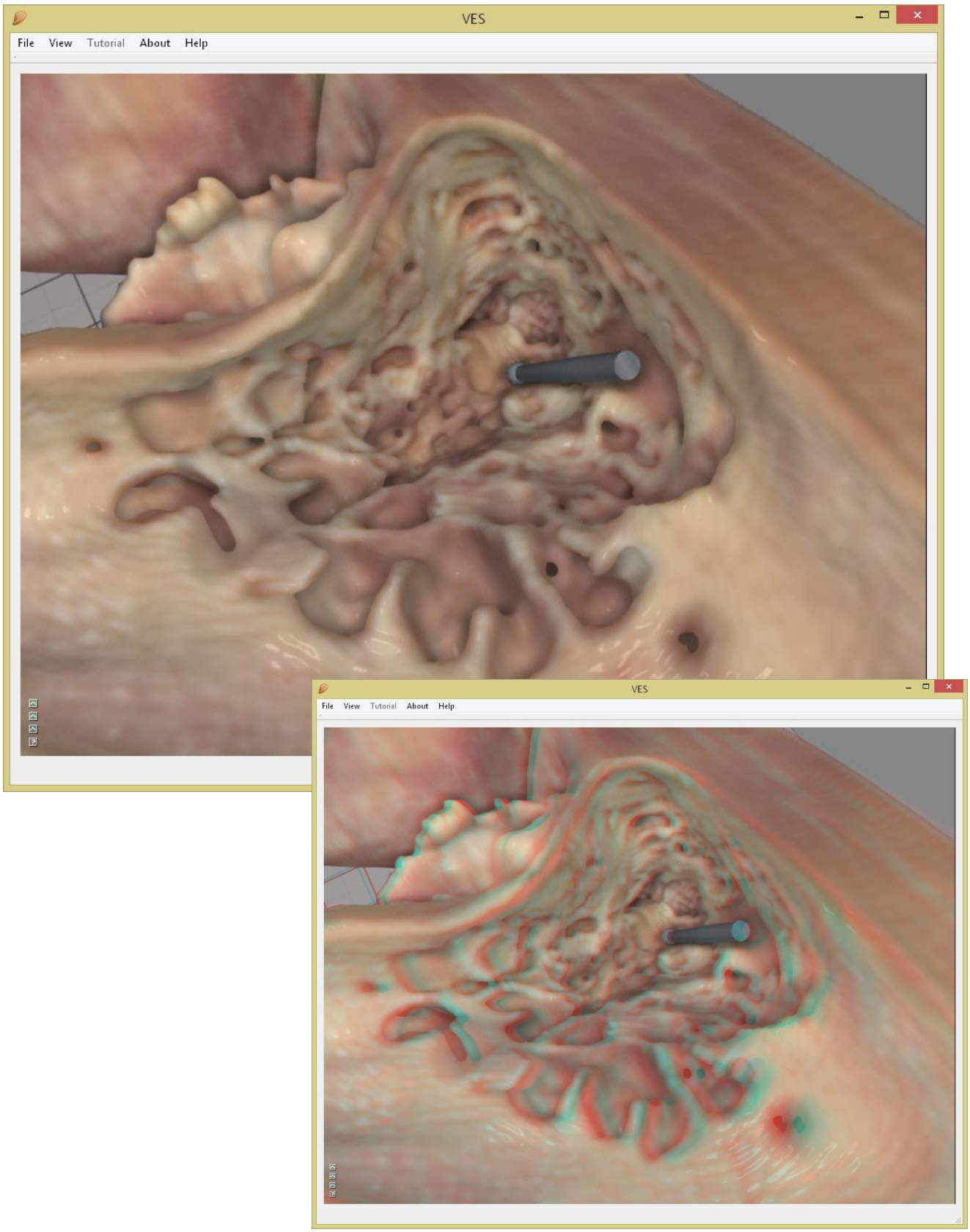


Remove the cortical bone systematically using a 6-7mm sharp drill to “saucerise” the developing cavity. Use safe strokes along the surface and keep moving so you never drill where you can´t see. **(VES-A-B)**



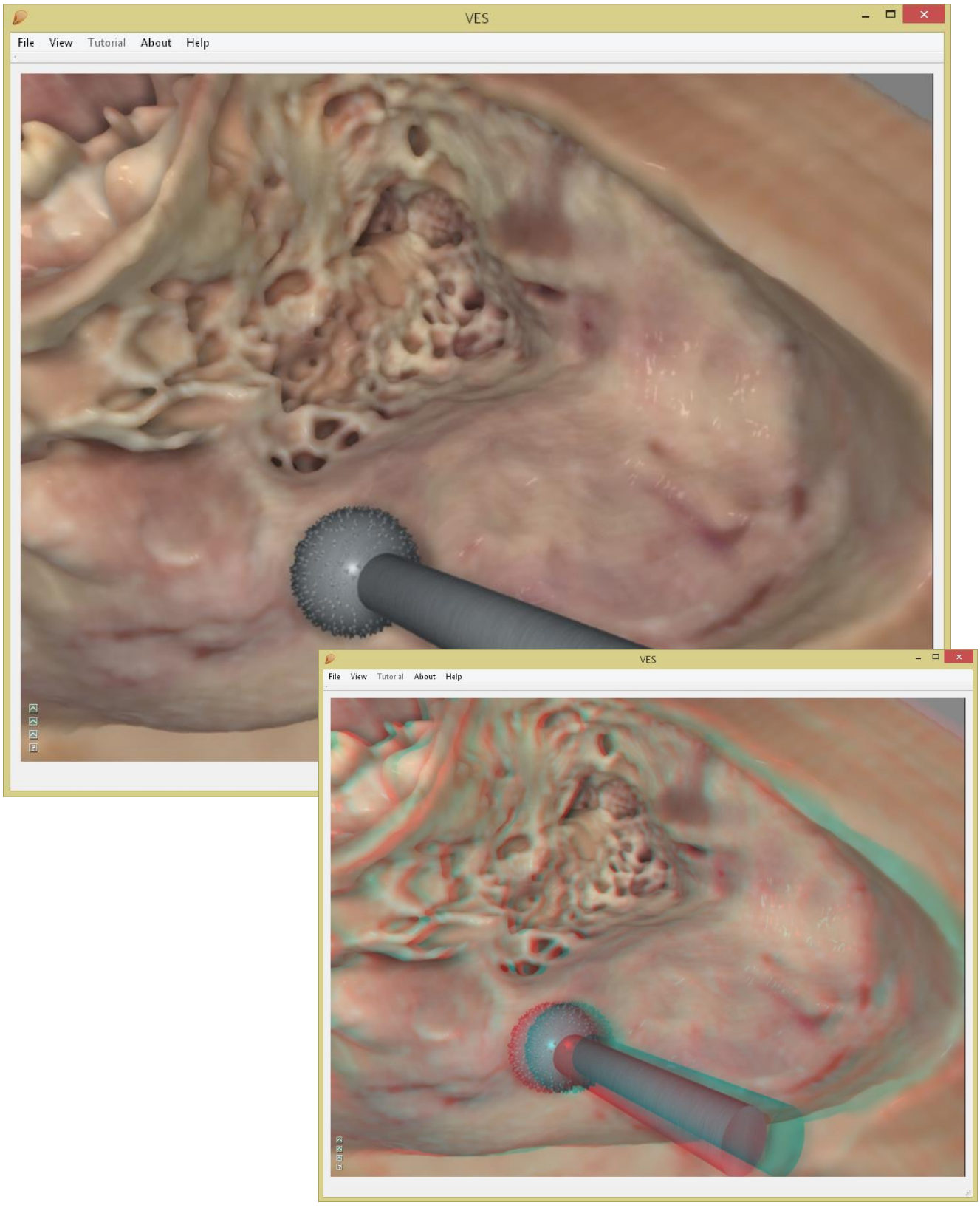
Follow the air cells at the zygomatic root down to the large antral air cells.
When you enter the antrum note the position and the depth of the lateral semicircular canal on the medial wall – but don't drill it! **(VES-B-D1)**

The drill is pointing at the lateral semi-circular canal in the mastoid antrum.

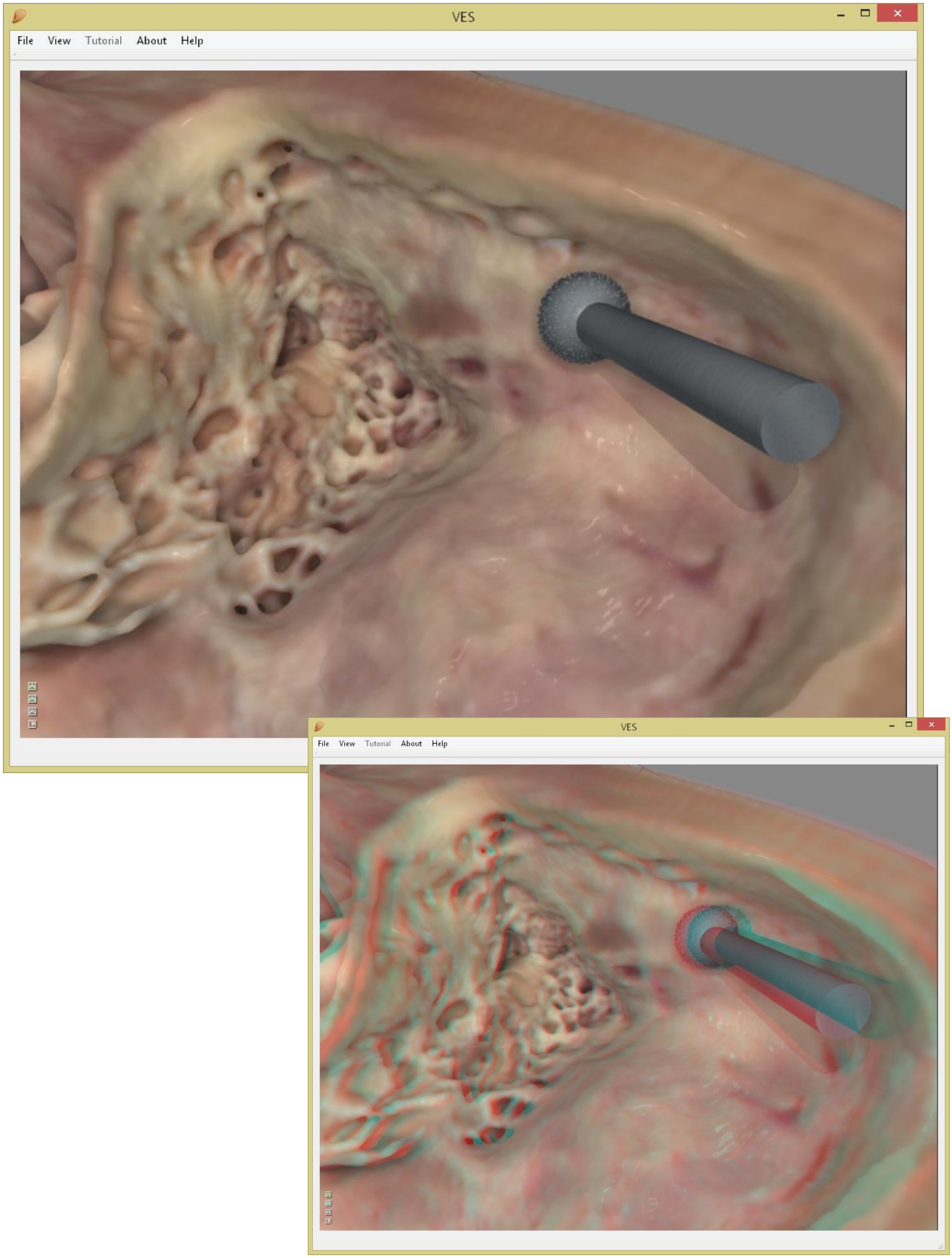


Clear out the air cells on the posterior part of the sigmoid sinus, on the dura of the mastoid attic and in the sino-dural angle. Look for the vascular texture of the dura visible through a thin layer of compact bone. Use a coarse diamond drill and never go beyond the bottom of the last air cell.**(VES-D-E)**

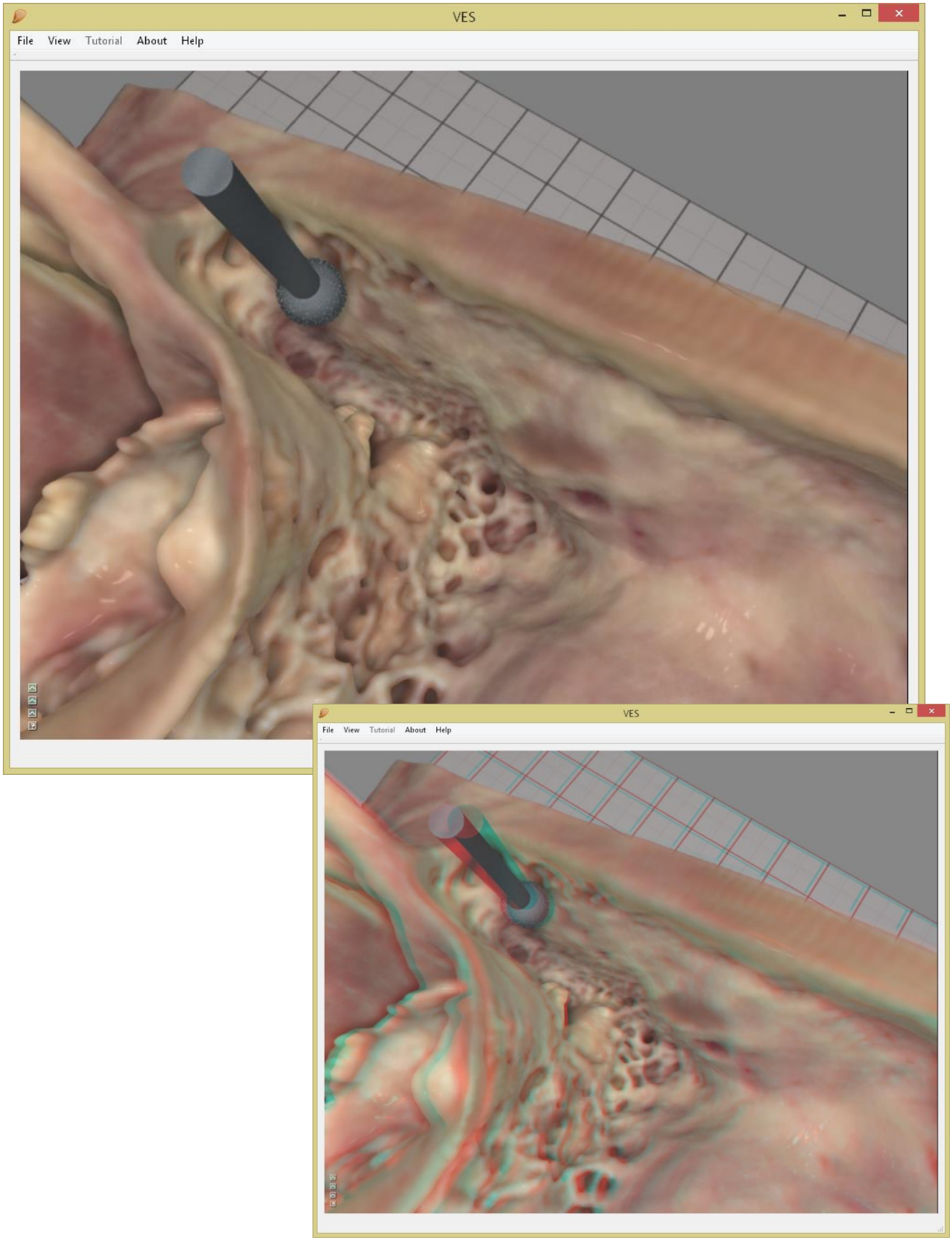
The drill is on the skeletonised sigmoid sinus. Further on up is the sino-dural angle, and then the dura on the medial fossa.



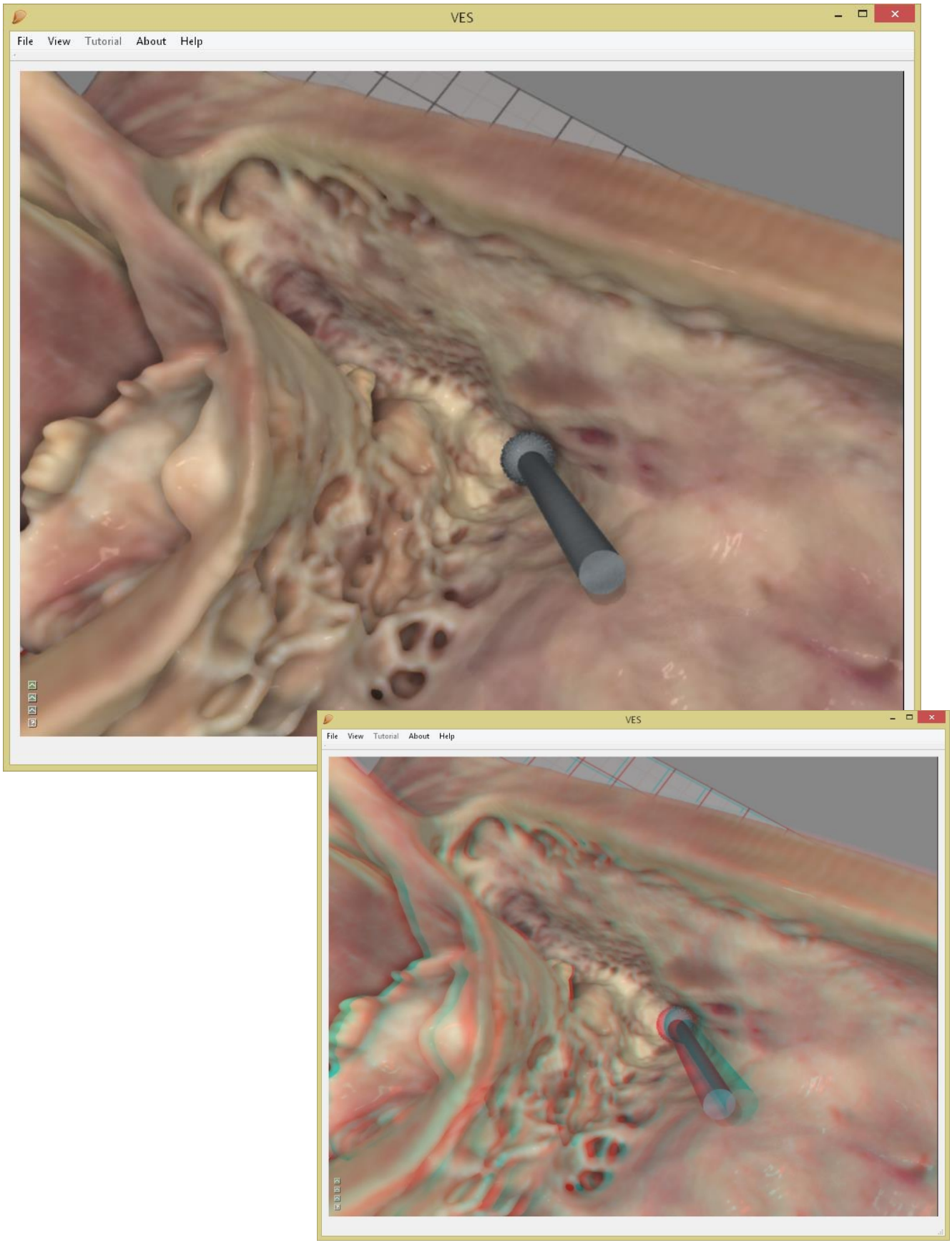
Remove the remaining air cells from the mastoid attic. Use a coarse diamond drill and never go beyond the bottom of the last air cell **(VES-E-F-G)**



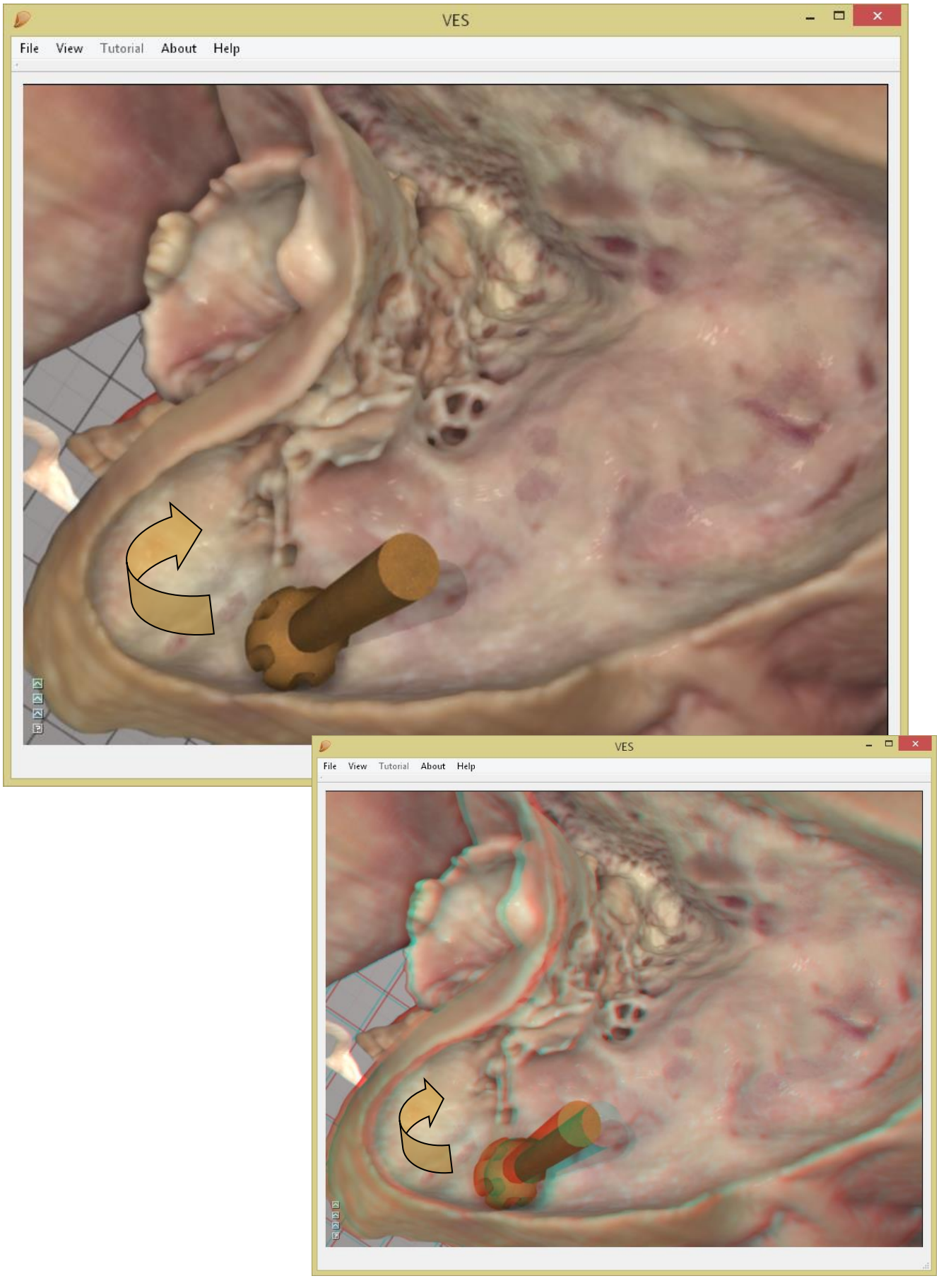
Proceed anteriorly to remove air cells from the tympanic attic. Be careful not to touch the incus and the head of the malleus, as they appear successively.



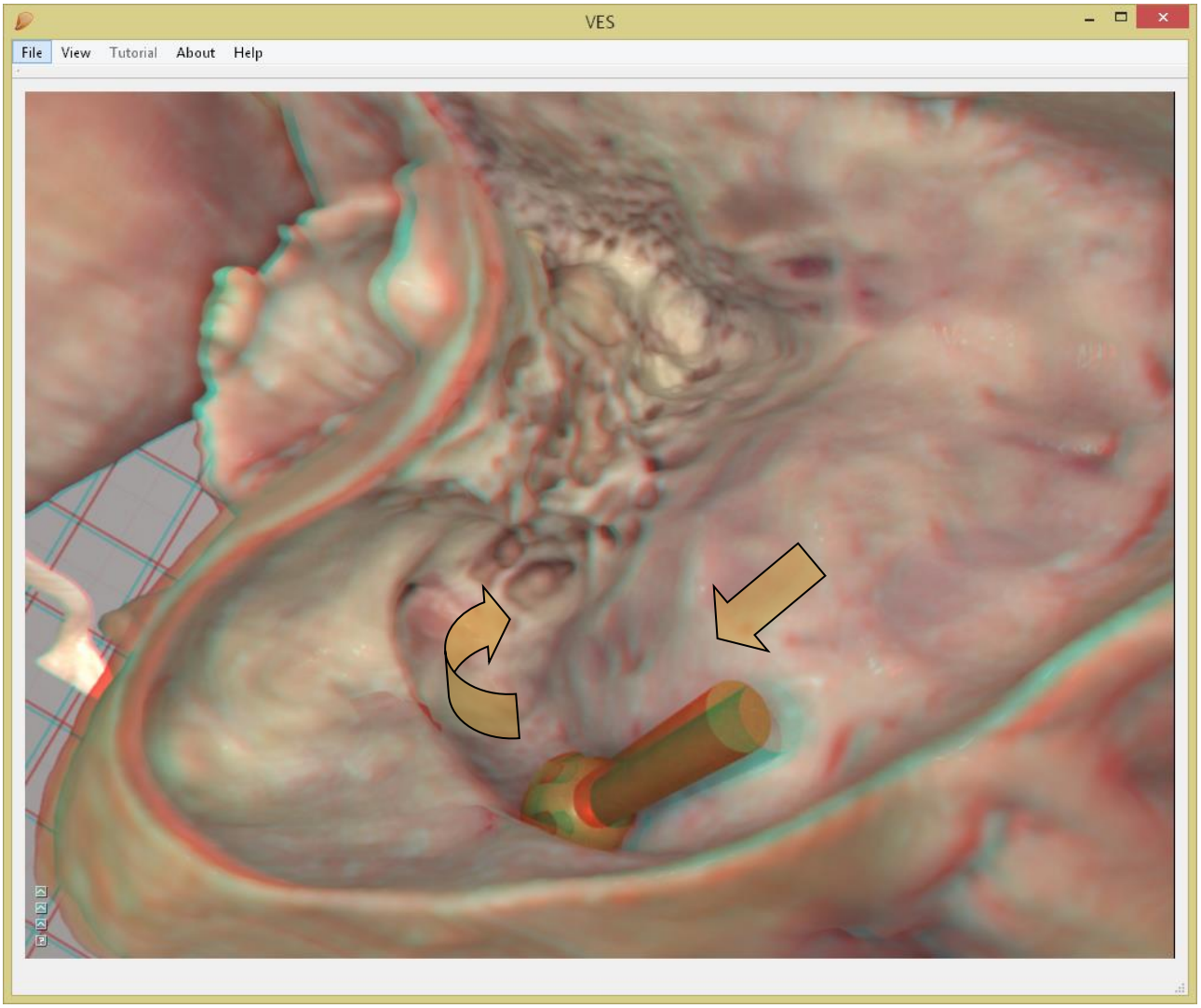
Skeletonise the dura along the entire superior face of your cavity. Use a fine diamond drill and leave a thin layer of bone on the dura. Look for the vascular texture of the dura. **(VES-G-H)**



Exenterate the mastoid tip. **(VES-H-I)**



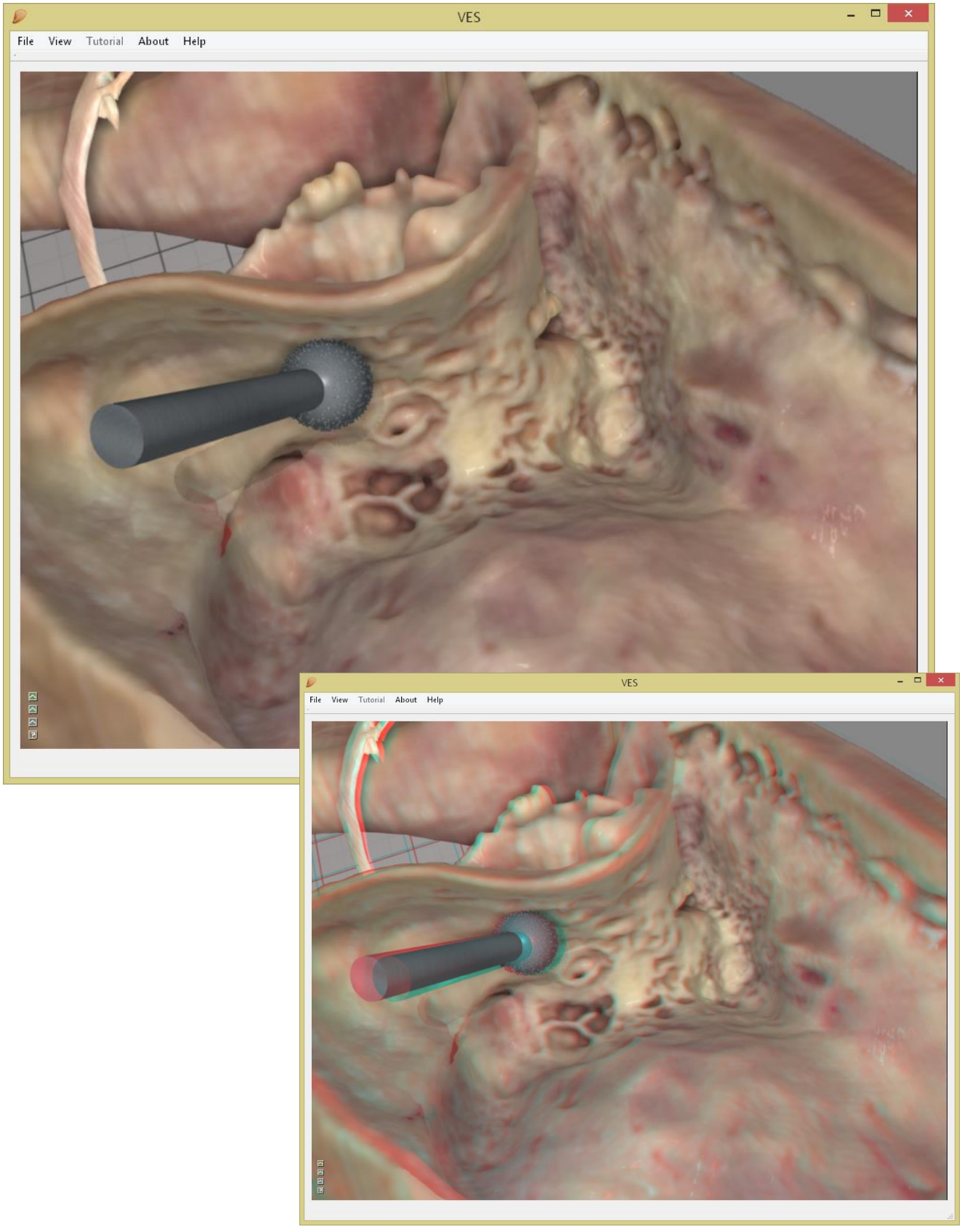
Next, skeletonize the sigmoid sinus as it courses anteriorly and inferiorly.




Identify the digastric ridge separating the two excavations (most likely you cannot avoid exposing part of the underlying digastric muscle. Note the direction of the stylo-mastoid foramen where the ridge terminates anteriorly

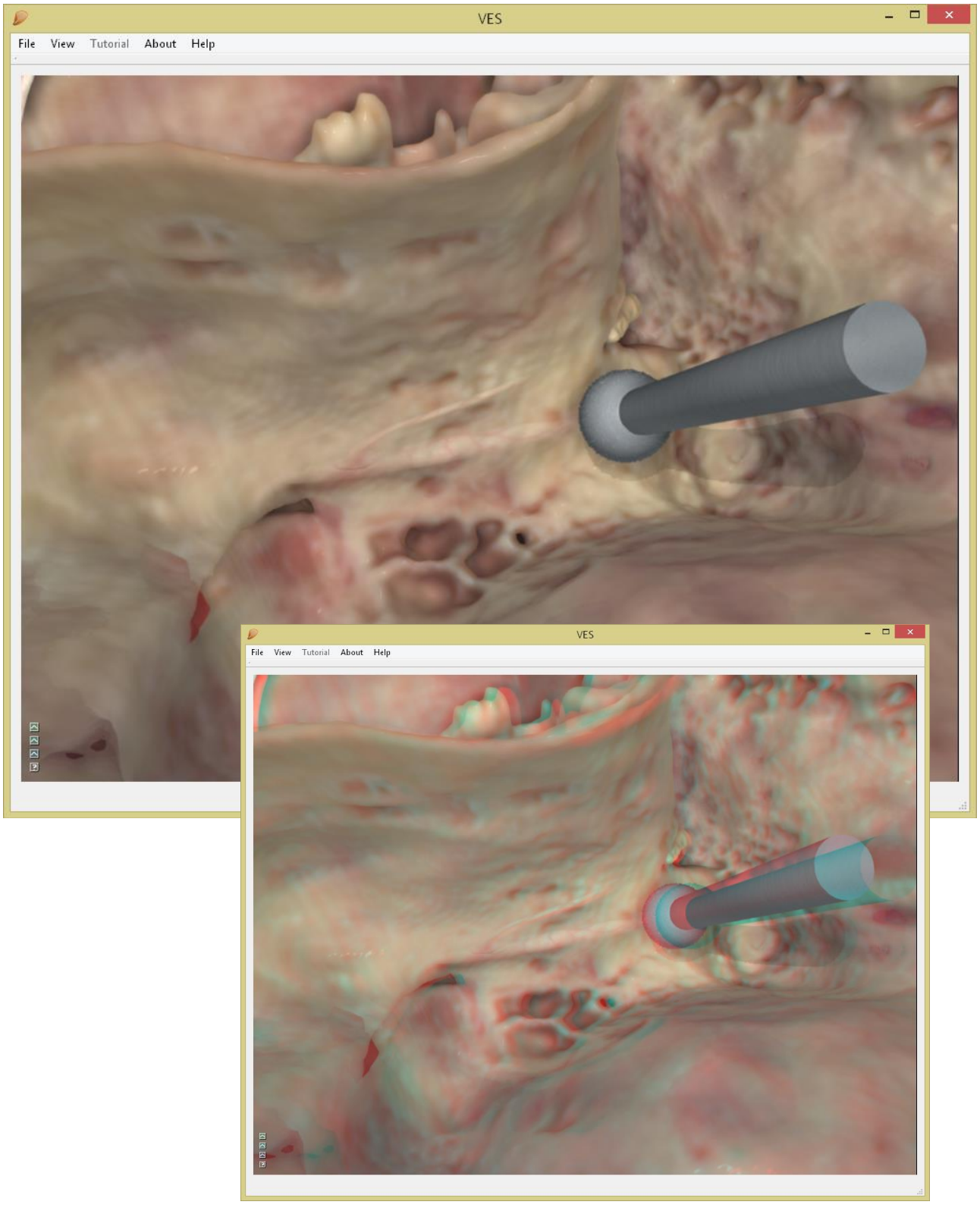
Clear the remaining large air cells from the posterior ear canal wall using a coarse diamond drill. **(VES-I-L)**

To anticipate the route of the facial nerve inside the posterior wall, use the incus (pointing to the cranial end of the vertical nerve portion), the lateral semicircular canal (indicating the depth) and the digastric ridge (pointing to the lower end of the vertical nerve portion) as landmarks.

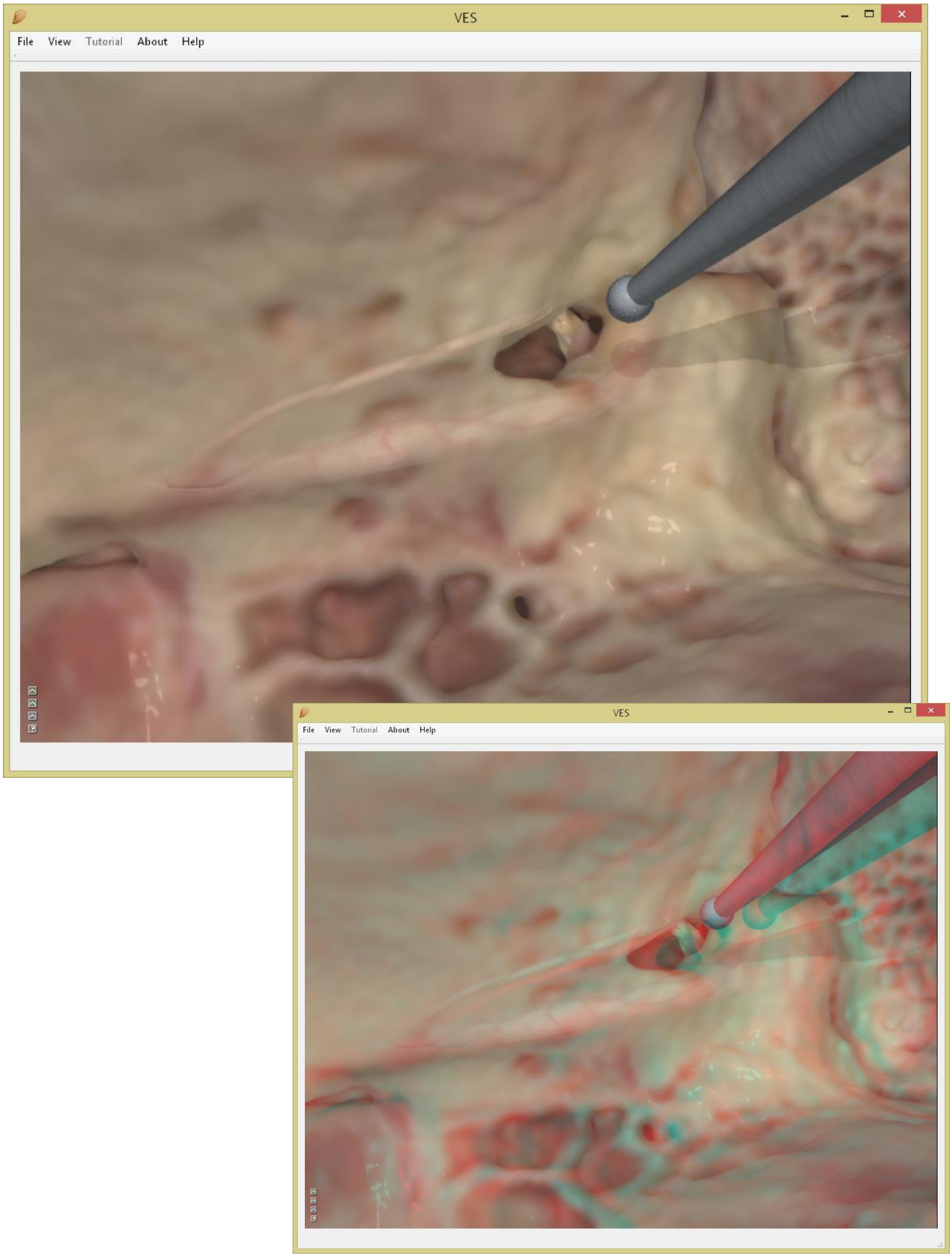


Use light strokes and a 3-mm fine diamond drill to thin the posterior wall until the facial nerve and the tympanic chorda are just visible through a thin layer of bone. Look for the vascular texture of the nerves. Don't perforate the wall or expose the nerve sheath. **(VES-L-N)**

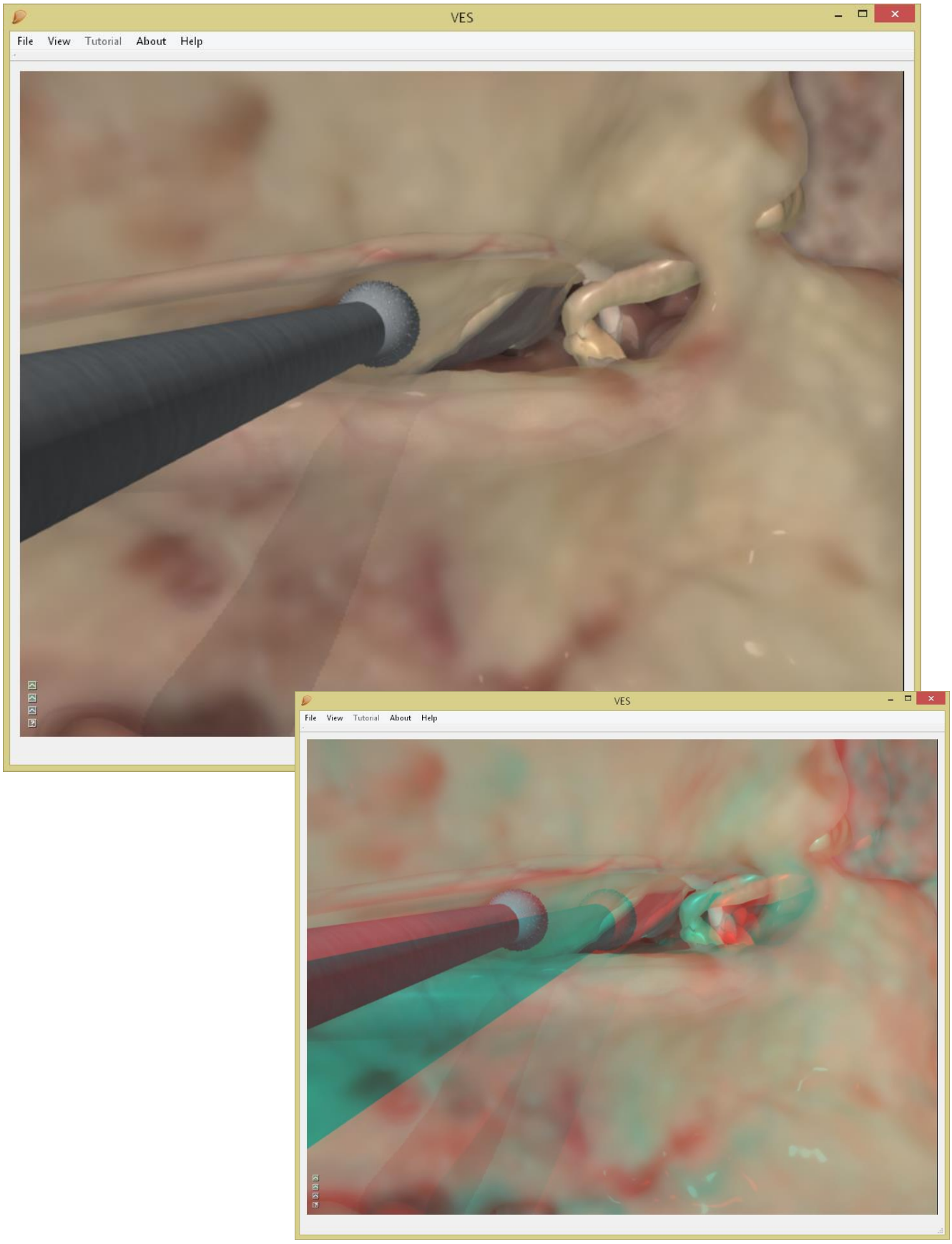
The first time you do this, you might want to use the "Bone Transparency" slider to increase transparency and get a preview of the nerves, but if you take your time the default "natural" transparency is all you need.



Use a 2-mm fine diamond drill bit to excavate the triangular bony plate framed by the (superior) incudal fossa, the (medial) facial nerve and the (lateral) tympanic chorda. Penetrate to enter the facial recess at the wider cranial end of the excavation, but leave a bony bridge (the Buttress) at the incudal fossa. **(VES-N-O)**

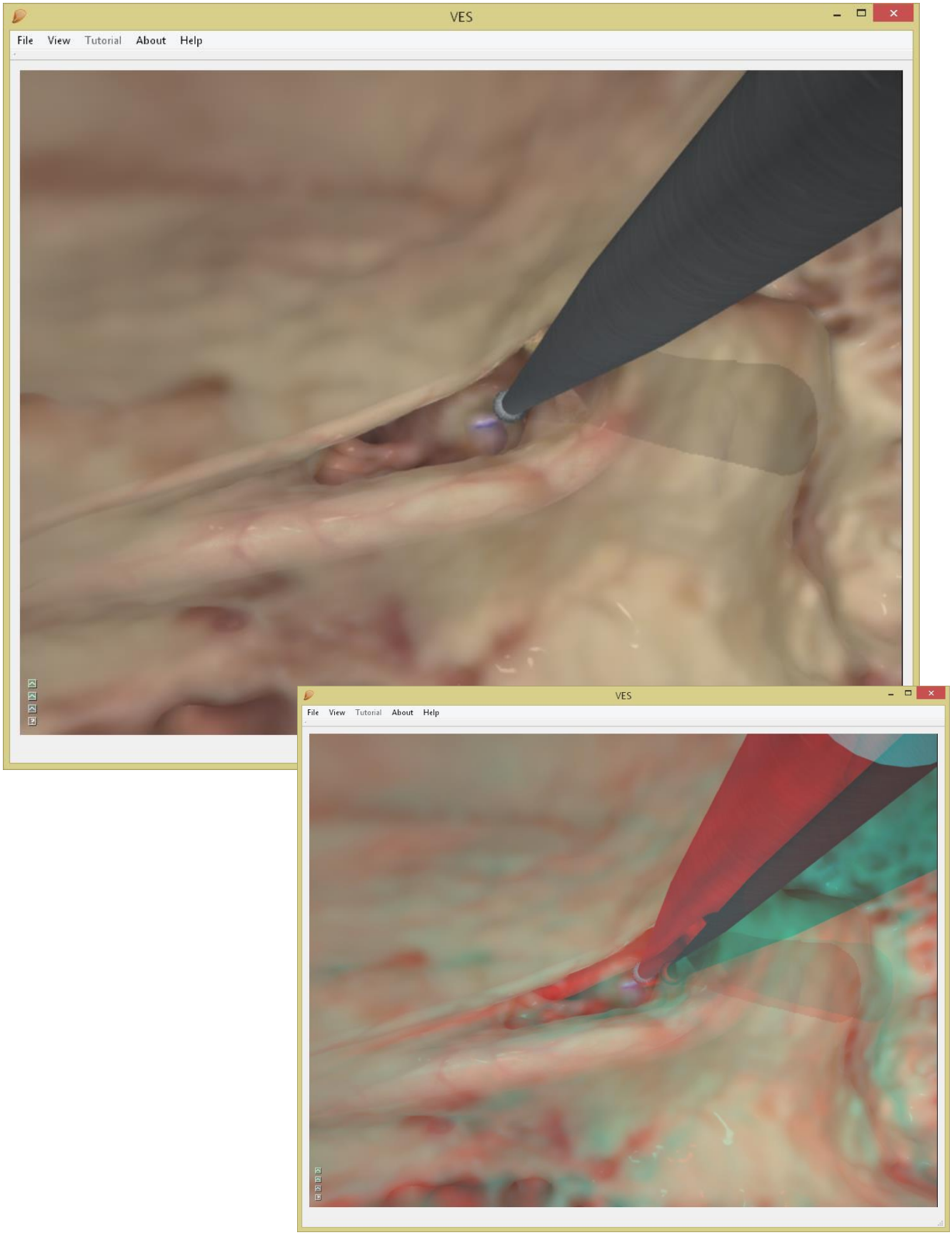


Use a 2-mm and 1-mm drill bit to widen the posterior tympanotomy as much as possible without exposing the nerves or touching the stapes, incus or the annular ligament of the tympanic membrane. Remove bone from the anterior face of the vertical portion of the facial nerve to view the round window niche.

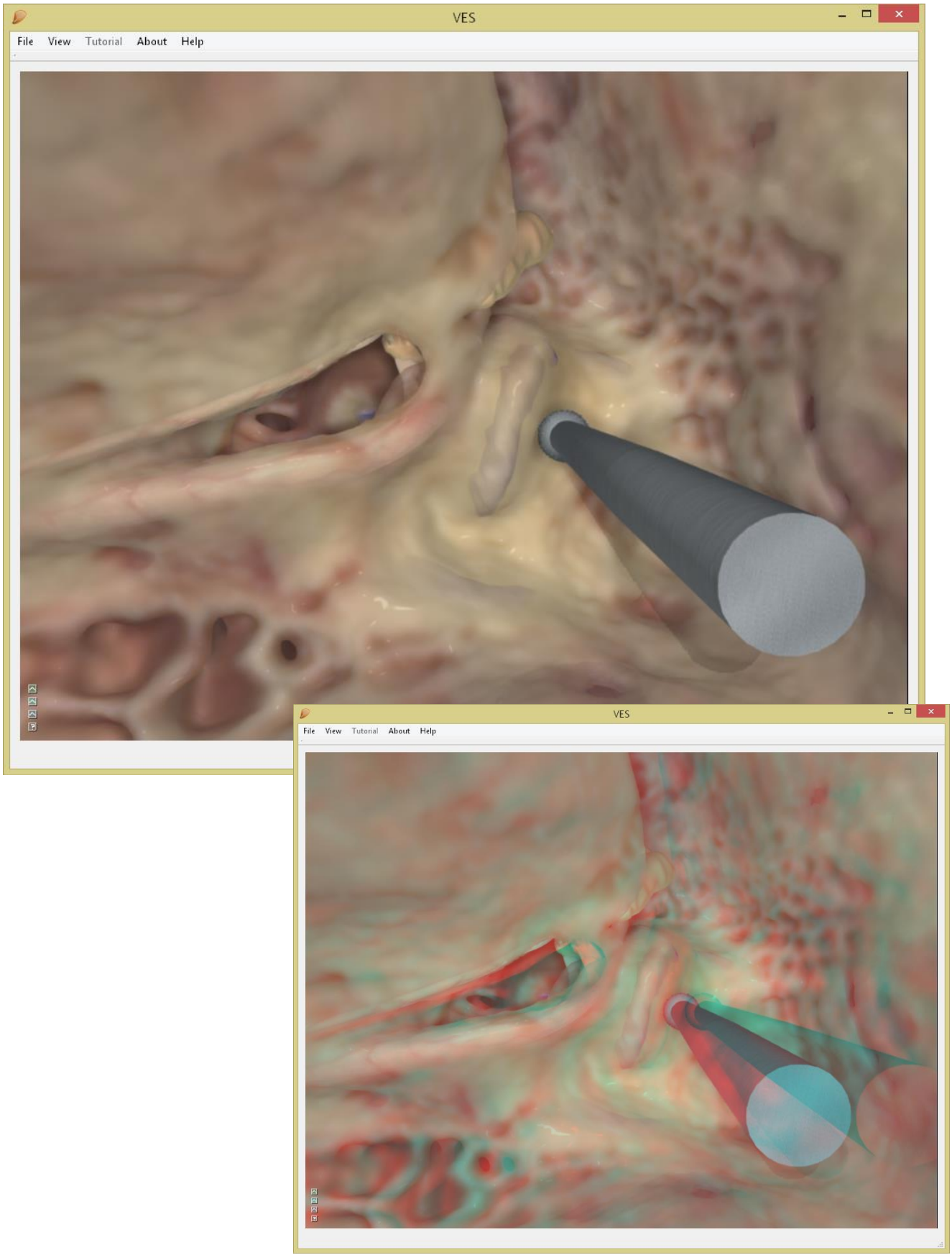


Use 1-2-mm fine diamond drills to expose (one mm of-) the round window membrane by drilling away the rim of promontory bone overhanging the round window niche antero-superiorly. Don’t touch the membrane itself! **(VES-Q-R)**

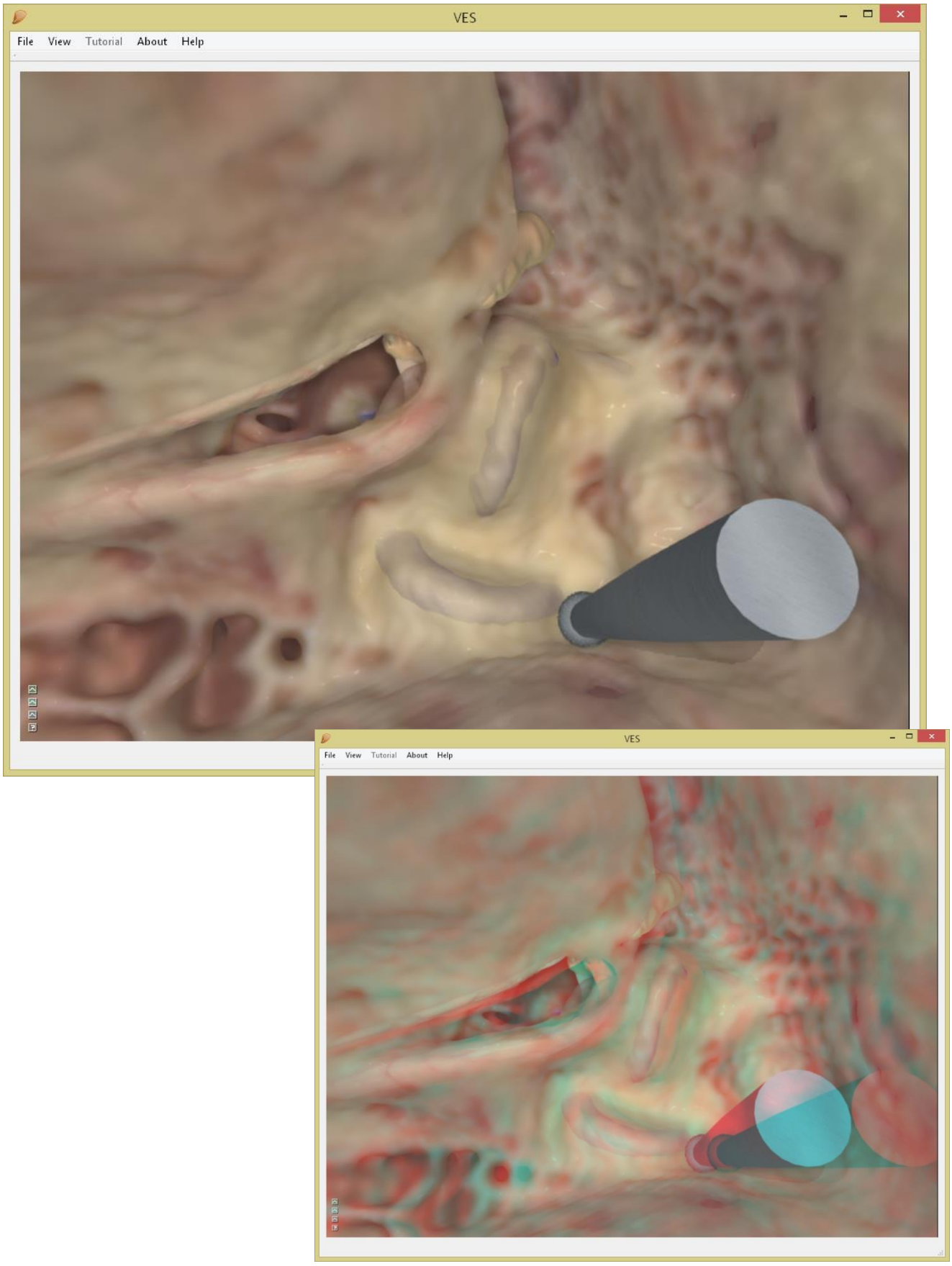
You may want to change “Bone Transparency” to view the exact relation of the promontory and overhang and the inner ear spaces.



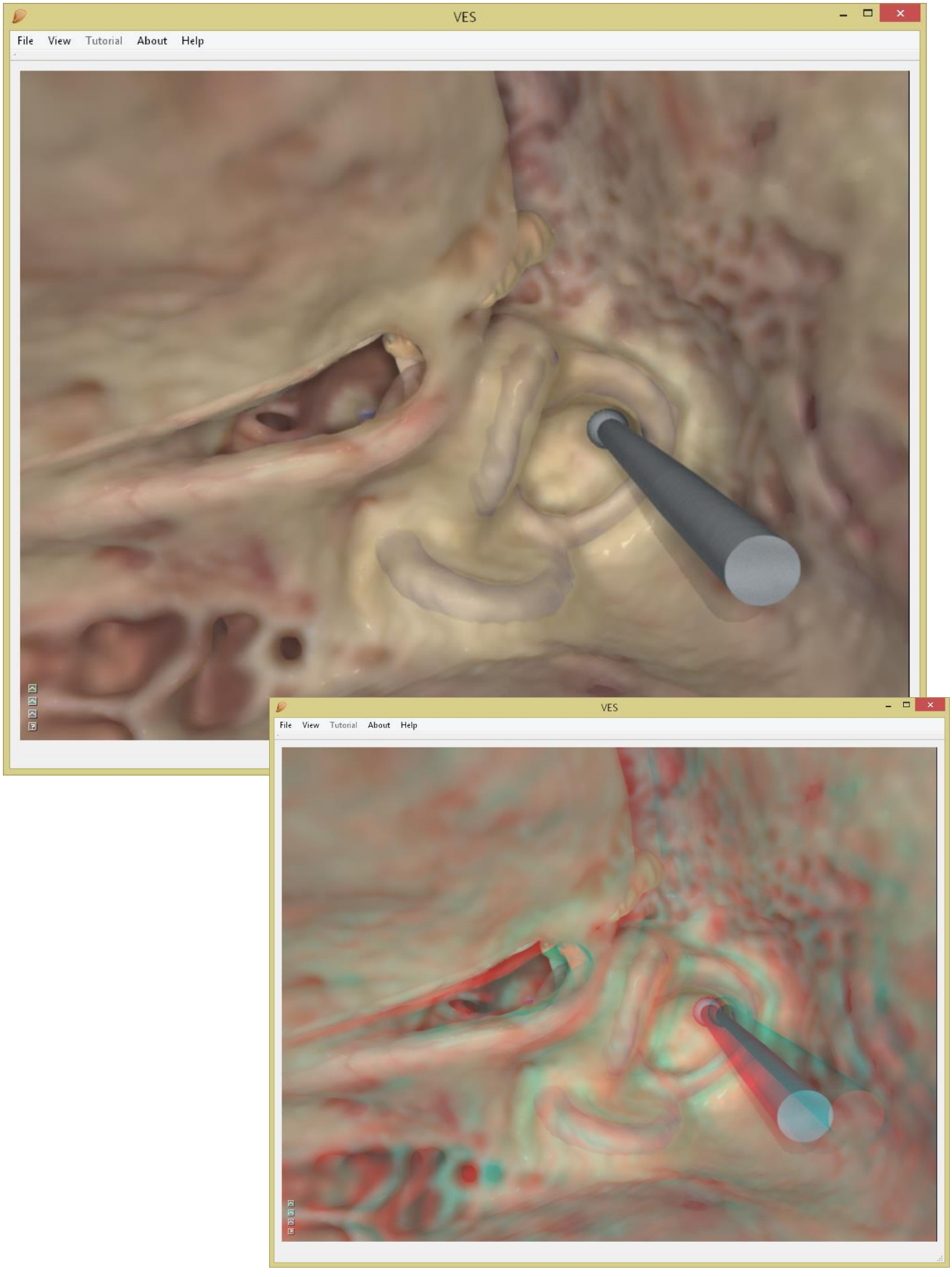
Use 1-3-mm fine diamond drill bits to blue-line the lateral (horizontal) semicircular canal. Leave a thin layer of bone on the membranous labyrinth. **(VES-P1)**



Use 1-3-mm fine diamond drill bits to blue-line the posterior (inferior) semicircular canal, perpendicular to and behind the lateral SCC. Leave a thin layer of bone on the membranous labyrinth. **(VES-P2)**

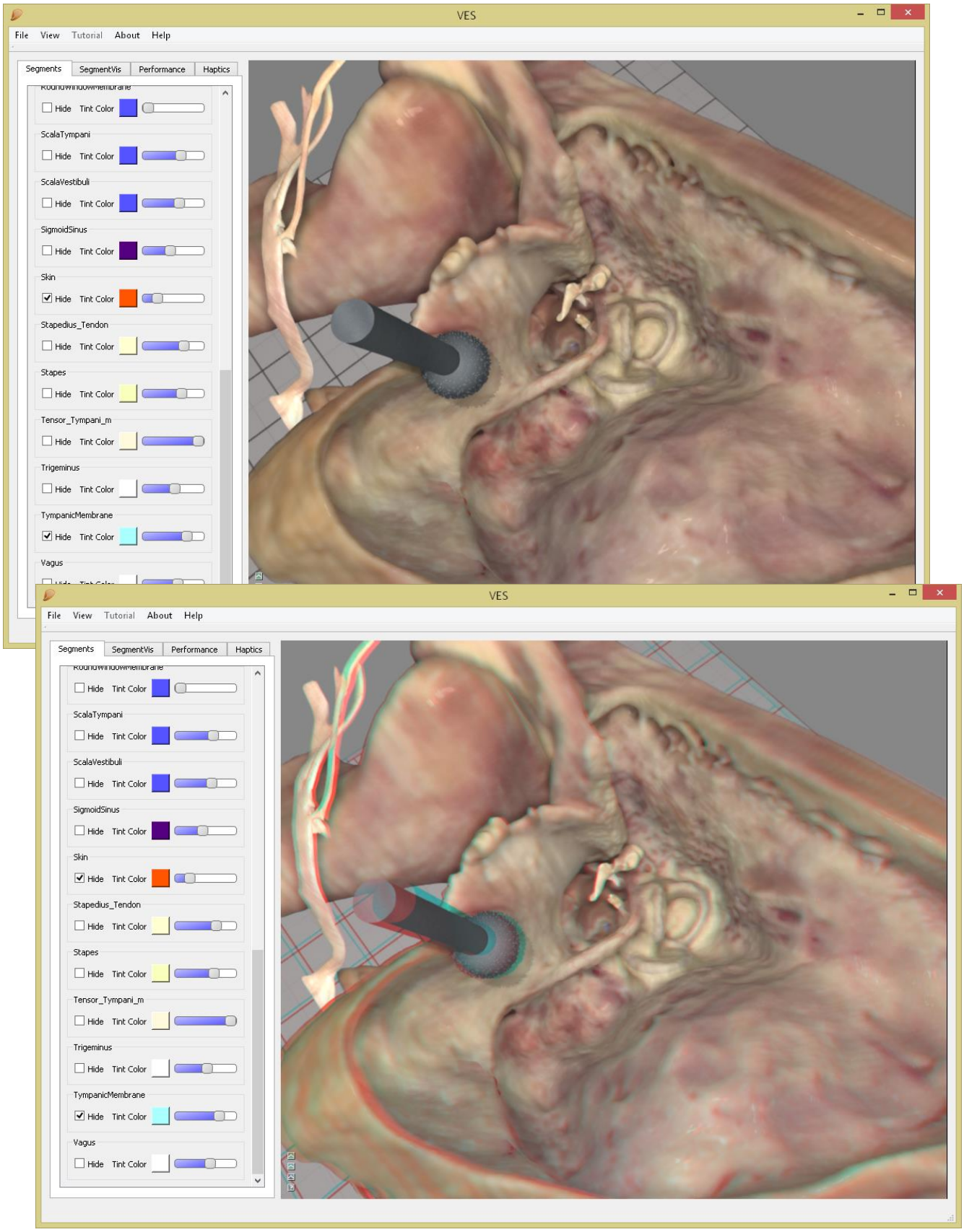


Use 1-3-mm fine diamond drill bits to blue-line the superior (anterior) semicircular canal. This canal is located deeper than the other SCCs. Leave a thin layer of bone on the membranous labyrinth. **(VES-P3)**



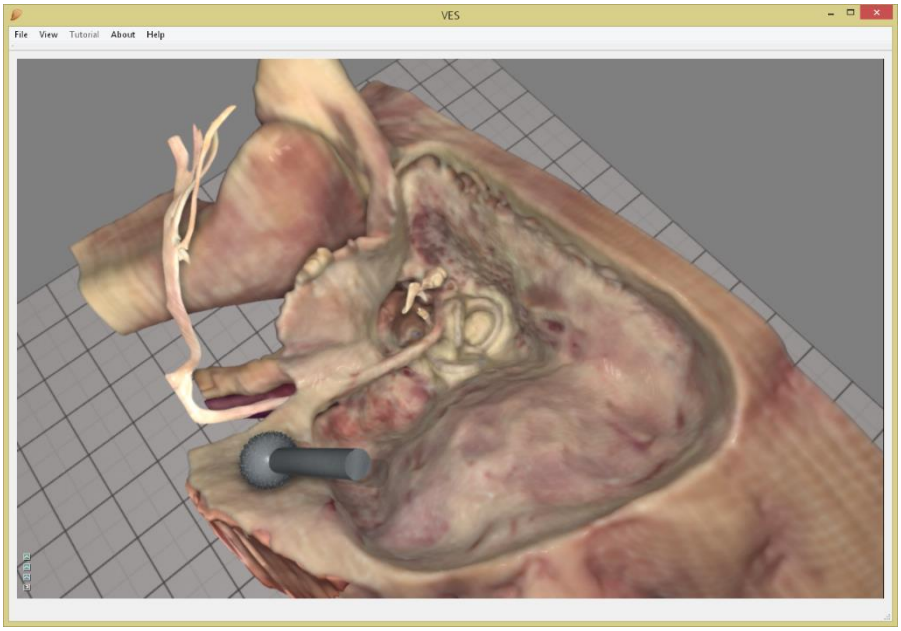
Use 1-4-mm coarse diamond drills to excavate the retro-facial air cells and bone. Take care to avoid drilling into the posterior SCC, the round window or the jugular bulb, where the sigmoid sinus swings around into the descending jugular vein. This procedure provides access to the tympanic sinus and the posterior hypotympanon.

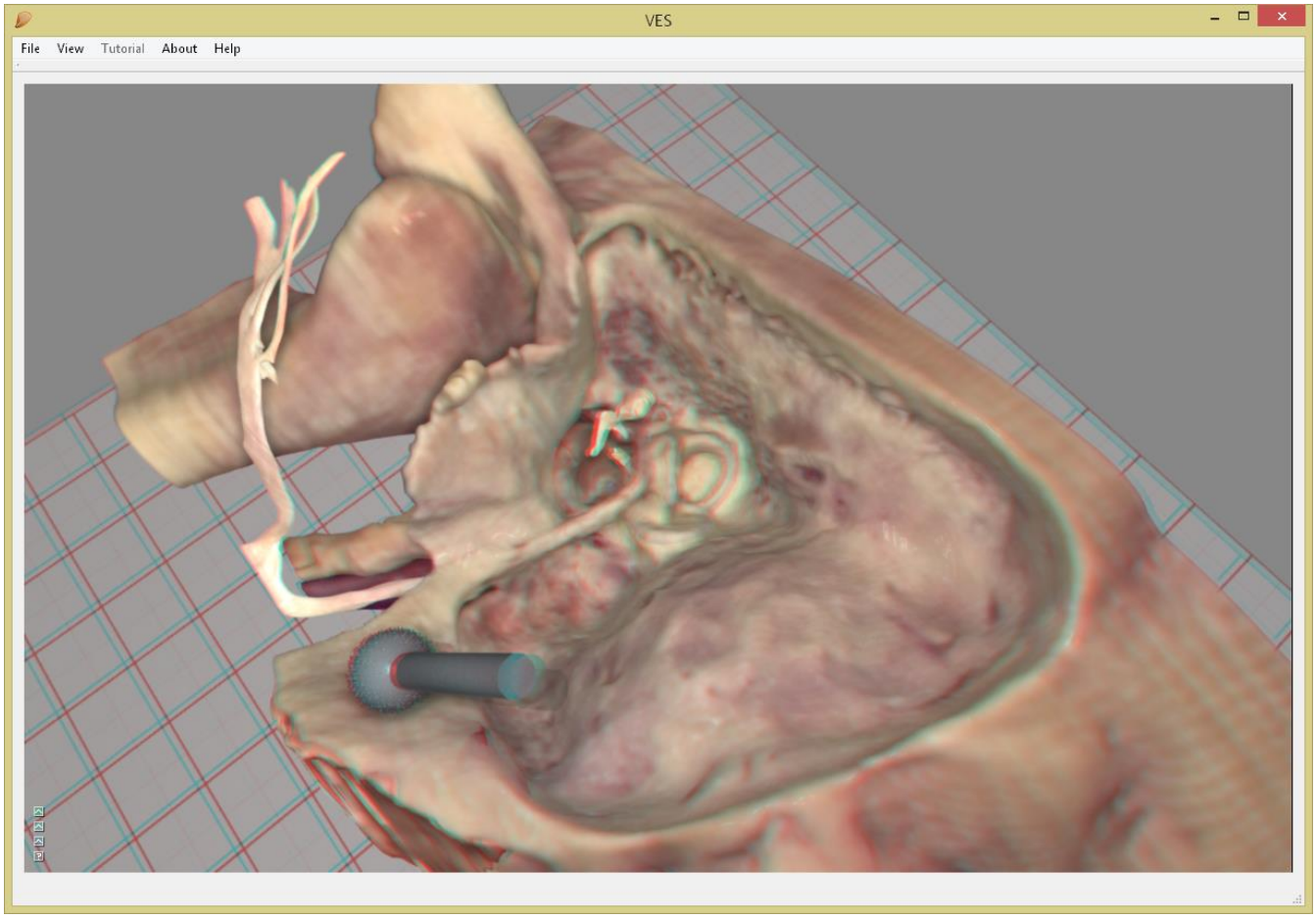
For a “Wall Down” mastoidectomy remove the posterior canal wall using sharp drills and leave a facial ridge. Lower the ridge using diamond drill bits until only a thin shell of bone remains on the vertical portion of the facial nerve. **(VES-R-S)**




You can hide the chorda, the tympanic membrane and the incus by right-double-clicking them.

For a “Subtotal Petrosectomy” remove all bone lateral to the facial ridge and the digastric ridge.

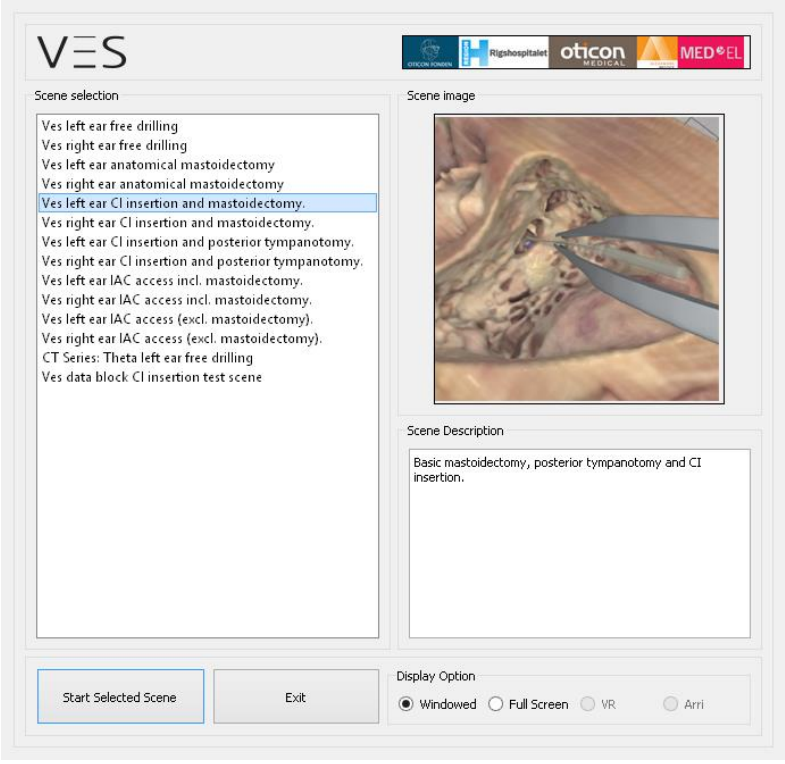


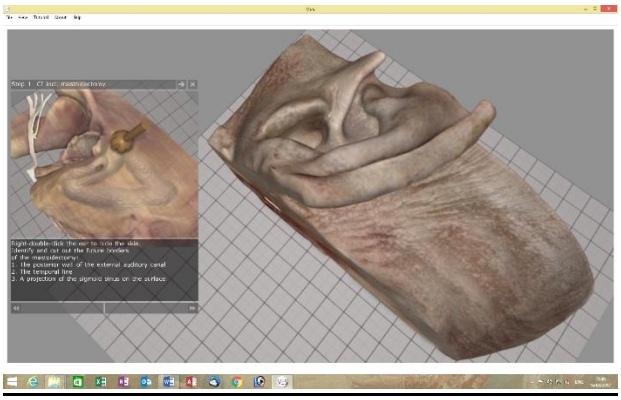

If your bone looks somewhat like this at the end of the session the VES team would like to compliment you on your fine drilling skills.

CI tutorial.

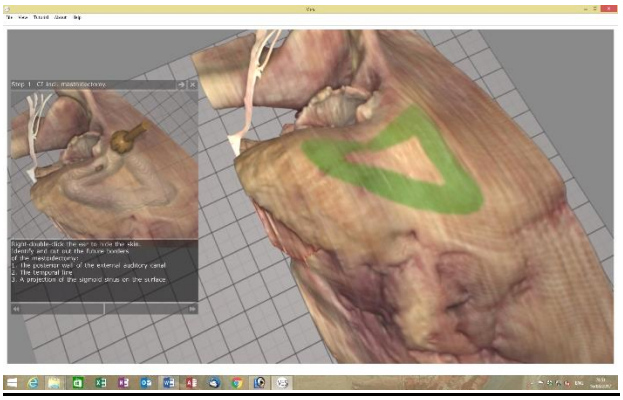
Select the “Ves left ear CI insertion and mastoidectomy”.




The “CI incl. mastoidectomy” opens.

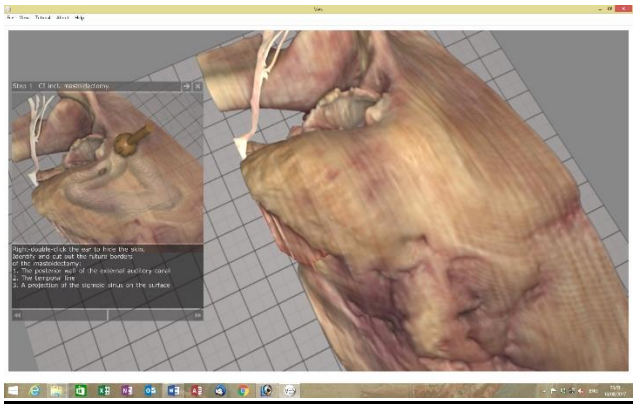


Right-double click the ear to hide the skin. Press “←” to move the tutor window left.

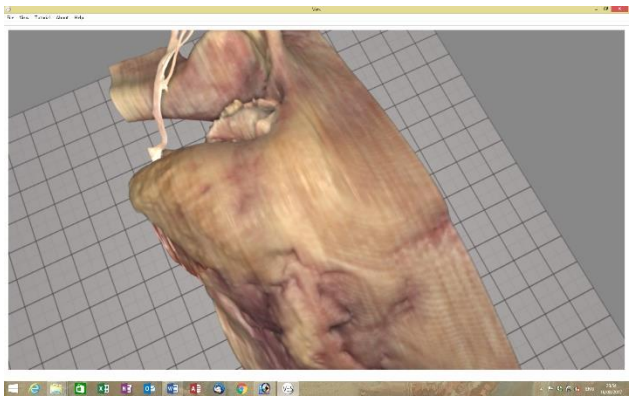


CI tutorial.

Drill away the green bone, press >> in the lower right corner of the tutor window and go on to green-light the next step.
If the green-lighting is not needed toggle it off with keyboard “G”.



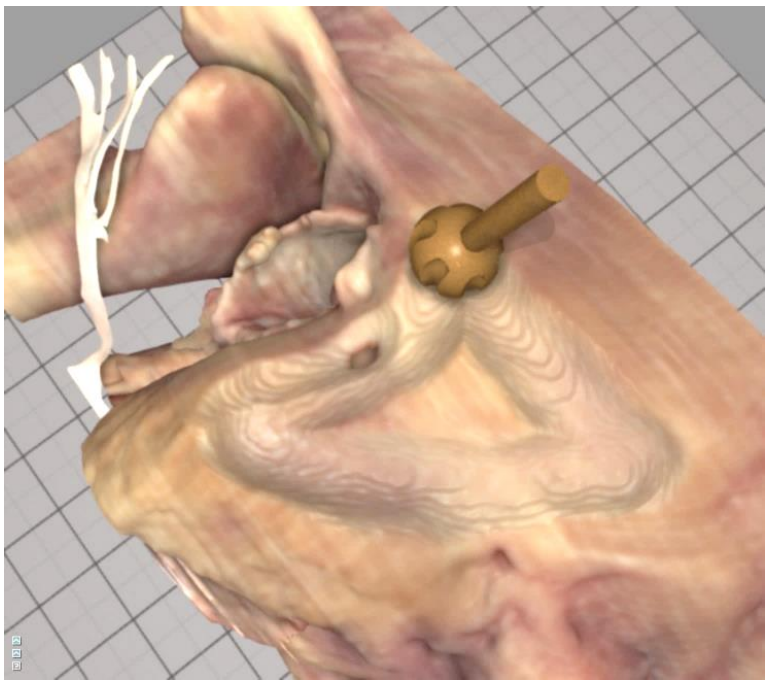
Follow the written instructions in the tutor window.
If the tutor text and sample images are not needed toggle them off with keyboard “T”.



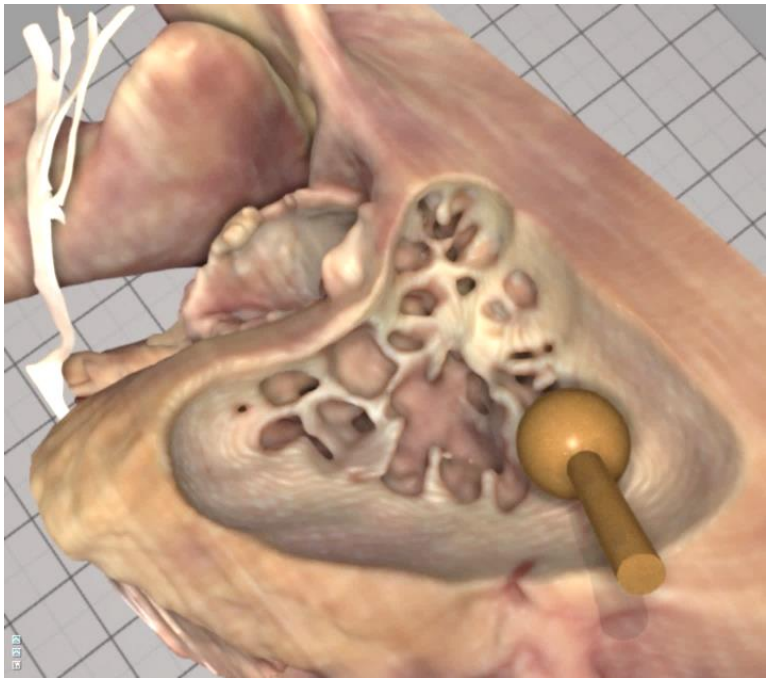
*(If no mastoidectomy is needed select “Ves left ear CI insertion and posterior tympanotomy” instead and follow the instructions.)*

CI tutorial.

Identify and cut out the borders of the future mastoidectomy.
1.The posterior wall of the external auditory canal
2.The temporal line (posterior projection of the zygomatic process)
3.A projection of the sigmoid sinus at the surface

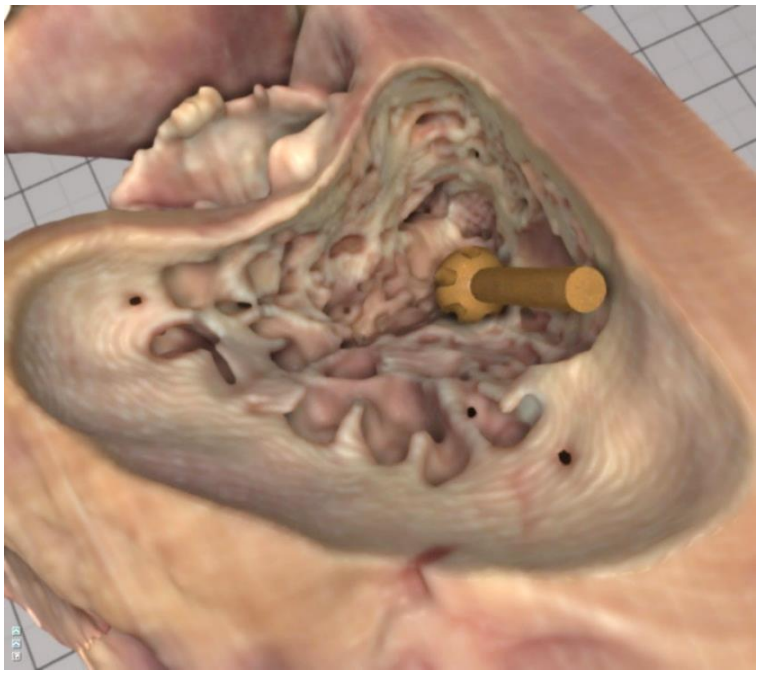


Remove the cortical bone systematically using a 6-7mm sharp drill to “saucerise” the developing cavity. Use safe strokes along the surface, keep moving and never drill where you can’t see.

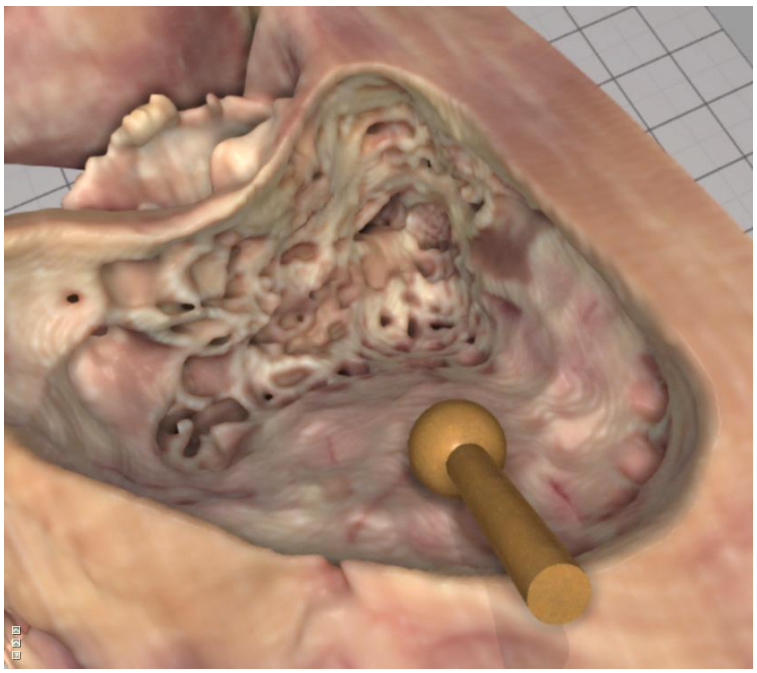


CI tutorial.

Follow the air cells at the zygomatic root down to the large antral air cells. Note the position and the depth of the lateral semicircular canal on the medial wall of the antrum – but don't drill on it.
The lateral SCC is easily seen when you use the mouse to rock the bone slightly back and forth. The drill bit is pointing at the lateral SCC.

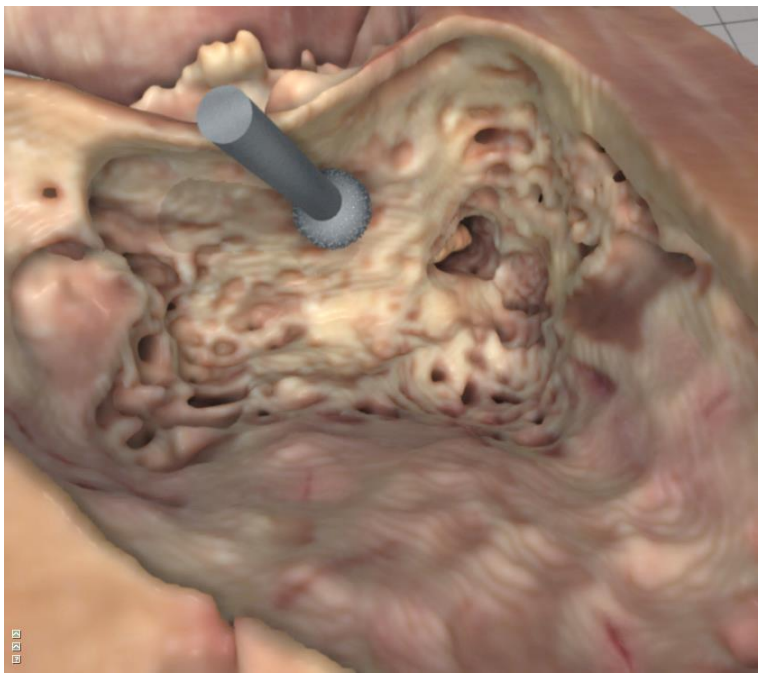


Clear out the air cells in the sino-dural angle and on the posterior part of the sigmoid sinus. The drill bit is on the skeletonised sigmoid sinus and further up is the sino-dural angle. Never drill beyond the bottom of the last air cell.

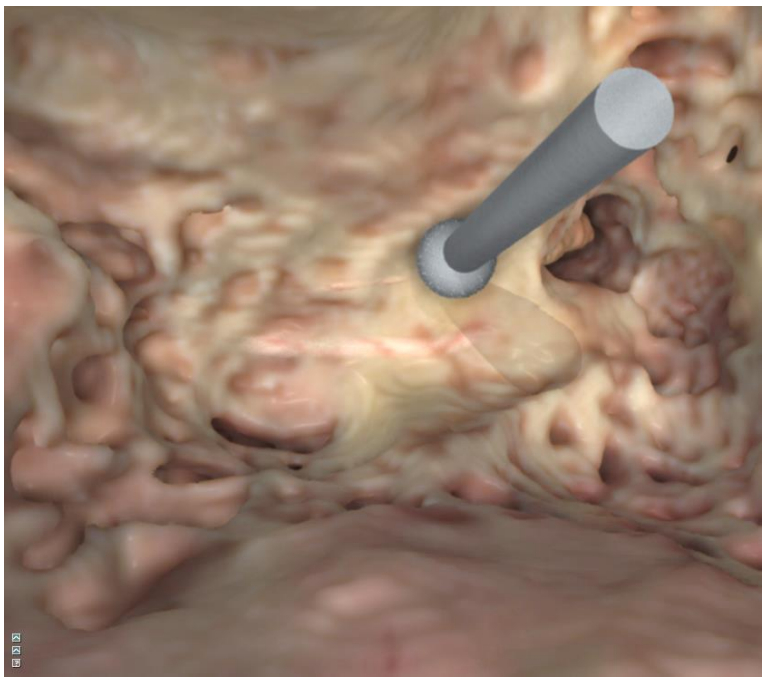


CI tutorial.

Clear the remaining large air cells from the posterior ear canal wall. Make sure the incus is just visible in the antrum.
To anticipate the route of the facial nerve inside the posterior wall use the incus pointing at the cranial end of the vertical nerve portion, and the lateral SCC indicating the depth as landmarks.
Avoid perforating the canal wall: use a coarse diamond drill, keep moving, use light strokes and don't drill beyond the bottom of the last air cell.

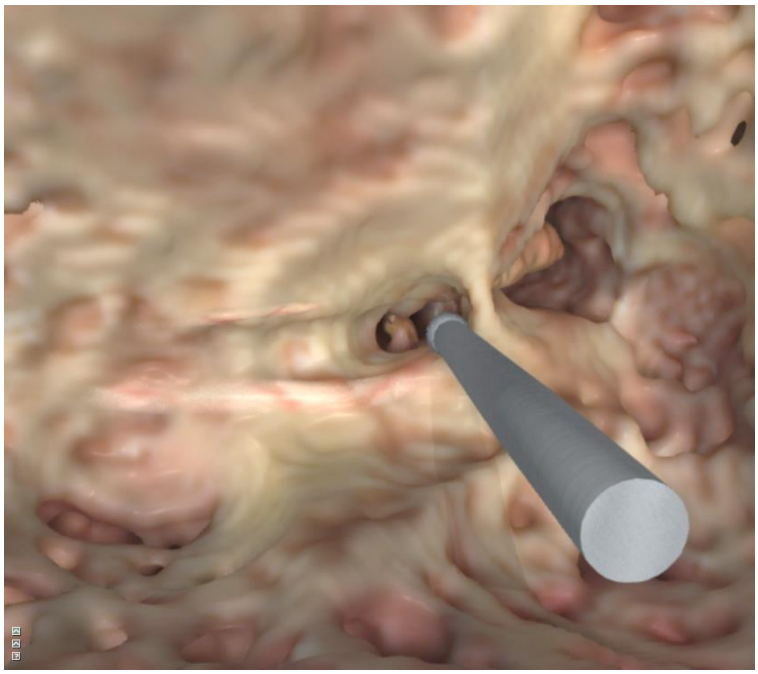


Use 3-5mm fine diamond drill bits to thin the posterior wall until the facial nerve and the tympanic chorda are visible through a thin layer of bone. Look for the vascular texture of the nerves as you approach and don't expose the nerve sheath.

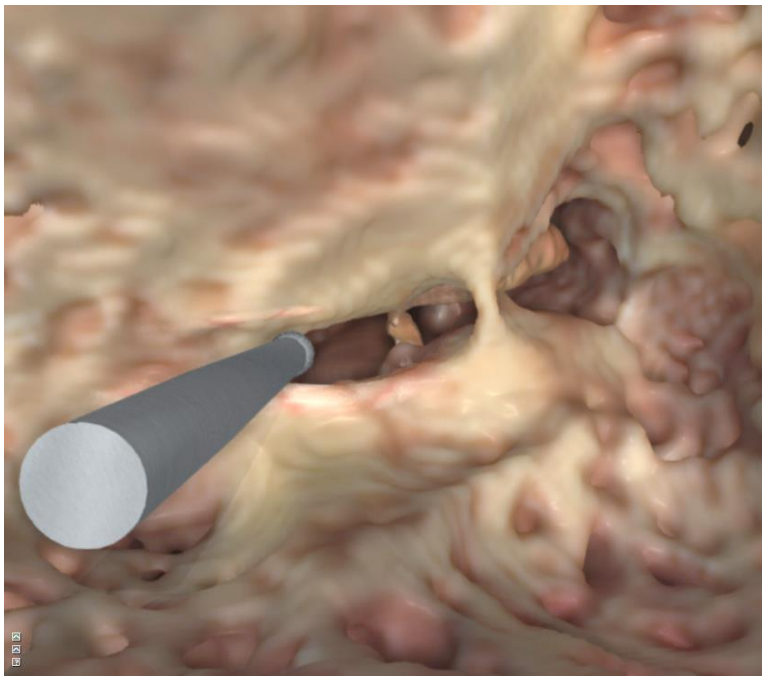


CI tutorial.

Use a 2mm, and then a 1mm fine diamond drill bit to excavate the triangular bony plate framed by the (superior) incudal fossa, the (medial) facial nerve and the (lateral) chorda tympani.
Penetrate to enter the facial recess at the wider superior end of the excavation, but leave a bony bridge (the Buttress) at the tip of the incus.

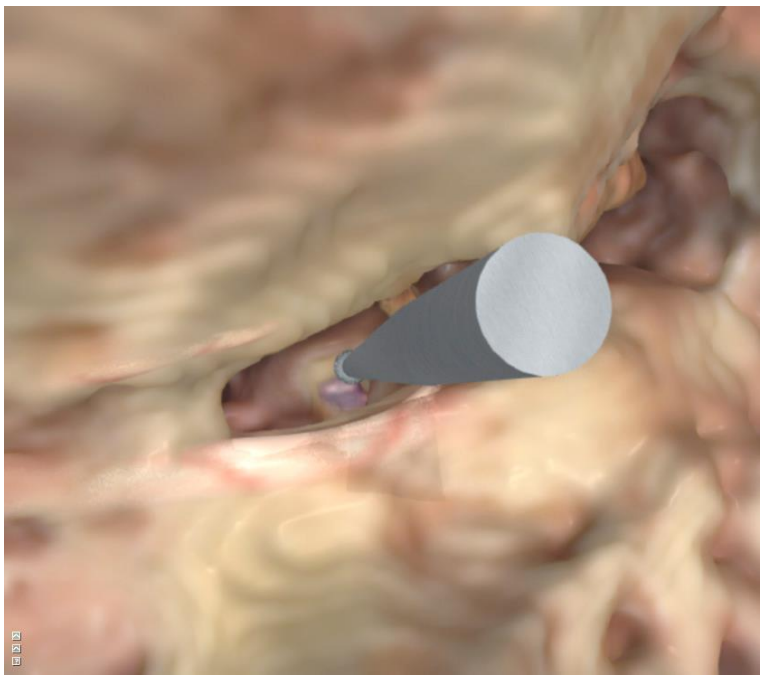


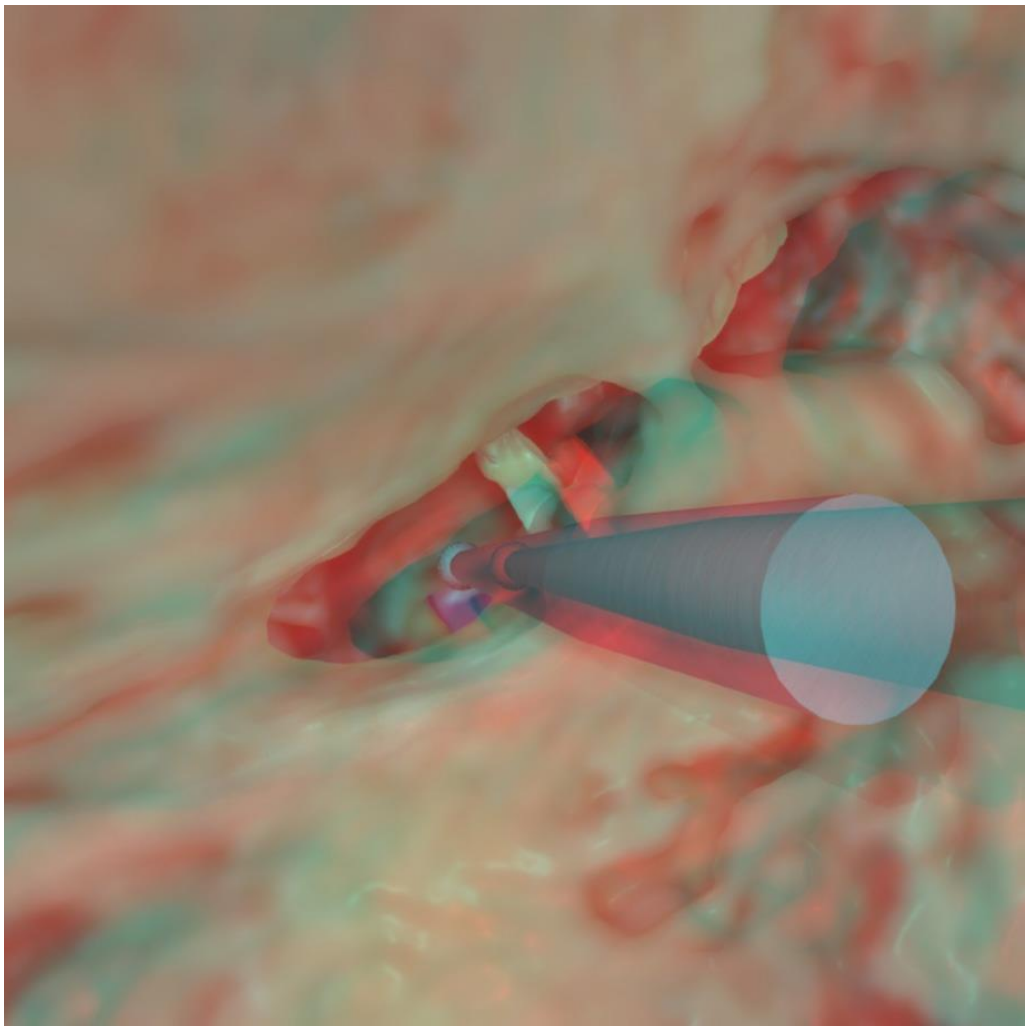
Widen the posterior tympanotomy as much as possible without exposing the nerves completely.
Note the positions of the stapes and stapedius tendon, and of the round window niche and the promontory overhang.
Carefully reduce bone thickness at the anterior face of the vertical portion of the facial nerve to fully expose the round window niche.



CI tutorial.

Drill away the rim of the bony overhang of the round window niche to expose 1mm of the round window membrane.

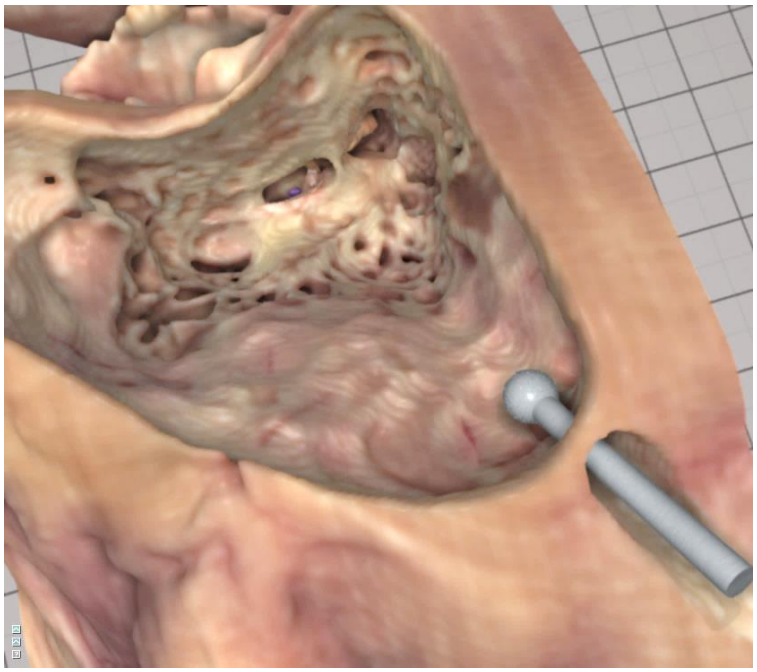




3D image

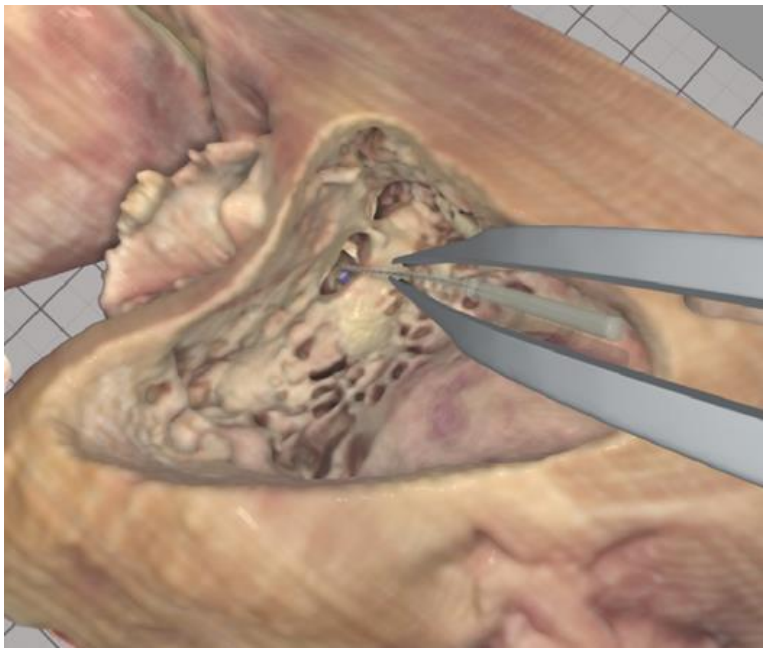
CI tutorial.

Drill a groove or canal where the electrode may enter the mastoidectomy.



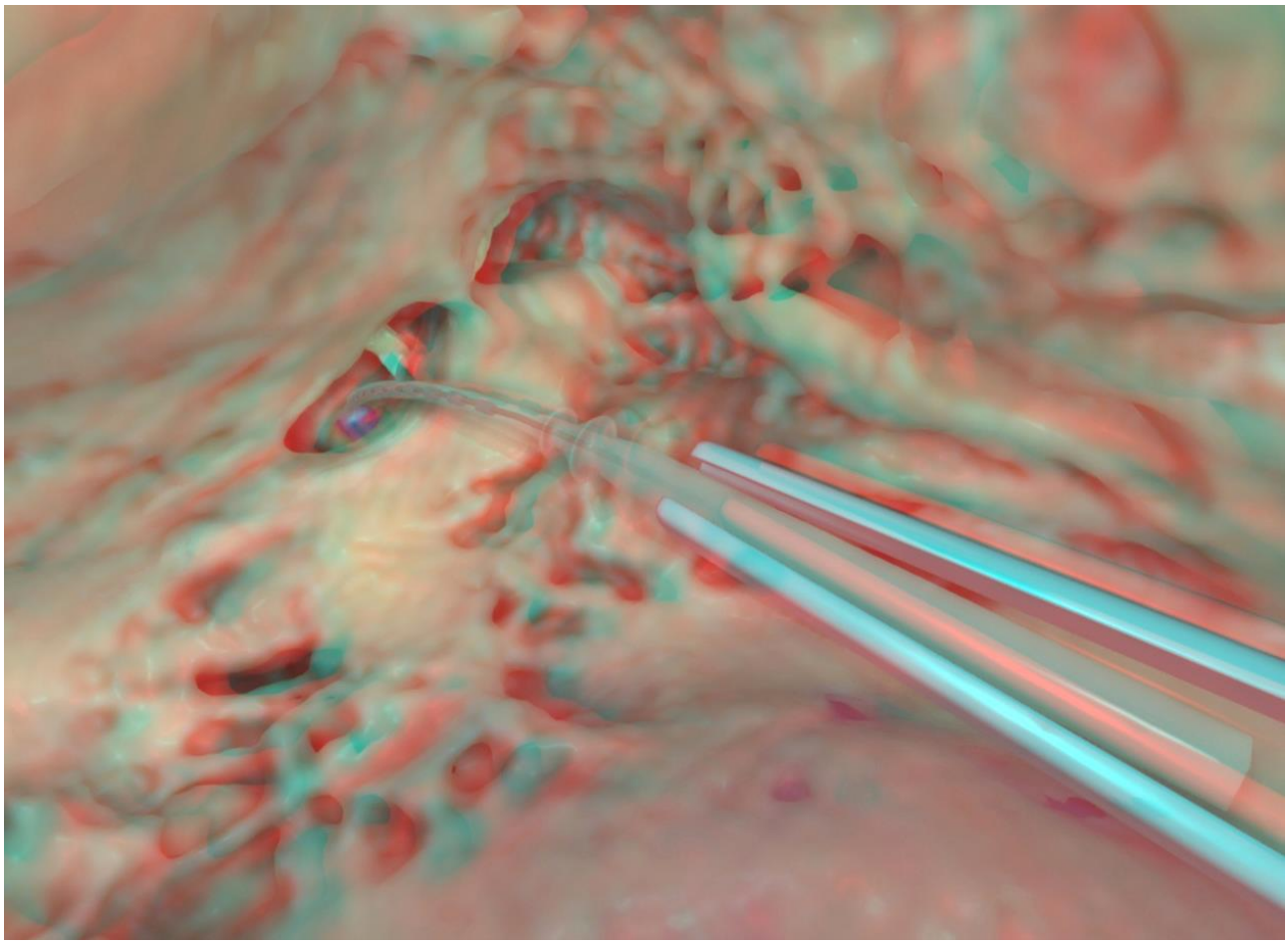
Press “Space” to select the forceps tool and “I” to produce an EVO® electrode.
Use the front button to release and grab the electrode.
Insert the electrode slowly through the round window.

The forceps goes through bone like a ghost but the electrode is all haptic.

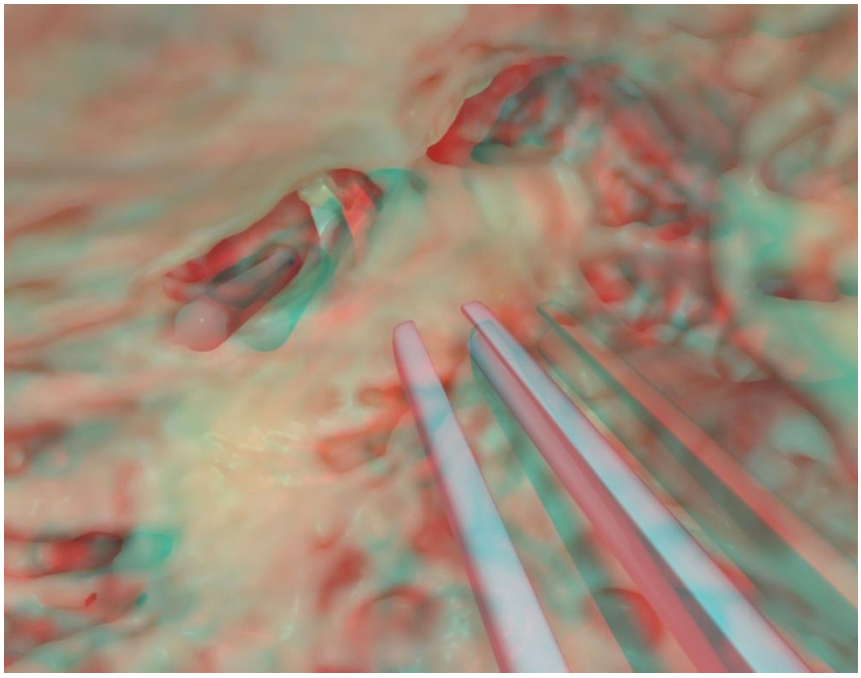


Right-double-click the bone, facial nerve, drum and other segments to hide them successively and get a better view of the electrode position inside the scala tympani. Newly hidden segments will re-appear when you press keyboard “L”.

CI tutorial.

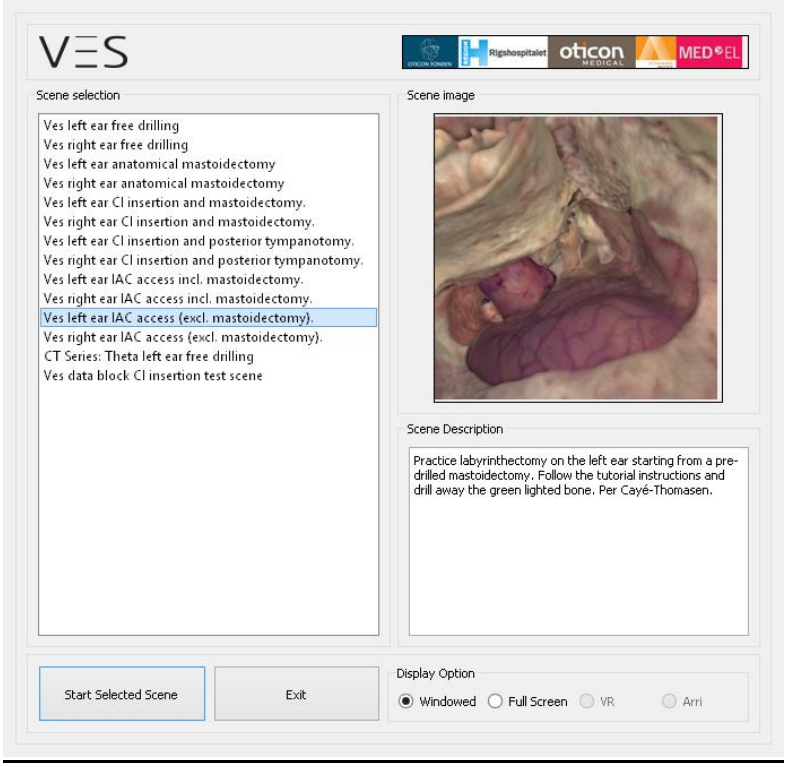


3D images



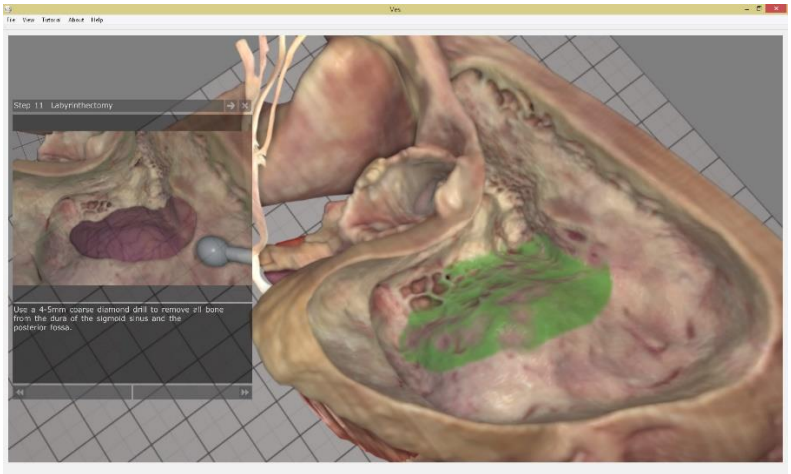
Inner Auditory Canal access by Labyrinthectomy.

Select the “Ves left ear IAC access (excl. mastoidectomy).



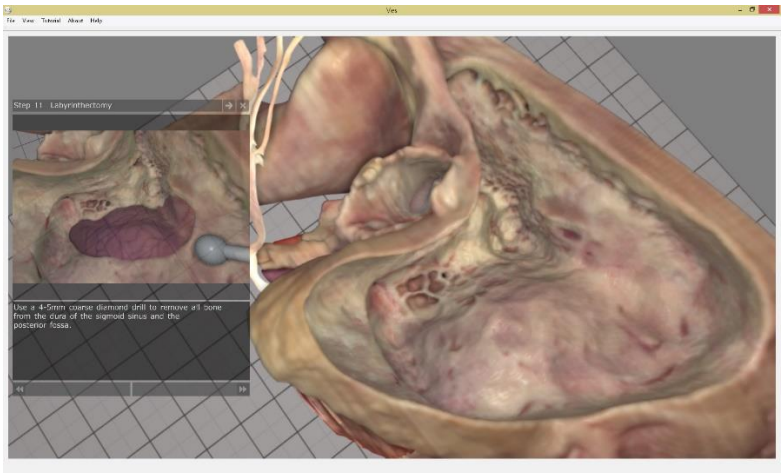

A tutorial opens, in which a large mastoidectomy is already prepared (corresponding to *“Ves left ear anatomical mastoidectomy” steps 1-10*).

*Please note that an additional “Ves left ear IAC access incl. mastoidectomy” tutor can take you all the way from the mastoid surface to the cerebellopontine angle step by step.*

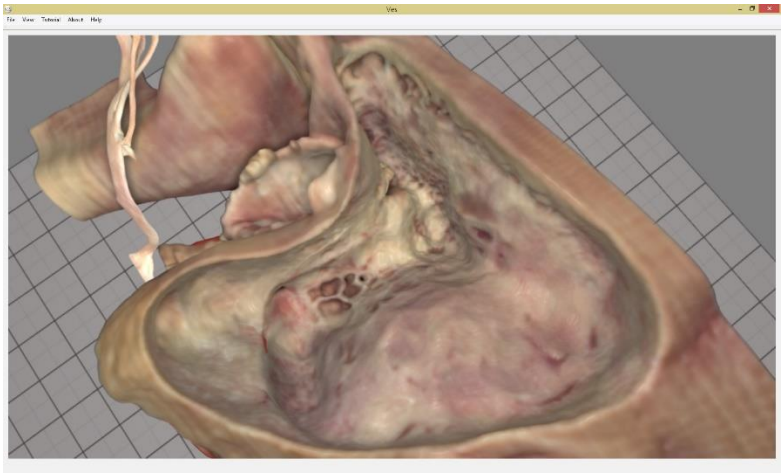


Inner Auditory Canal access by Labyrinthectomy.

You can drill away the green bone and press >> to see the next step greenlighted. Or you can toggle off the greenlighting by pressing keyboard “G” and use only the instruction in the tutor window.




If even the tutor window is not needed press keyboard “T” to toggle instructions off.



Inner Auditory Canal access by Labyrinthectomy.

First use a 4-5mm coarse diamond drill to remove all bone from the dura of the fossa posterior and the sigmoid sinus.

*(In this tutorial, the drill collision warnings for the ELS, the dura and sigmoid sinus are disabled. The membranous scala tympani is hidden, only the labyrinthine spaces remain.)*

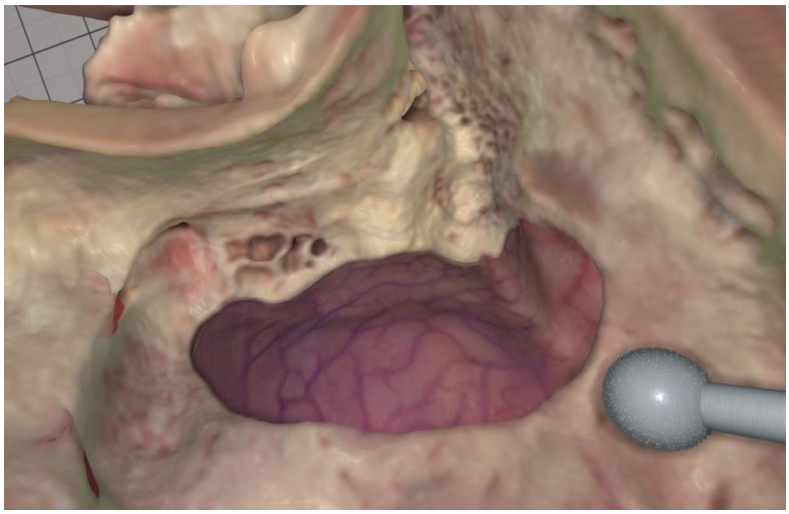
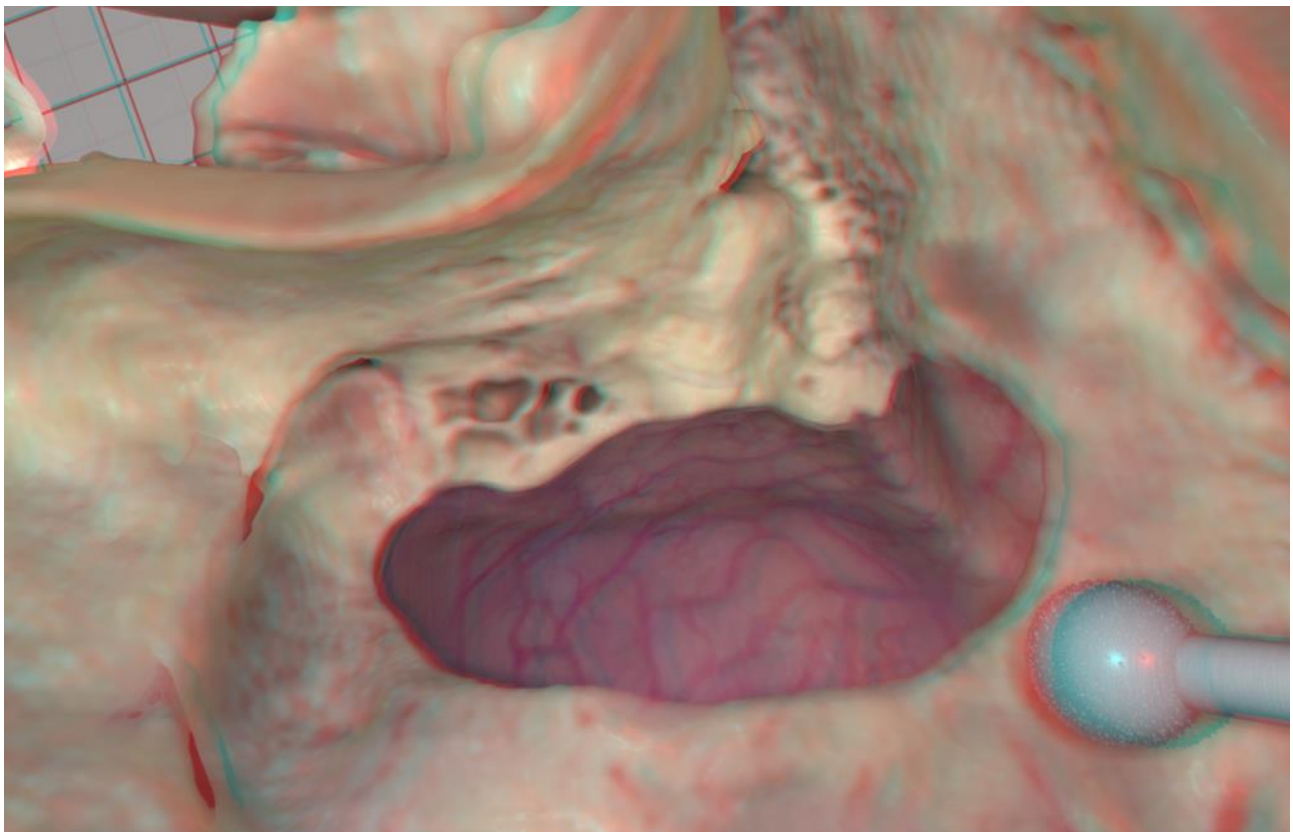


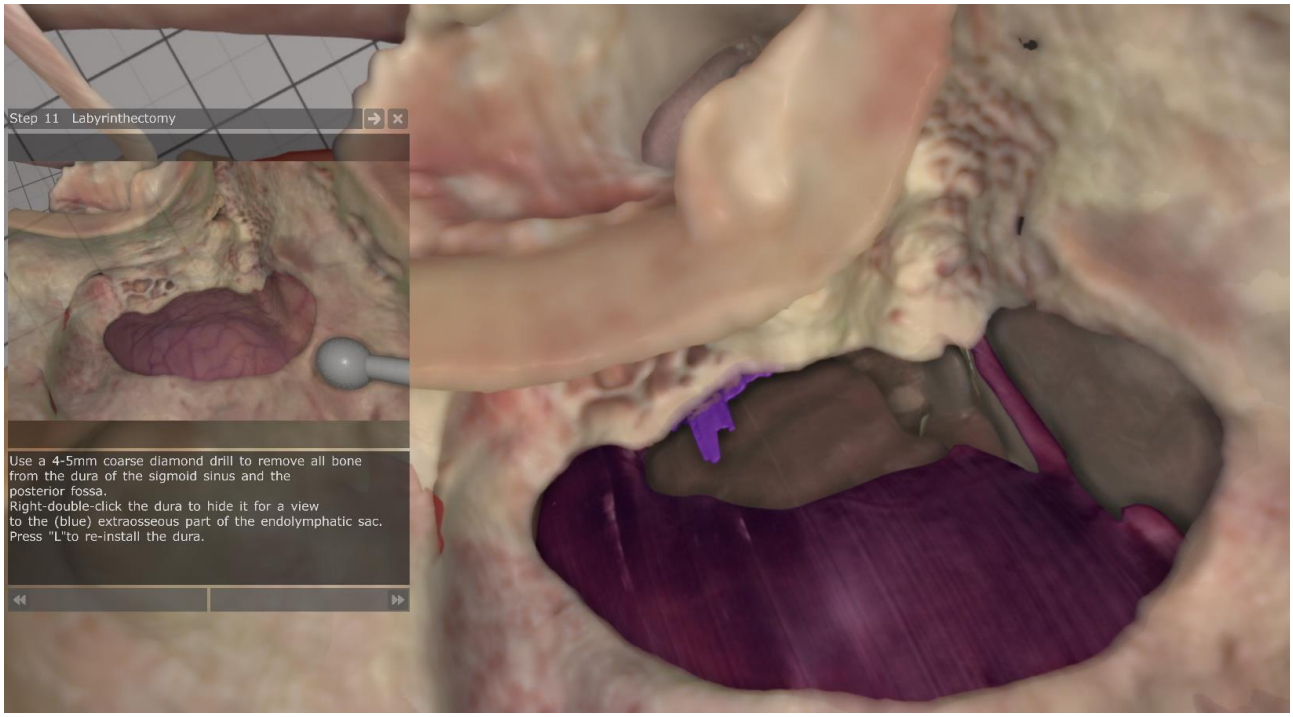
Image in 2D

Image in red/blue 3D

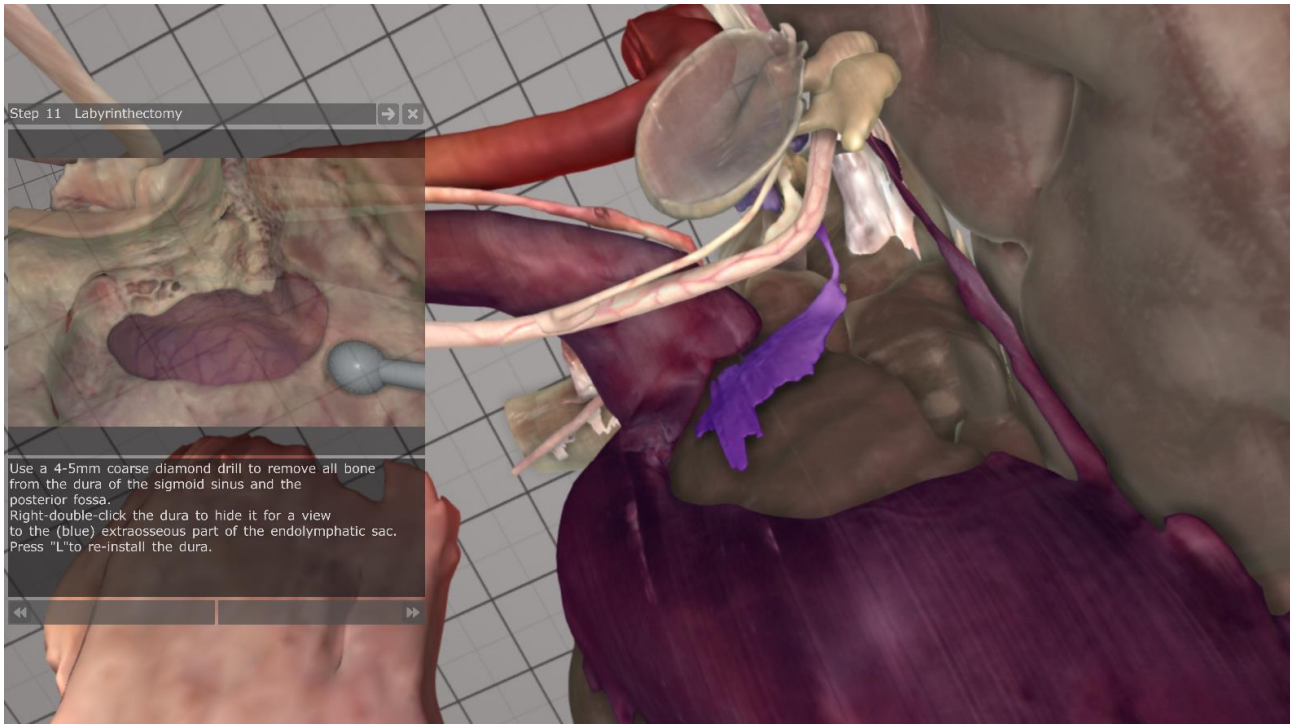


Inner Auditory Canal access by Labyrinthectomy.

Double-right-click the dura to hide it and view the extraosseous part of the endolymphatic sac.



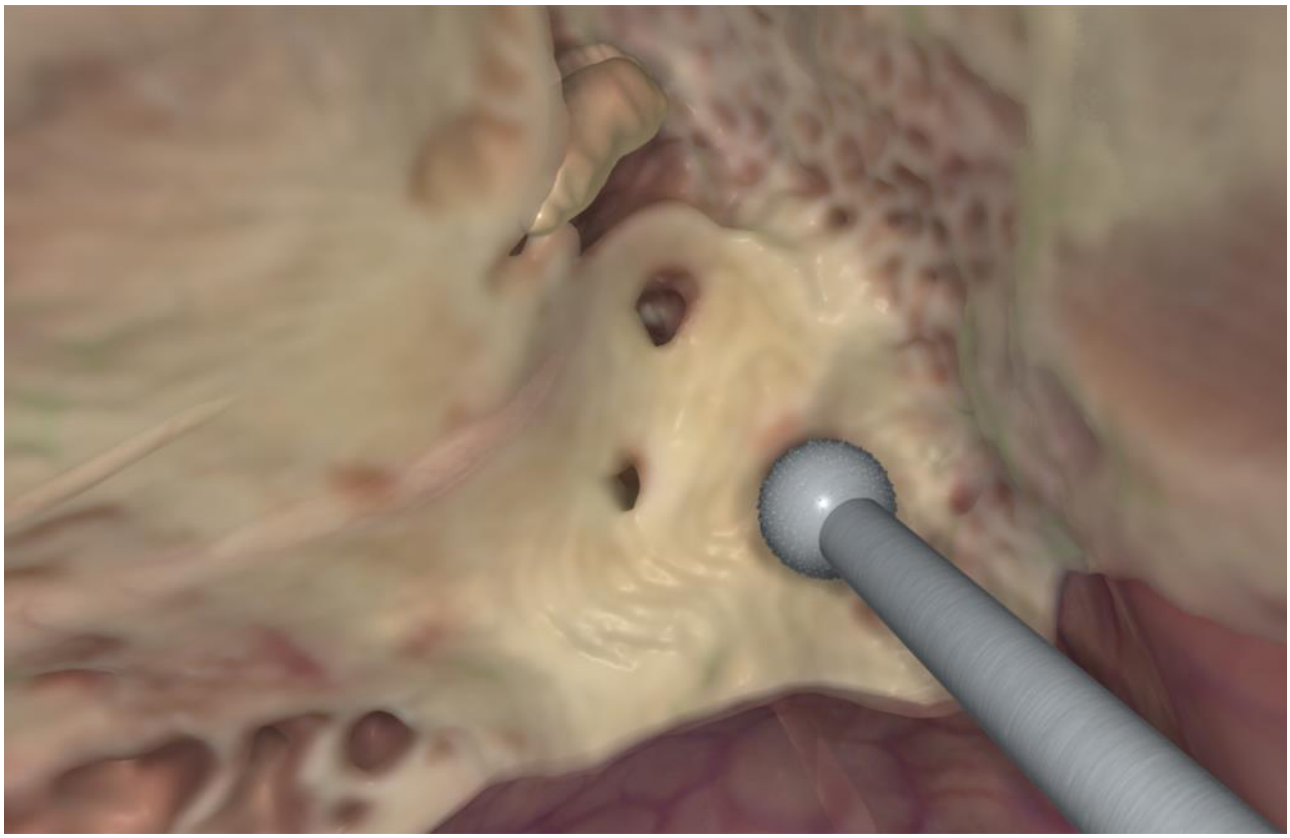

Double-right-click the bone to hide it and view more of the endolymphatic sac.

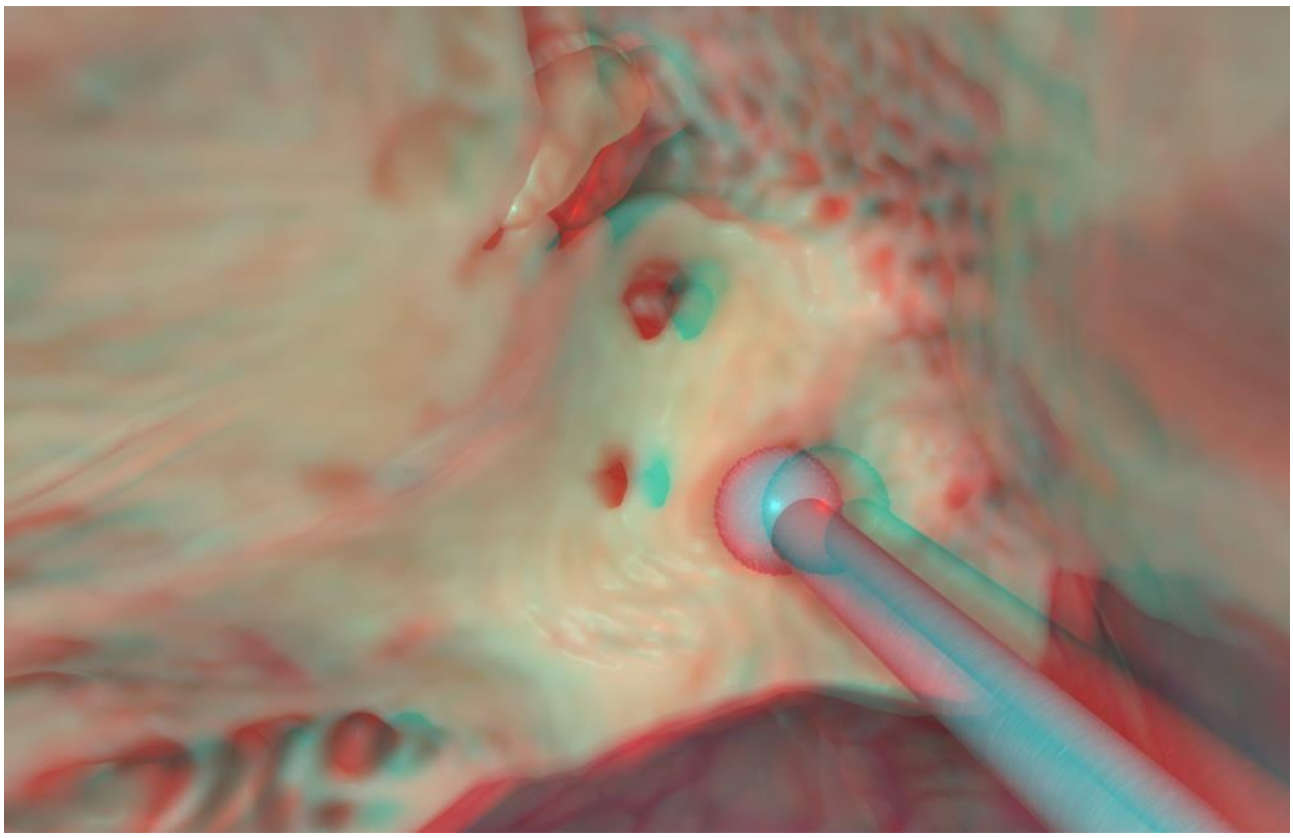



Press “L” twice to bring back the bone and the dura.

Inner Auditory Canal access by Labyrinthectomy.

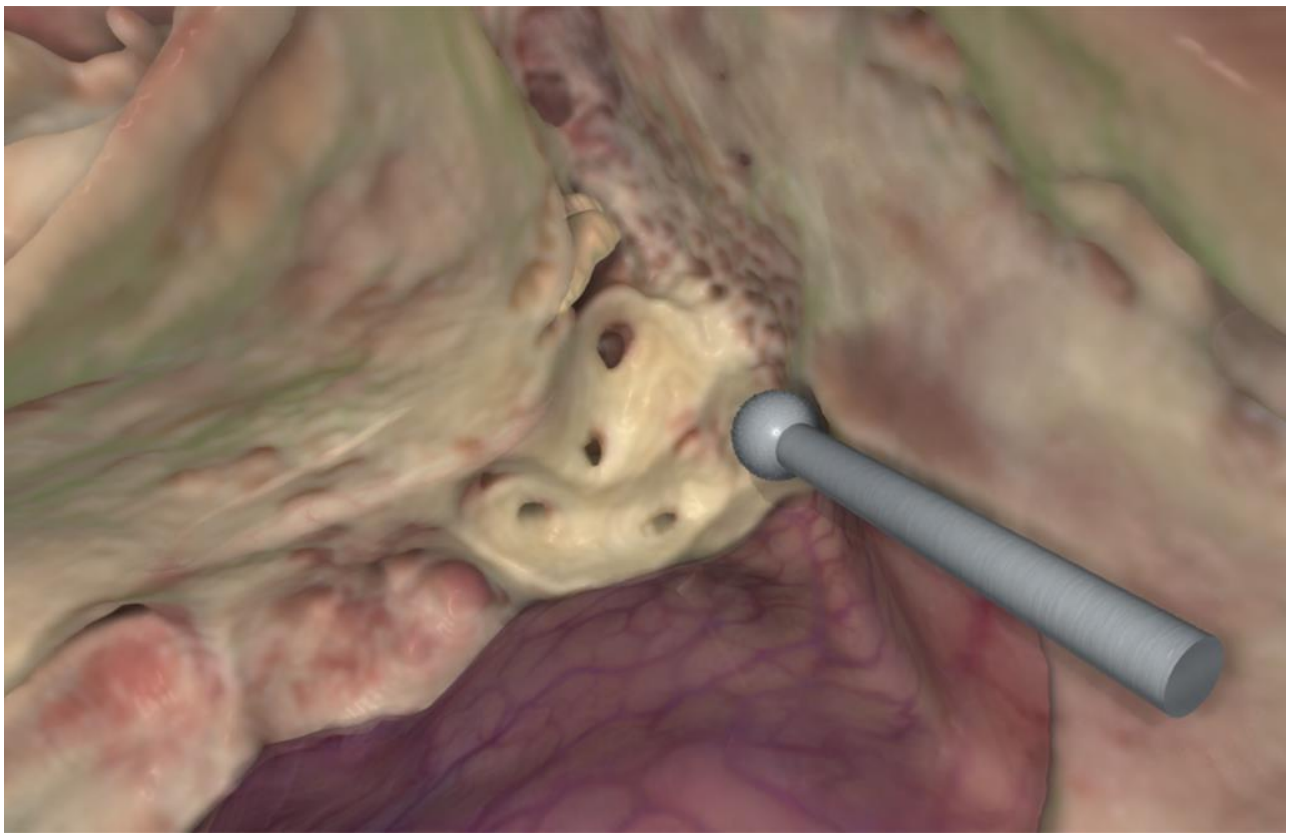
Use a 3-4mm coarse diamond- or sharp drill to open the lateral semicircular canal.

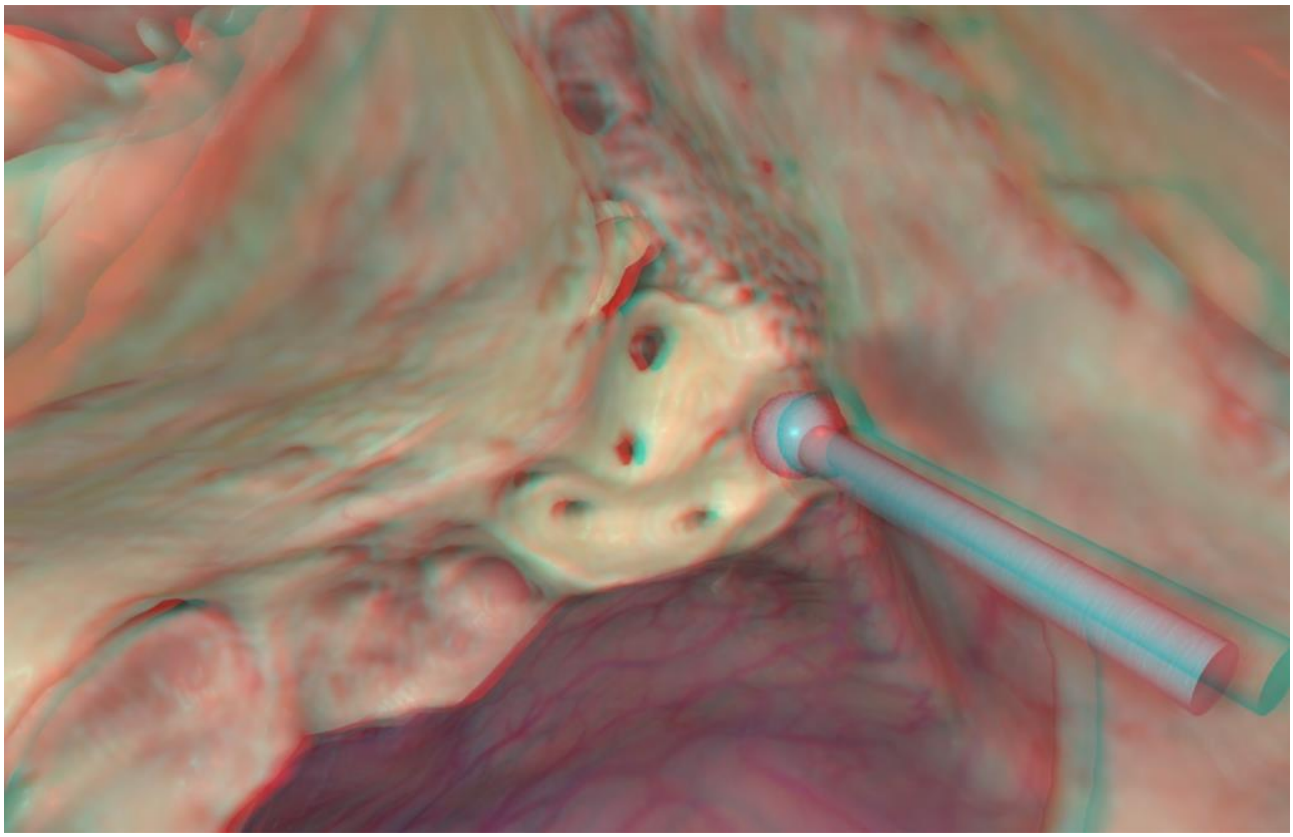




Inner Auditory Canal access by Labyrinthectomy.

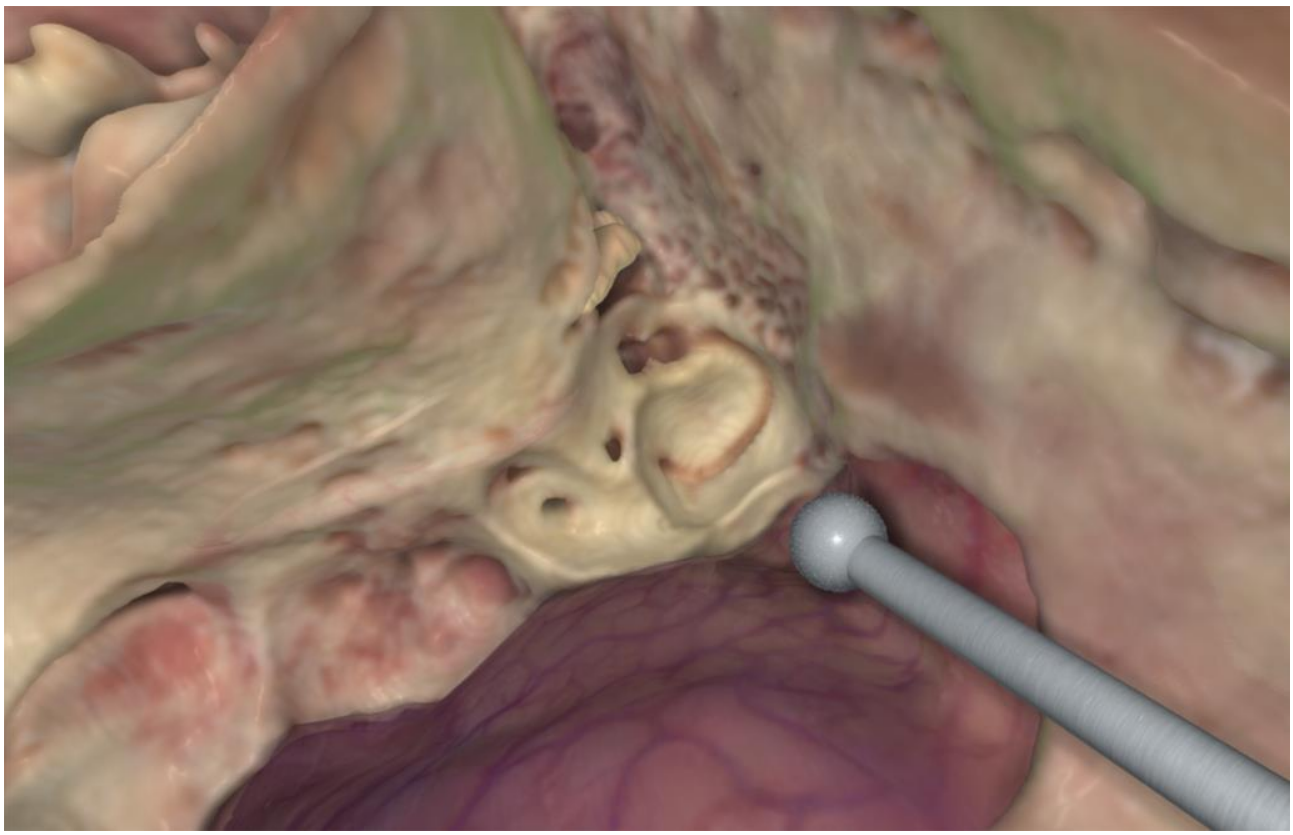
Use 3-4mm coarse diamond- or sharp drills to open the posterior semicircular canal and start drilling away retro-facial bone overlying the jugular bulb.

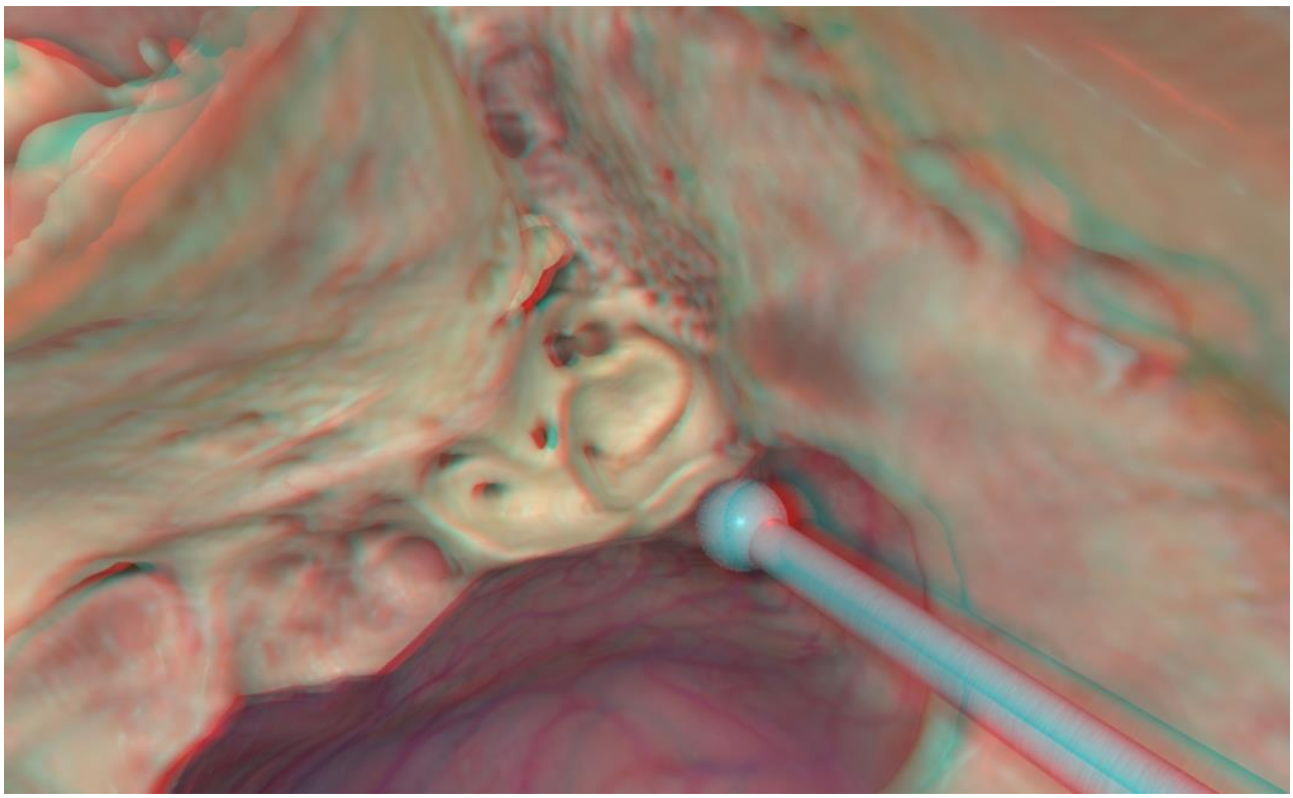




Inner Auditory Canal access by Labyrinthectomy.

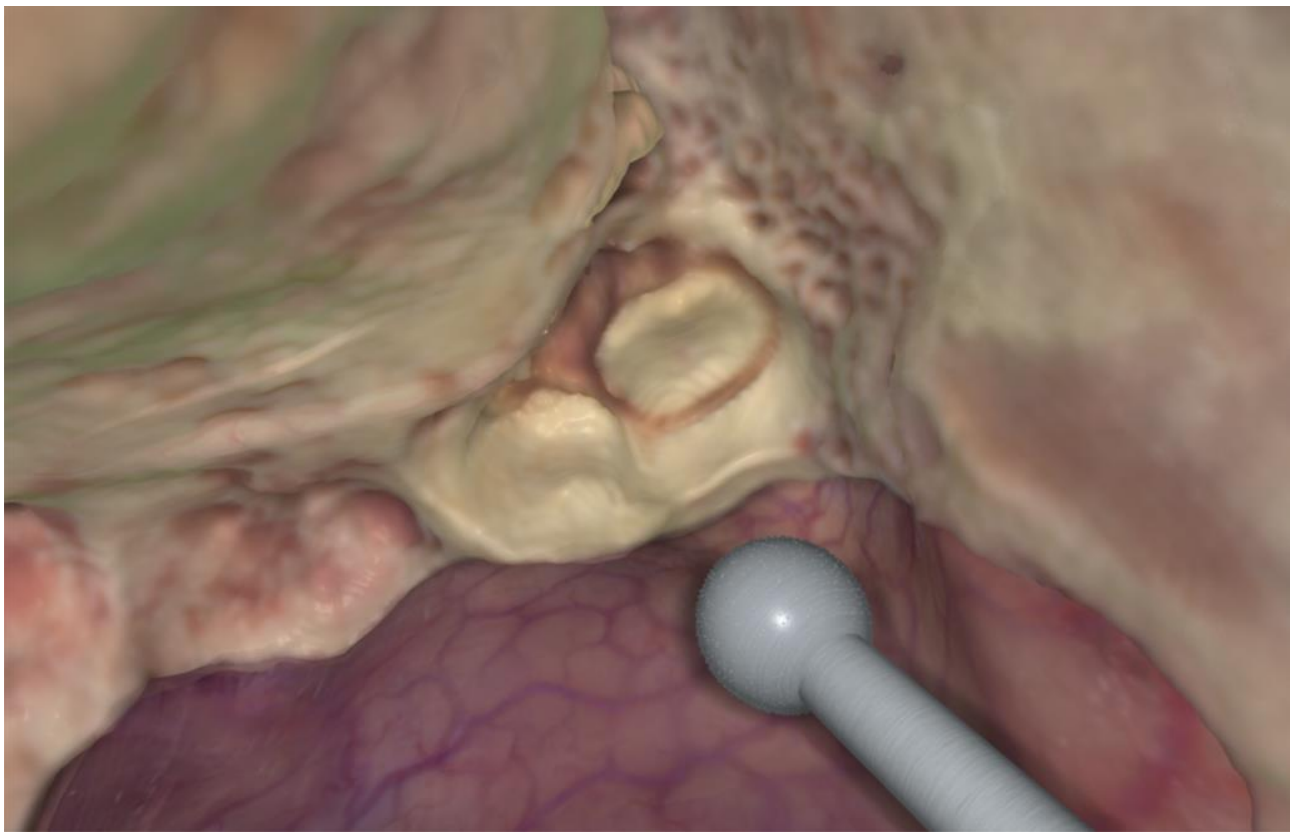
Open the superior semicircular canal with a 3mm coarse diamond drill. This canal is located deeper than the other semicircular canals.

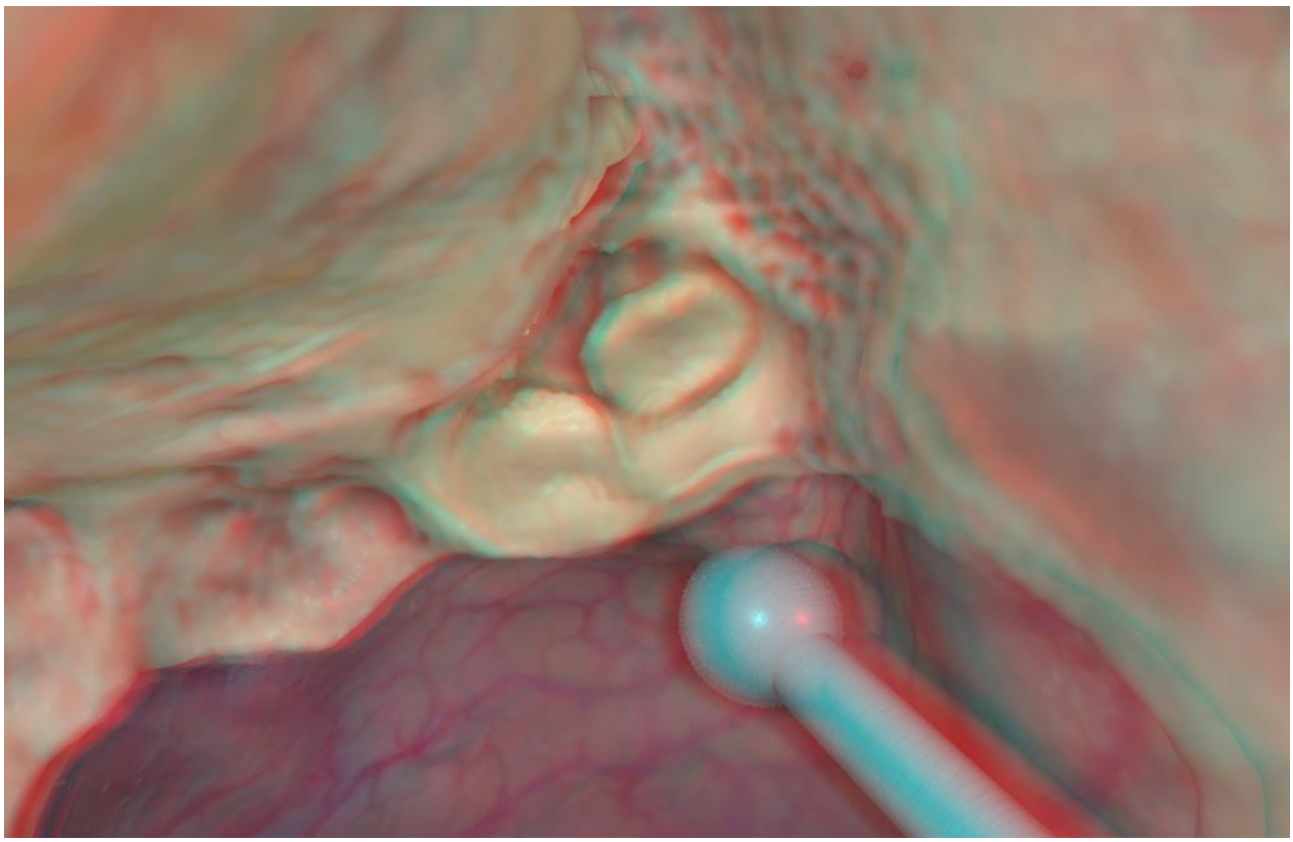




Inner Auditory Canal access by Labyrinthectomy.

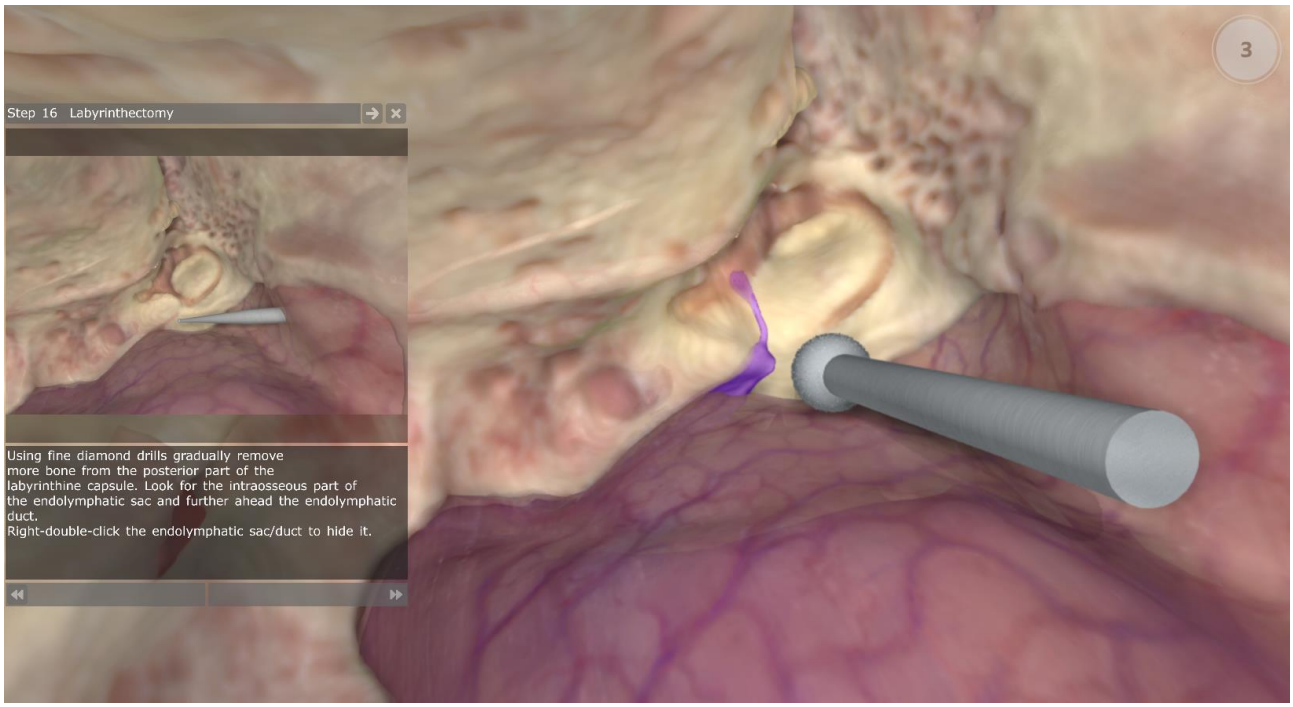
Open the vestibulum.



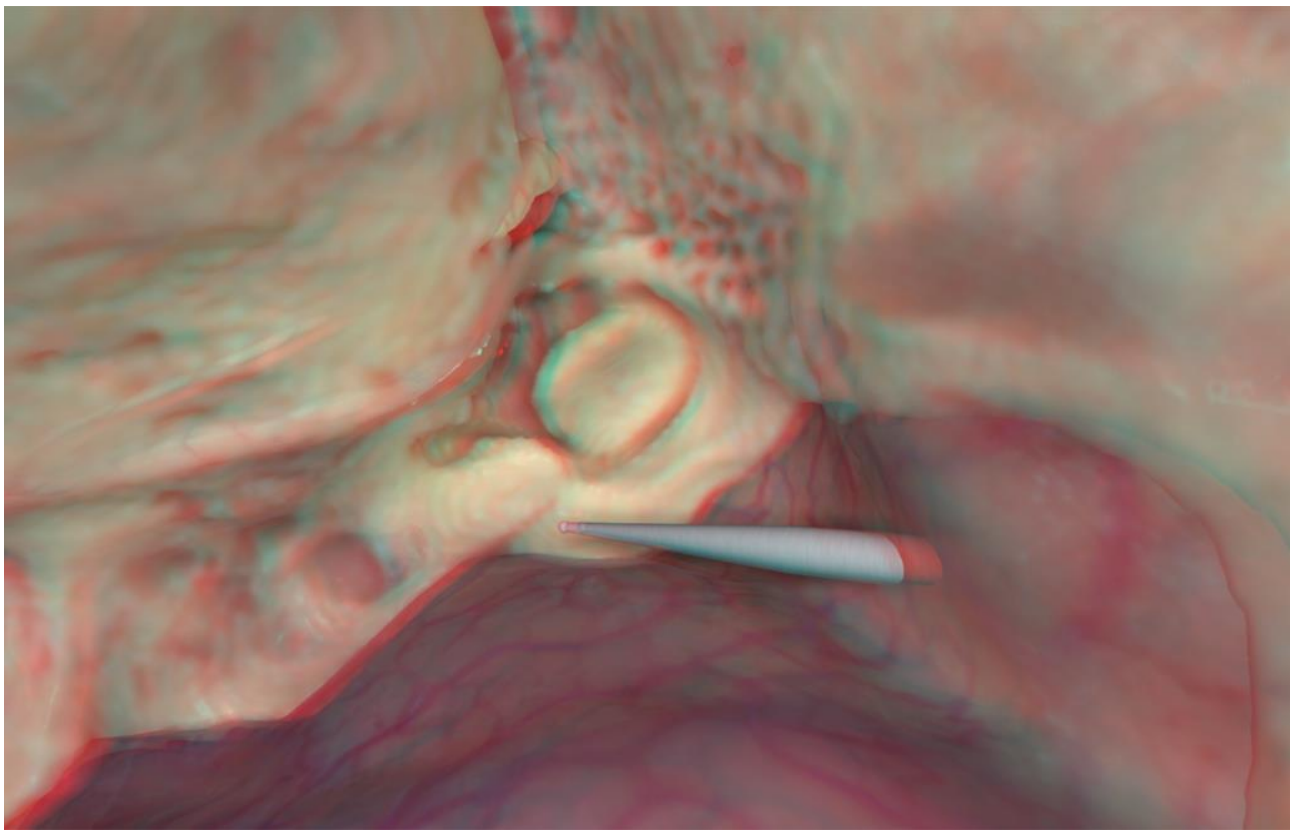


Inner Auditory Canal access by Labyrinthectomy.

Using fine diamond drills gradually remove more bone from the posterior part of the labyrinthine capsule. Look for the (blue) intra-osseous part of the endolymphatic duct and the endolymphatic duct further ahead as illustrated at the tip of the drill.

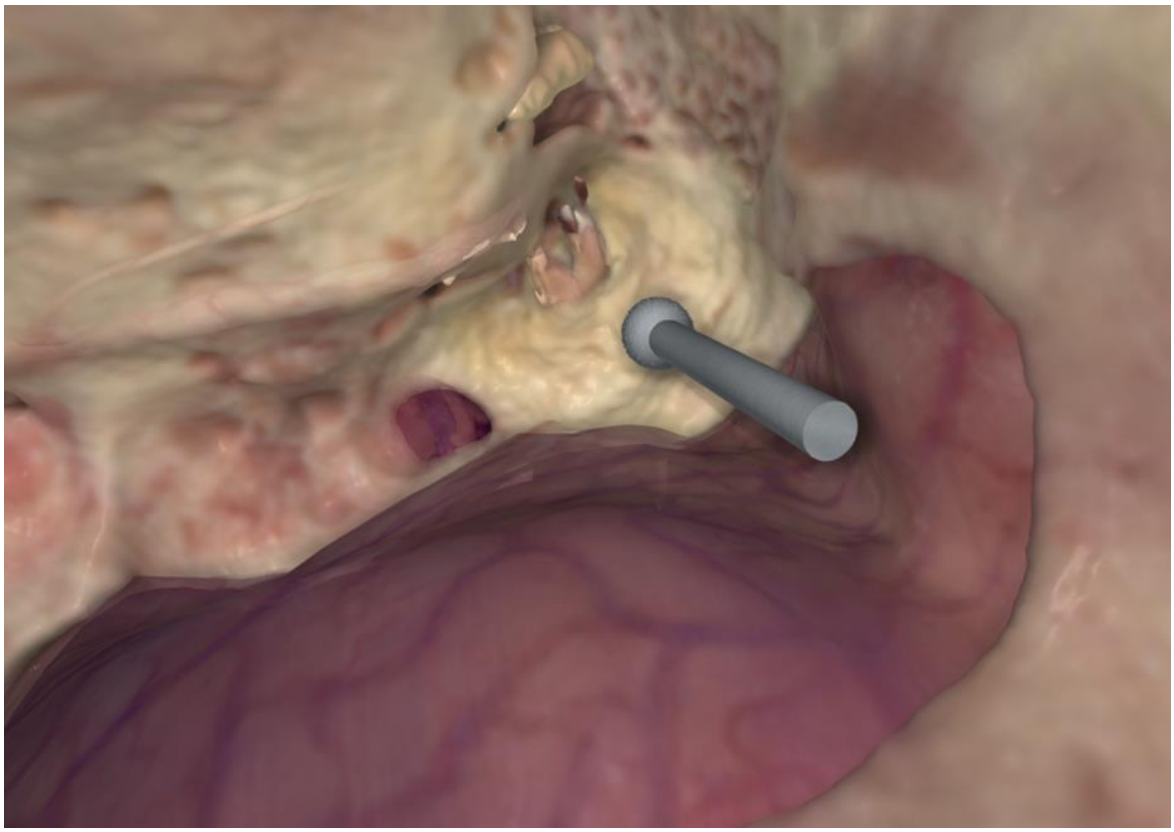


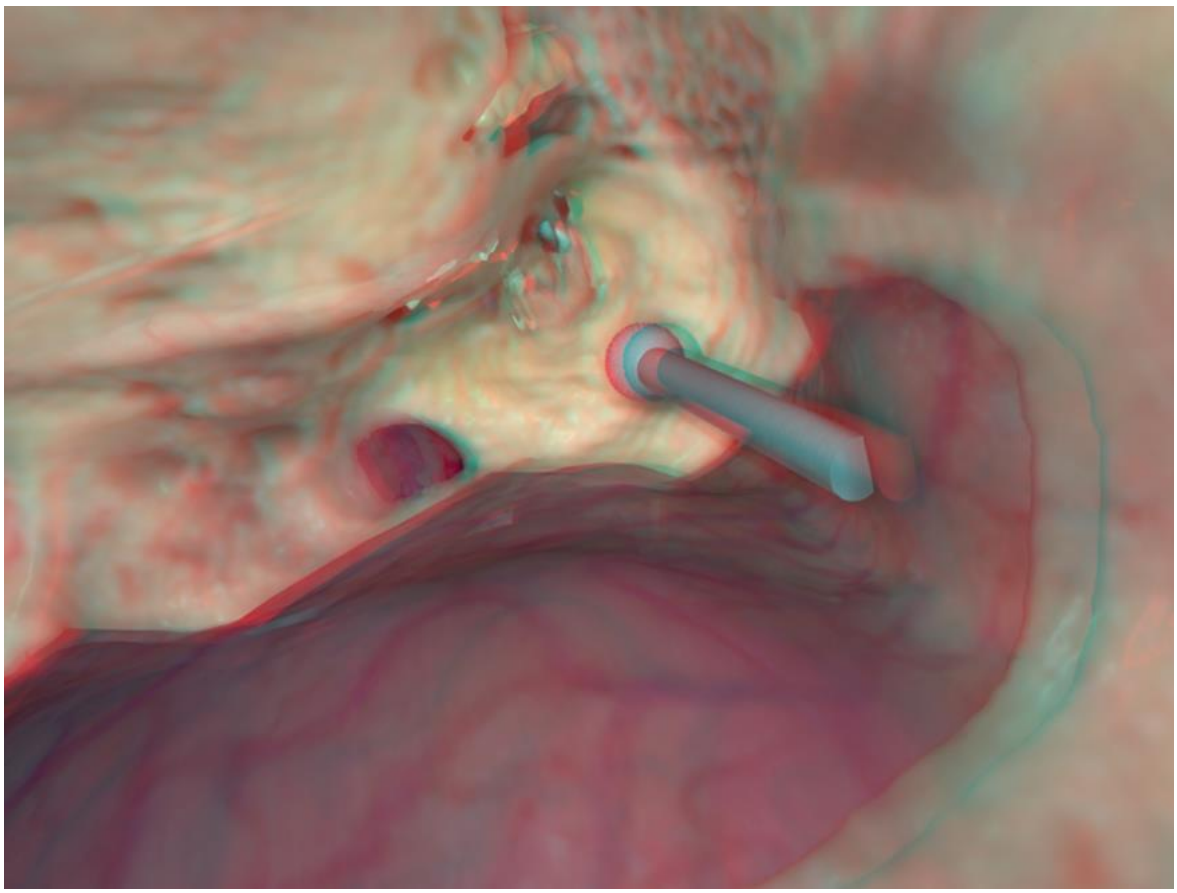

Right-double-click the endolymphatic sac/duct to hide it.



Inner Auditory Canal access by Labyrinthectomy.

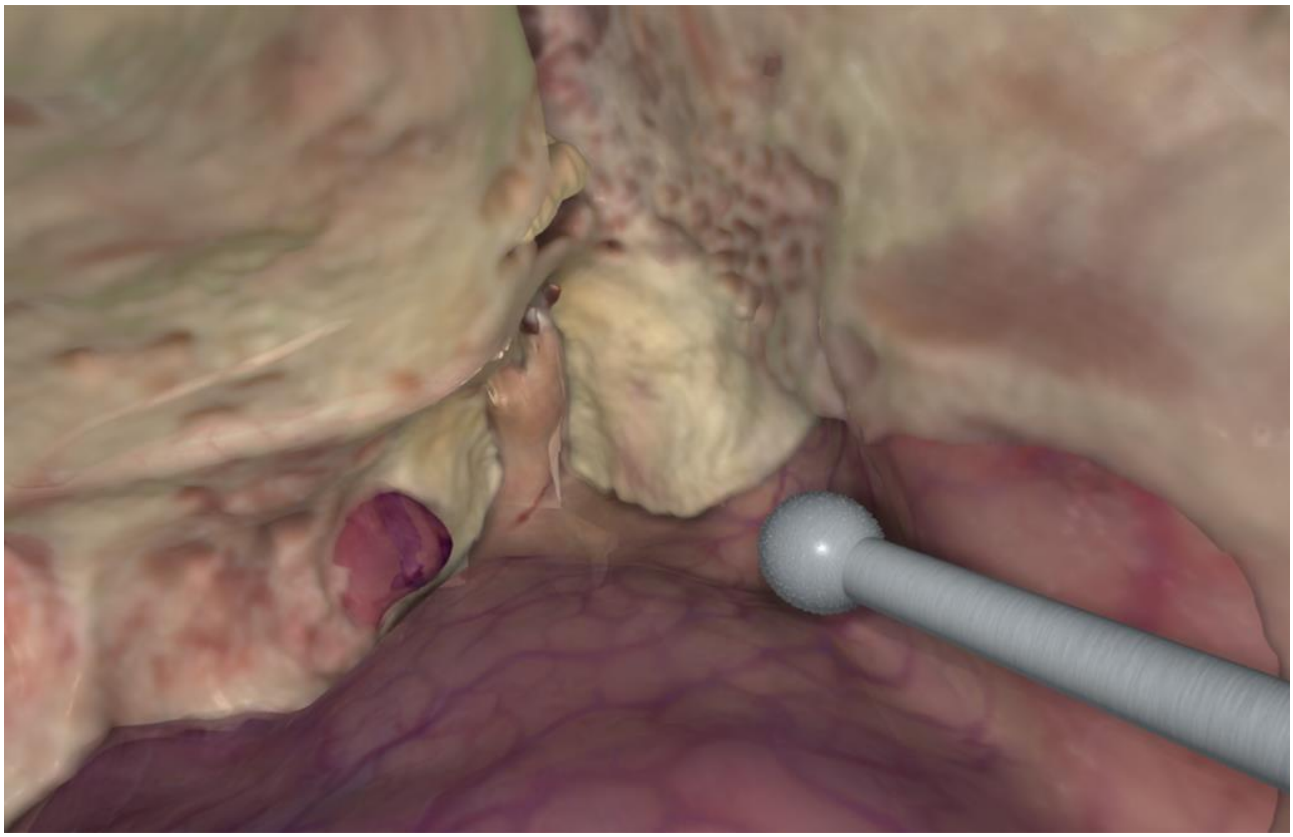
Find the lateral end of the internal auditory canal just on the far side of the vestibulum. Note the position of the jugular bulb.

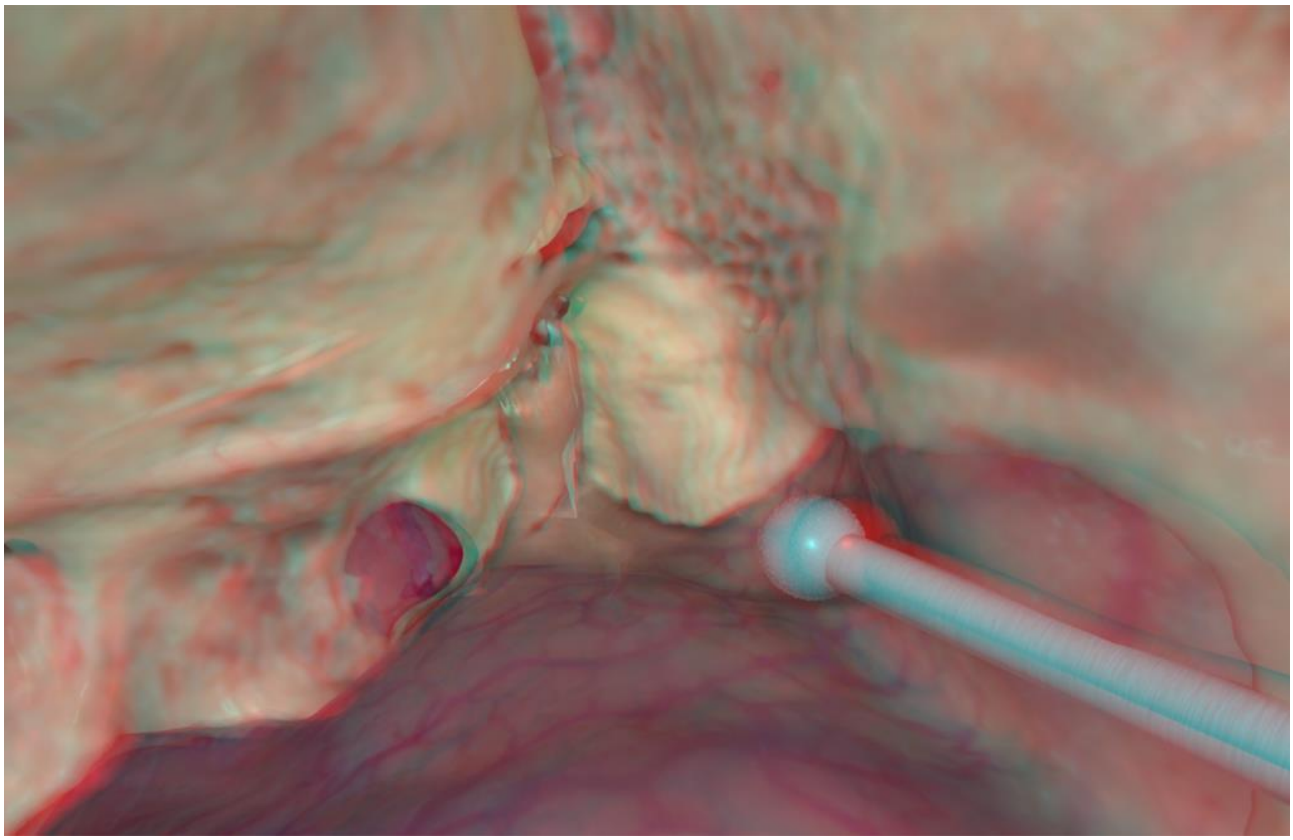




Inner Auditory Canal access by Labyrinthectomy.

Open the internal auditory canal along its entire length.

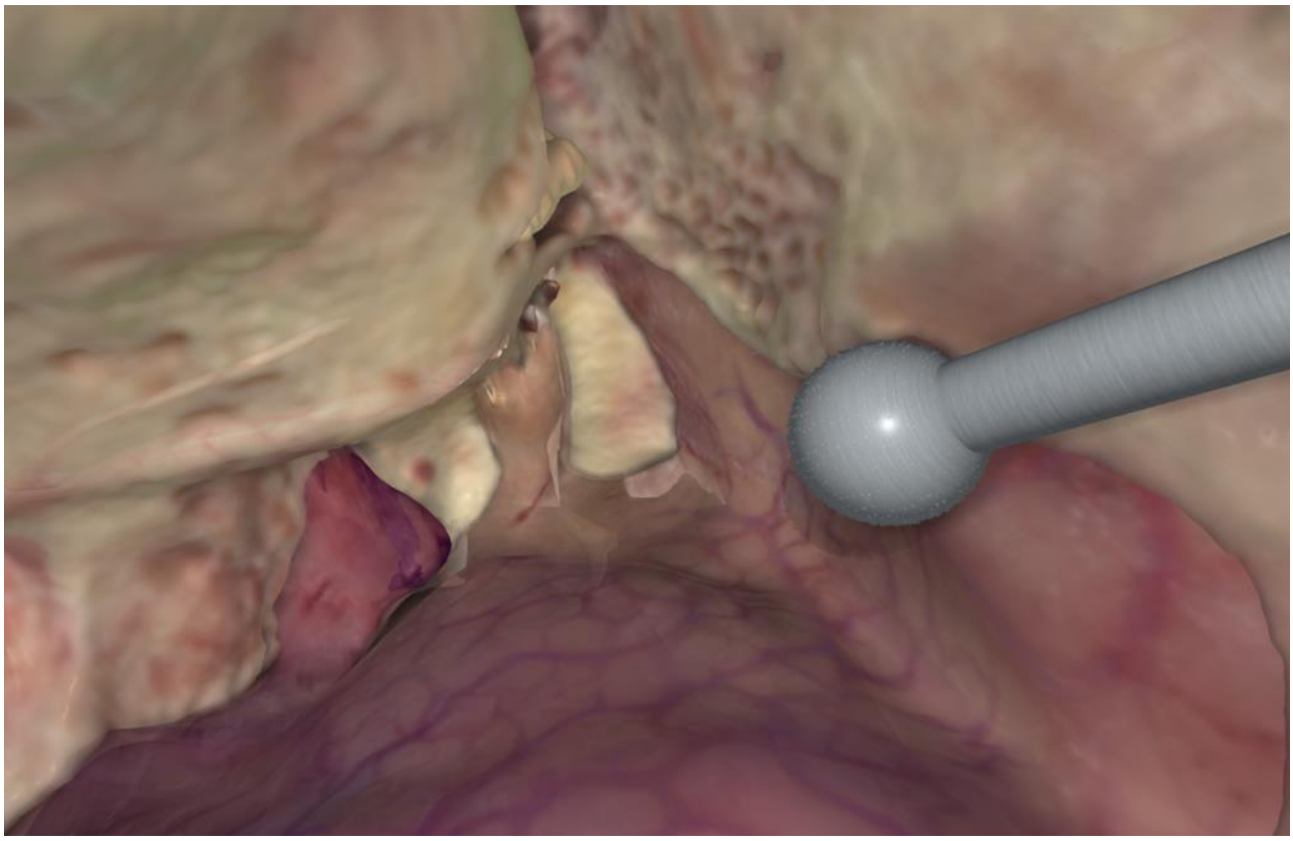


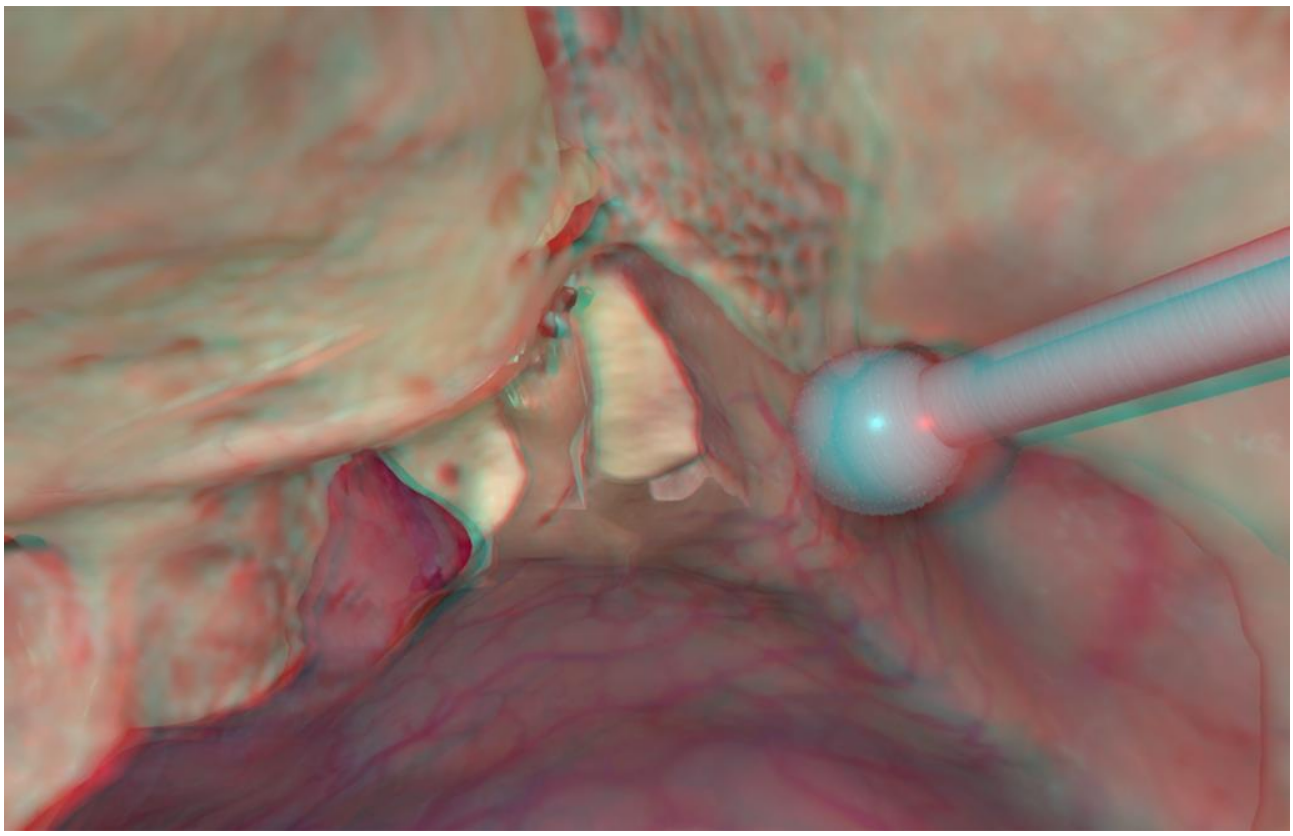


Right-double-click the dura to hide it and see the vestibule-cochlear- and the facial nerves.
Press keyboard “L” to bring the dura back (or any other structure you just hided).

Inner Auditory Canal access by Labyrinthectomy.

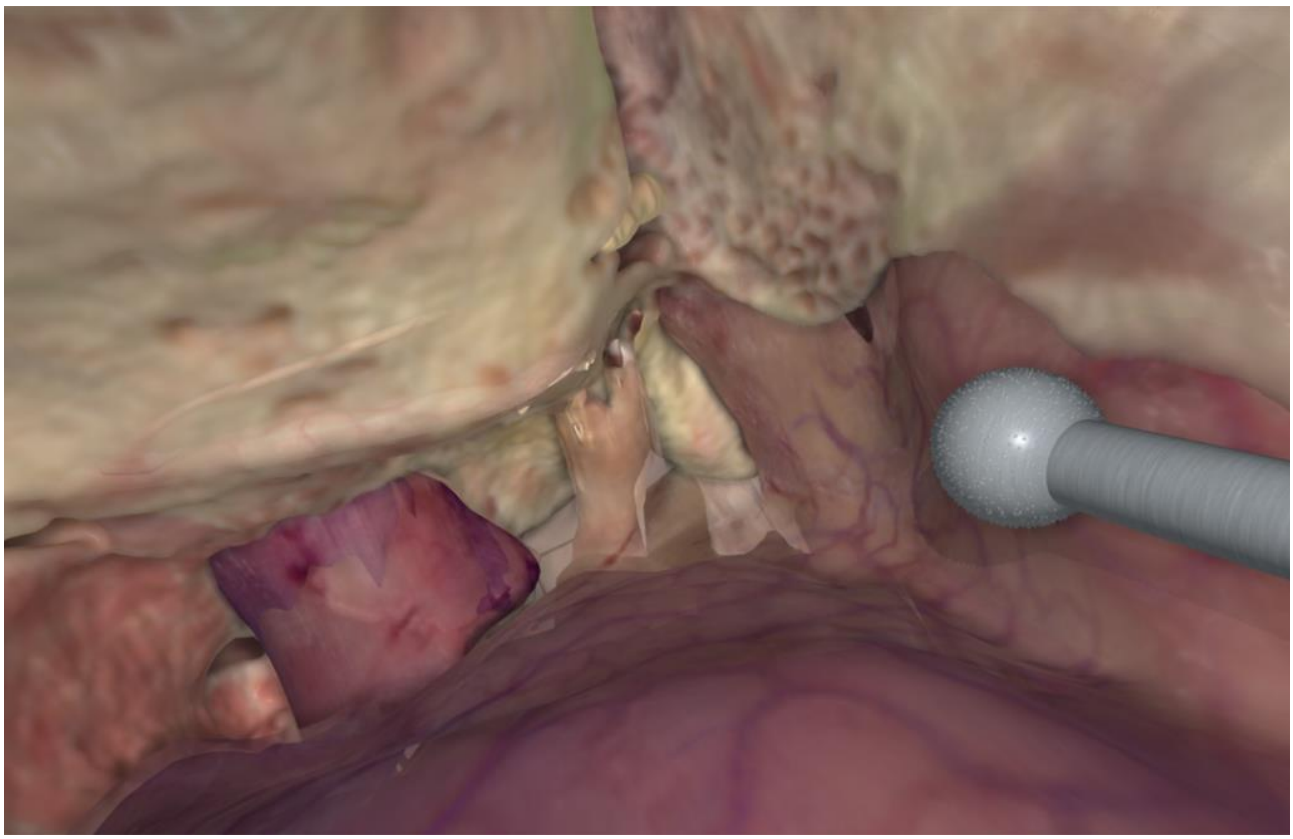
Develop your access to the cerebello-pontine cisterna on both sides of the IAC.
Don’t drill beyond the anterior wall of the IAC.
Note the cochlear aqueduct (dark spot) between the IAC and the jugular bulb.

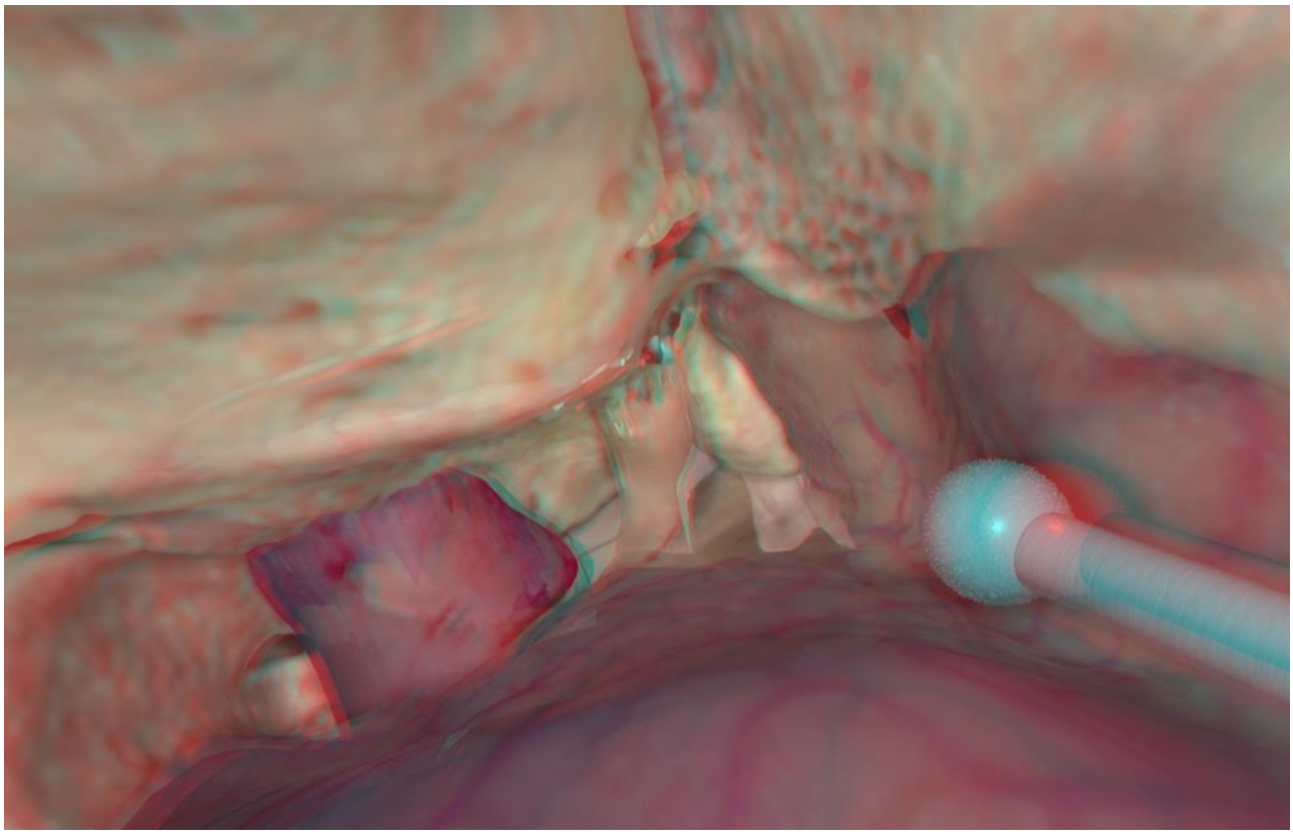




Inner Auditory Canal access by Labyrinthectomy.

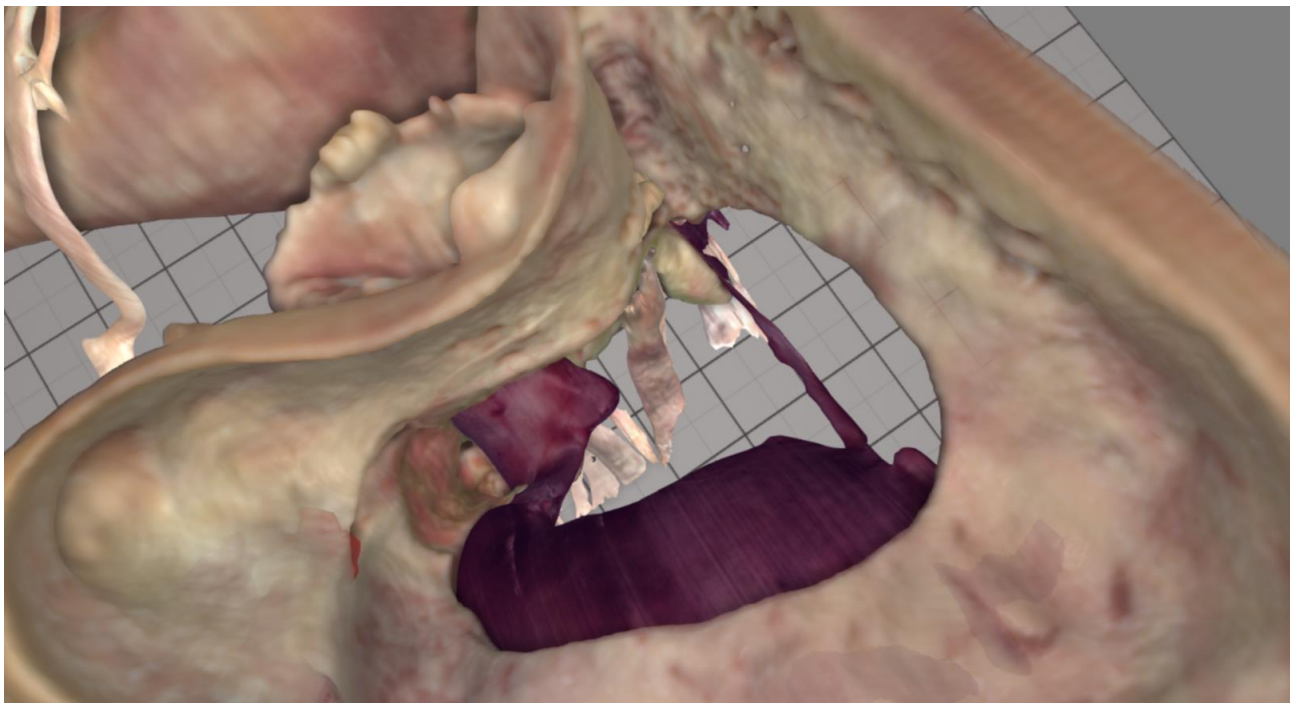
*Skeletonize the entire jugular bulb and finish your excavation.*

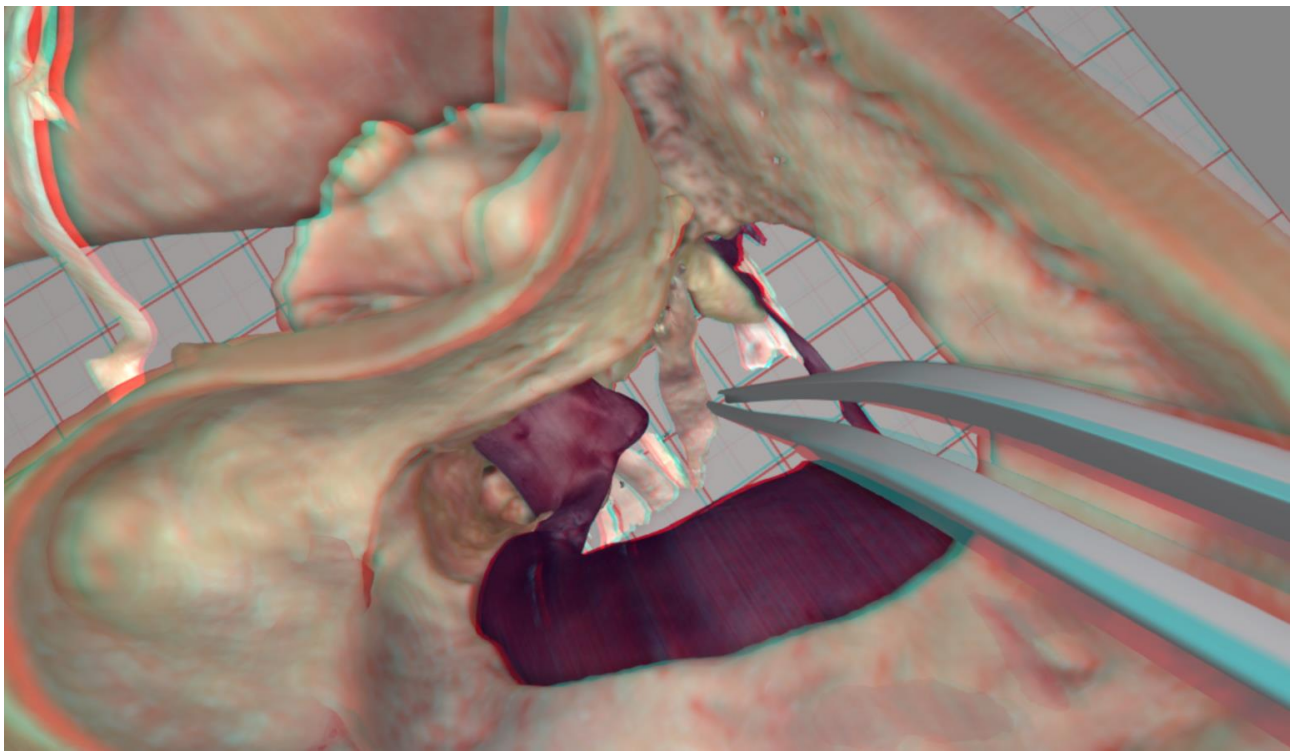




Inner Auditory Canal access by Labyrinthectomy.

Hide the dura, the brain and brain stem by successively right-double-clicking the structures to inspect the access you just created.





At this time, the VES3 jugular bulb and the dura are not deformable (but they will be soon).

In real surgery, these structures can be depressed by speculae and the access to a vestibular schwannoma further improved.

You can practise any drilling procedure just like on a “wet” temporal bone and we sure hope you will.

If you would like to do a tutorial/evaluation for the VES3 by preparing corresponding screenshots, brief texts and saved sessions go to the VES homepage and send us an email. We can add this tutorial to your VES3, and we might be able to include your tutorial into the next published VES version. Development of the VES3 will continue, and many major features are scheduled for this version.

Concerning the previous VES1 and VES2 they will stay available for download from the homepage and we will continue to fix bugs when we find them. However, no further developments will be published.

Please check the VES homepage every now and then for updates.

PTM, SA & MSS August 2017

IMPORTANT NOTE: If you have the new Geomagic Touch USB device with a cooler fan in the base remember to cut the power to the device when you are not using it. On the other hand, never try to run it without the fan – it will break down instantly.