



Analyze 15.0: HNA

Head and Neck Analysis Add-On

User's Guide



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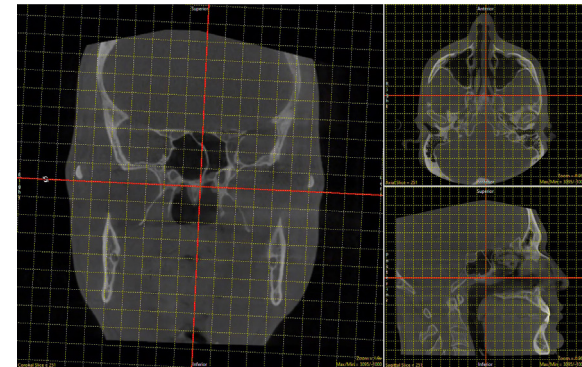


Introduction

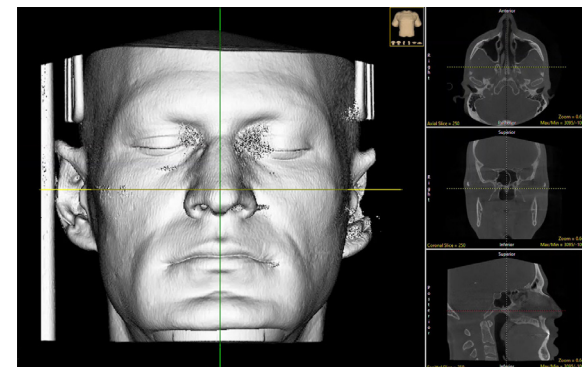
The Head and Neck Analysis (HNA) App for Analyze 15.0 is a research application for the analysis of craniofacial anomalies. It offers an easy-to-use, guided, sequential analysis of Cone Beam CT (CBCT) volumetric datasets of the head and neck, providing tools for making accurate, cephalometric-based measurements and creating compelling, informative visualizations from pre- and post-intervention scans of a subject. The HNA app allows for the analysis of a single scan or both the pre- and post-intervention scans at the same time.

Single Scan Analysis (Using Pre- OR Post-Intervention Data)

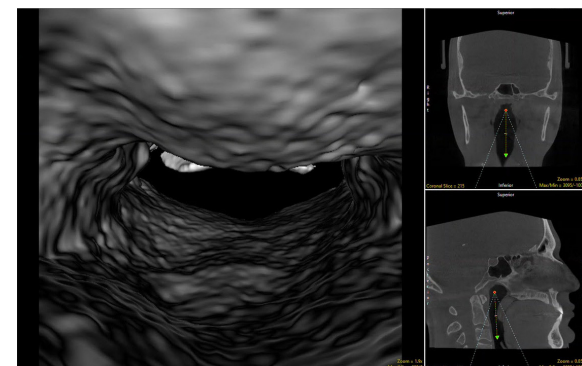
If a single volume is selected when opening HNA, which can be either a pre- or a post-intervention scan, the first step in the analytical task flow, **Align**, provides tools to easily realign the volume. The **Visualize** step is then used to assess the realignment and more importantly, to explore the soft tissue and bone morphology of the subject using a set of advanced visualization tools including perspective rendering and mirroring. At this point, the Align step may be revisited for modification of the alignment. Next is the **Airway** step, which offers tools to generate endoscopic visualizations of the airway. For quantitative analysis of the scan, detailed linear and angular measurements can be made in the **Measure** step. By default, these are based on standard cephalometric landmarks, but custom points and measurements can be added as desired. After all measurements are obtained, the **Segment** step provides intuitive, streamlined segmentation tools to extract the soft tissue, bone, and airway from the images, creating a variety of visualizations and renderings. The final **Results** step generates a summary document which includes all desired images, renderings and measurements selected throughout the analysis sequence.



Align



Visualize



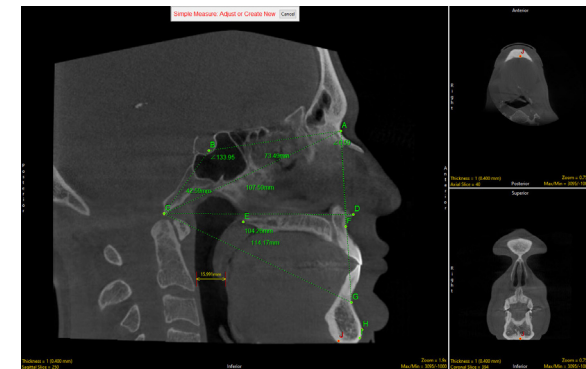
Airway



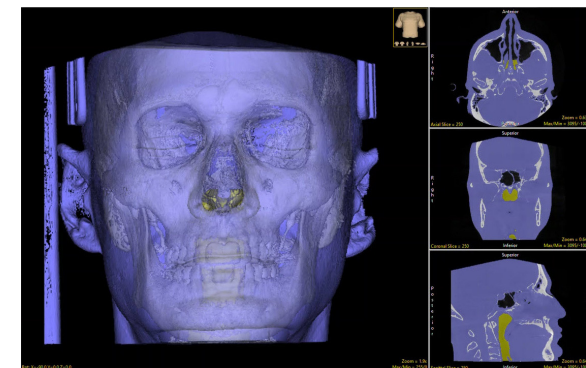
Introduction (continued)

Dual Scan Analysis (Using Pre- AND Post-Intervention Data)

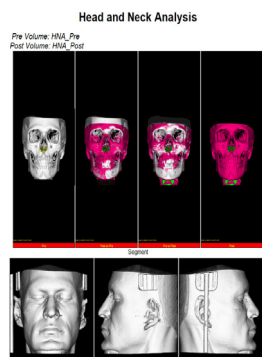
If two volumes are selected when opening HNA, analysis for the pre and post volume will be similar to the single volume analysis, but two additional tasks are introduced. The pre volume can be aligned/realigned if desired using **Align**, after which a **Register** step is required. Registration is the process of realigning the post volume to match the pre volume, even though the scans were taken at different times and the subject could never have been positioned in the scanner the same for each scan. The Register task aligns the volumes to appear as though the two scans were taken at the same time, making pre/post comparisons far more informative and revealing. The **Visualize, Airway** and **Measure** steps described above are then performed for both pre and post volumes. In the **Segment** step, following the definition of the soft tissue, bone and airway for each volume, a **Segmentation Comparison** offers a variety of ways to visualize the segmented objects, including pre/post superimposed renderings. The **Results** step for dual volume selection is similar to single selection.



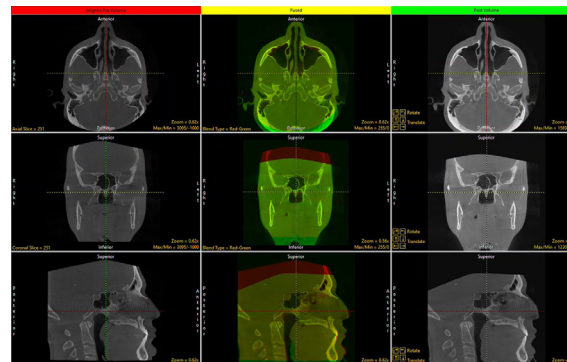
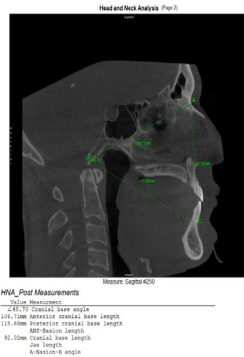
Measure



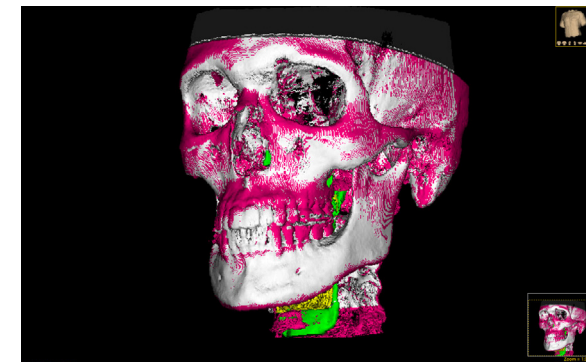
Segment



Results



Register



Segmentation Comparison



Single Scan Analysis

Using Pre- or Post-Intervention Data

This section of the HNA User's Guide will focus on how to perform an analysis involving a single scan, that is, the head and neck analysis of a subject at a single point in time. Later in the User's Guide we will look at how to compare head and neck data at two different points in time, usually with scans taken before and after a certain intervention. For now we will look at how to analyze a single pre-intervention scan. The same sequence will apply if a single post-intervention scan were to be analyzed.

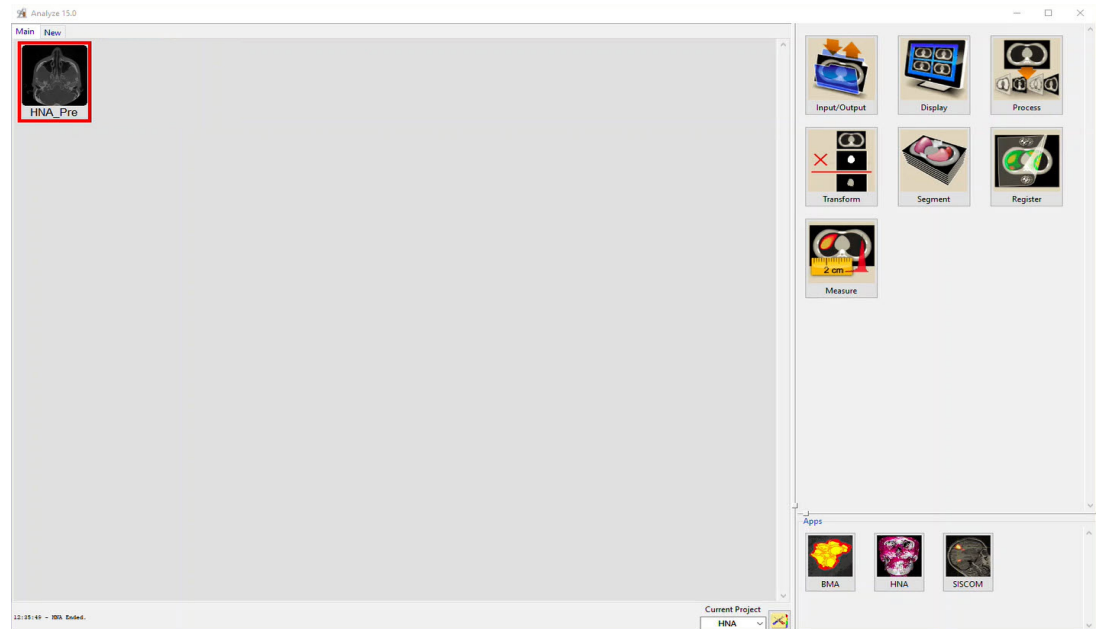
For single scans, the sequence of analysis is as follows:

- Align
- Visualize
- Airway
- Measure
- Segment

For each step, images and measurements can be added to the Results section, which can be saved as a pdf file.

To start, first load a single scan, known as a "volume", into the Analyze 15.0 workspace using the Input/Output button, then select the volume and click on the HNA app button.

- **To load Pre- or Post- Intervention data** into the Analyze 15.0 workspace, first press the Input/Output button on the right-hand side of the interface, navigate to the desired image dataset on the disk and load it. The volume will appear in the workspace.



- **To analyze a Pre- or a Post- Intervention volume with the HNA app**, select the volume you wish to analyze in the workspace by clicking on it. Then click on the HNA button in the lower right-hand side of the interface. This will open the HNA app in a separate window.

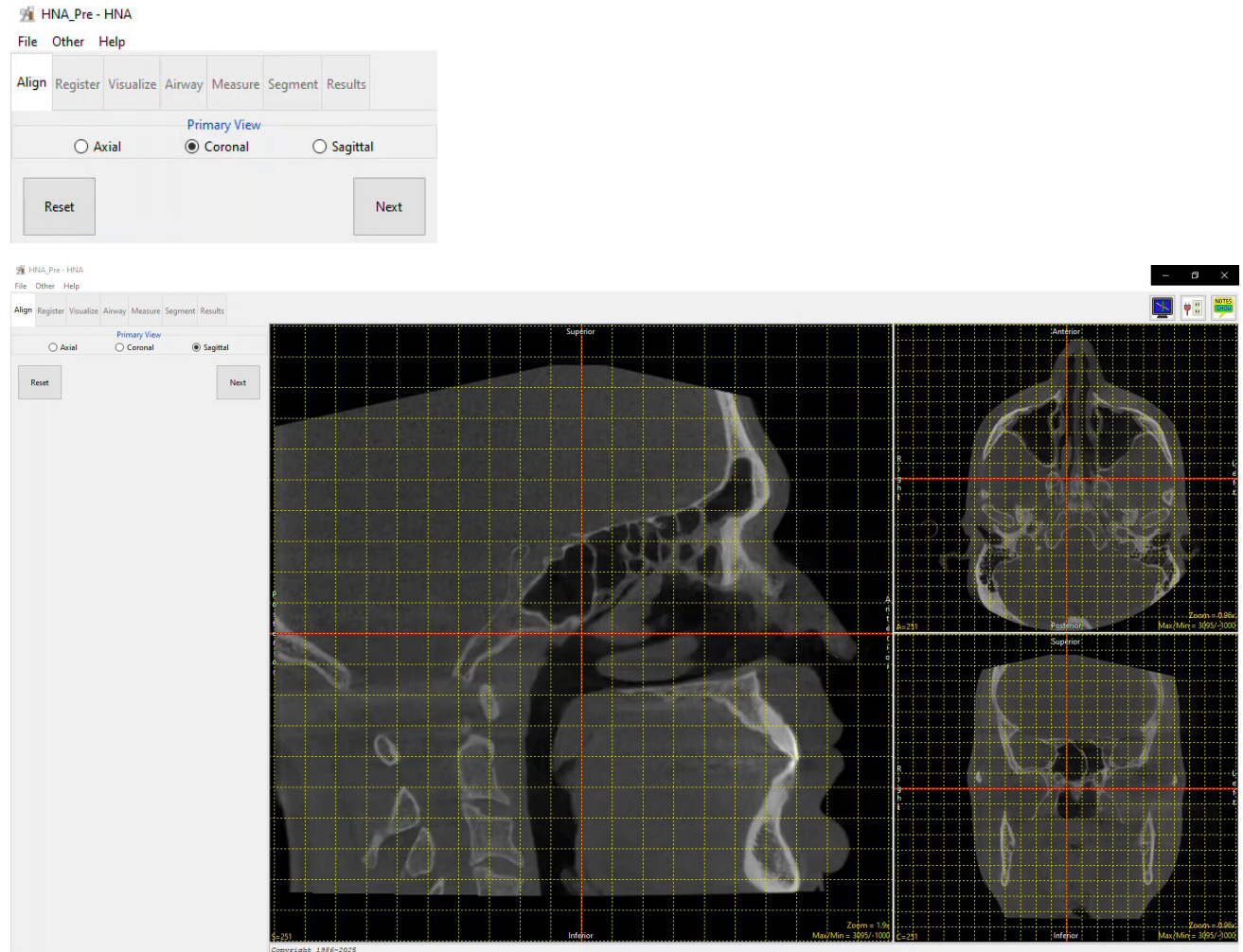




Align

The HNA app opens to the first function tab, which is the Align tab. This provides a way to realign the volume if it wasn't lined up precisely as desired during the scan procedure. If no realignment is required, the user can simply press the Next button and no alignment will take place.

However, if realignment is desired, the red crosshairs in each of the orientation image panels are utilized, with the yellow grids providing guidance for the image translations and rotations.



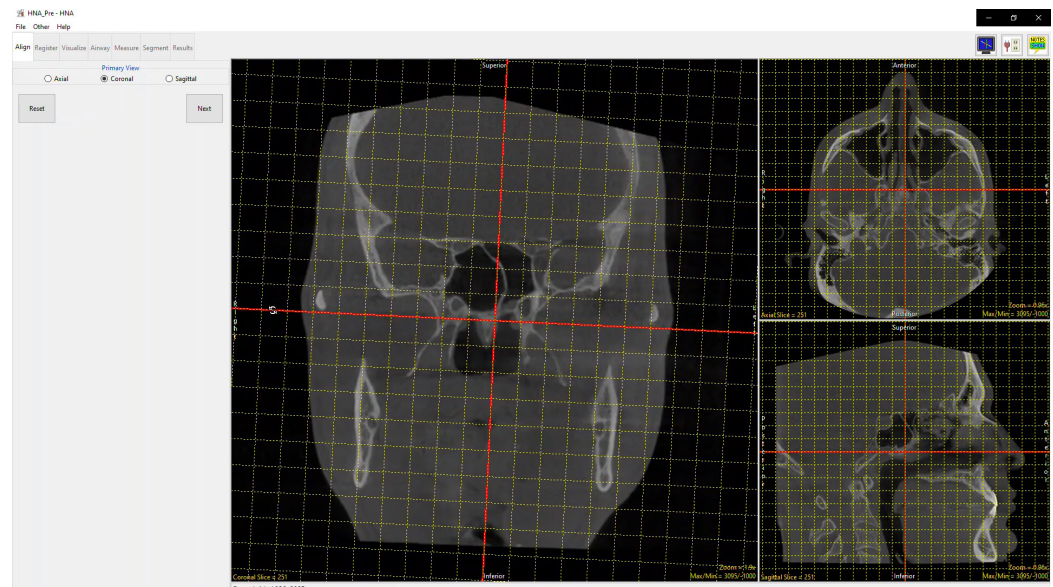
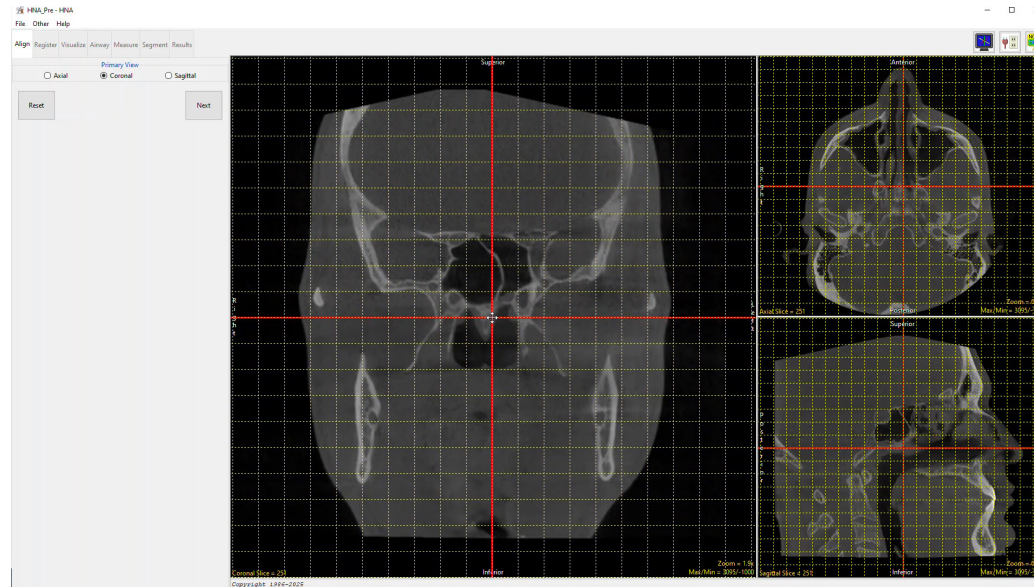


Align: Realignment

These realignment transformations can be performed in any of the three orientation panels. The Primary View is the larger of the three panels and can be set to Axial, Coronal or Sagittal, which can be selected either with the Primary View button under the function tabs, or by double clicking the orientation panel of choice.

To translate the image, the center of the crosshair in the middle of the grid is grabbed and moved to the desired image center location. For rotation, one of the ends of the crosshair is grabbed and pulled in the direction that properly reorients the image vertically and horizontally.

Releasing the cursor during translation or rotation of the image will reset the grid, and the volume will be realigned.



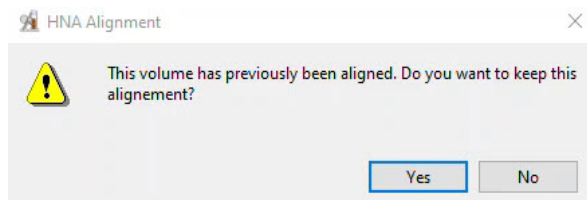
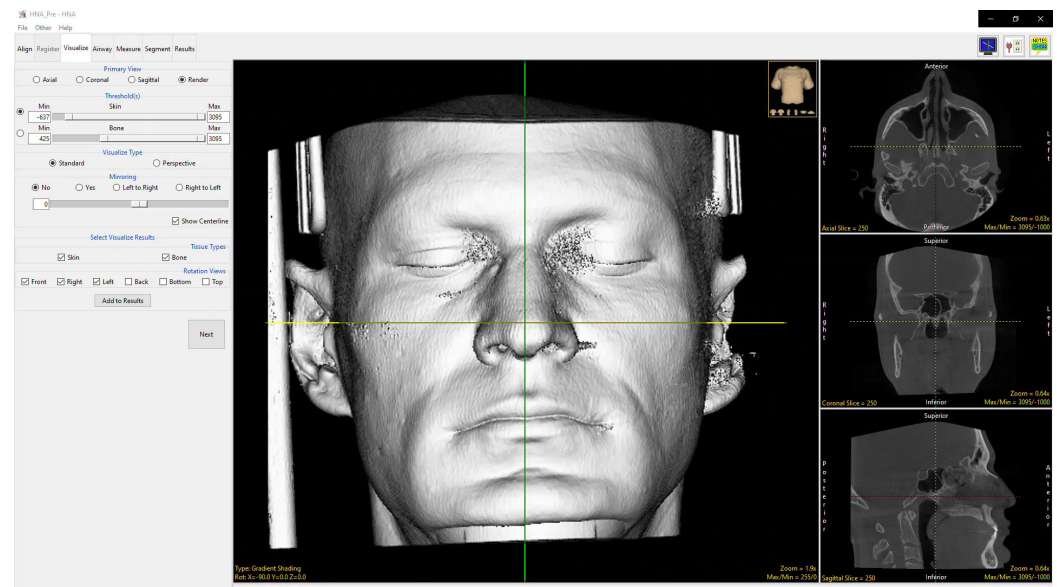
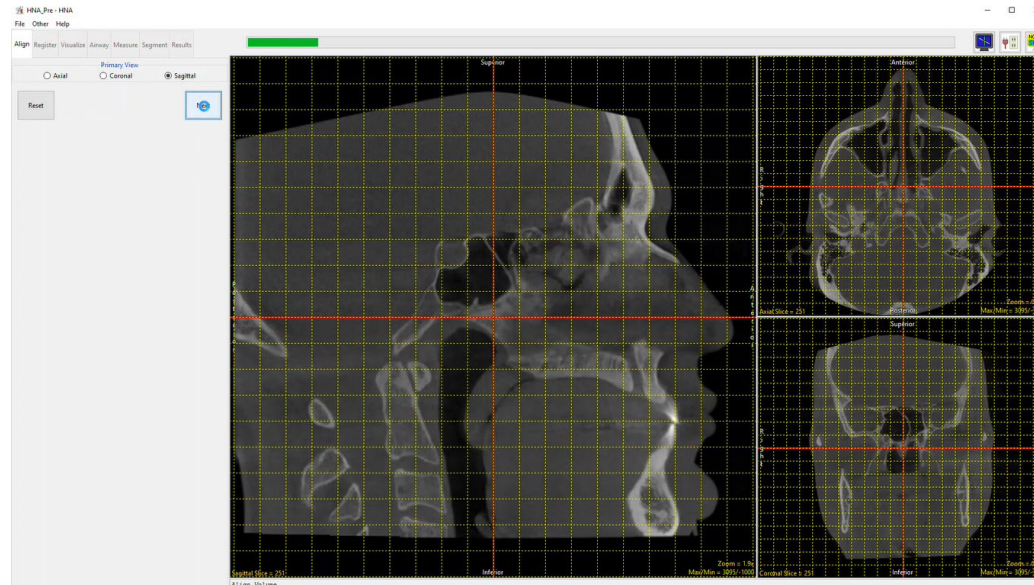


Align: Realignment

When the orientation is complete the Next button is pressed which opens the Visualize tab, where a rendering of the volume is displayed to allow for assessment of the alignment.

If the alignment is not satisfactory, the Align tab can be pressed again and realignment can be performed.

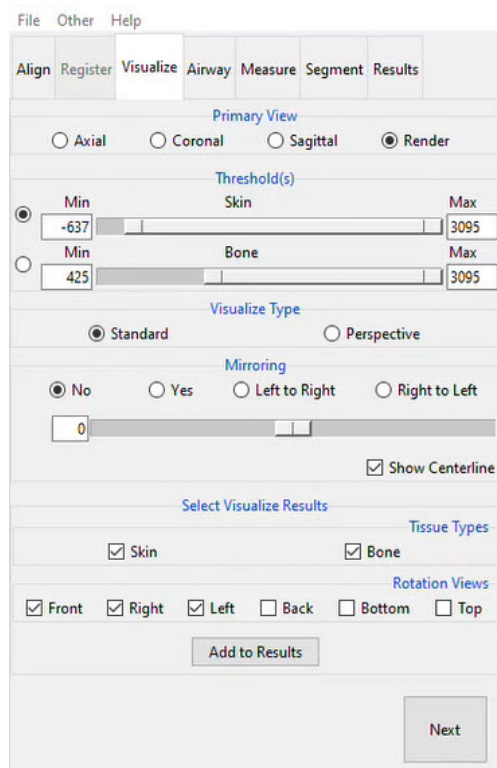
If this volume had been previously aligned, then an alert will appear, giving the choice of Yes to keep the previous alignment or No to start the alignment process again. If Yes is clicked, the HNA process will continue to the Visualize tab.



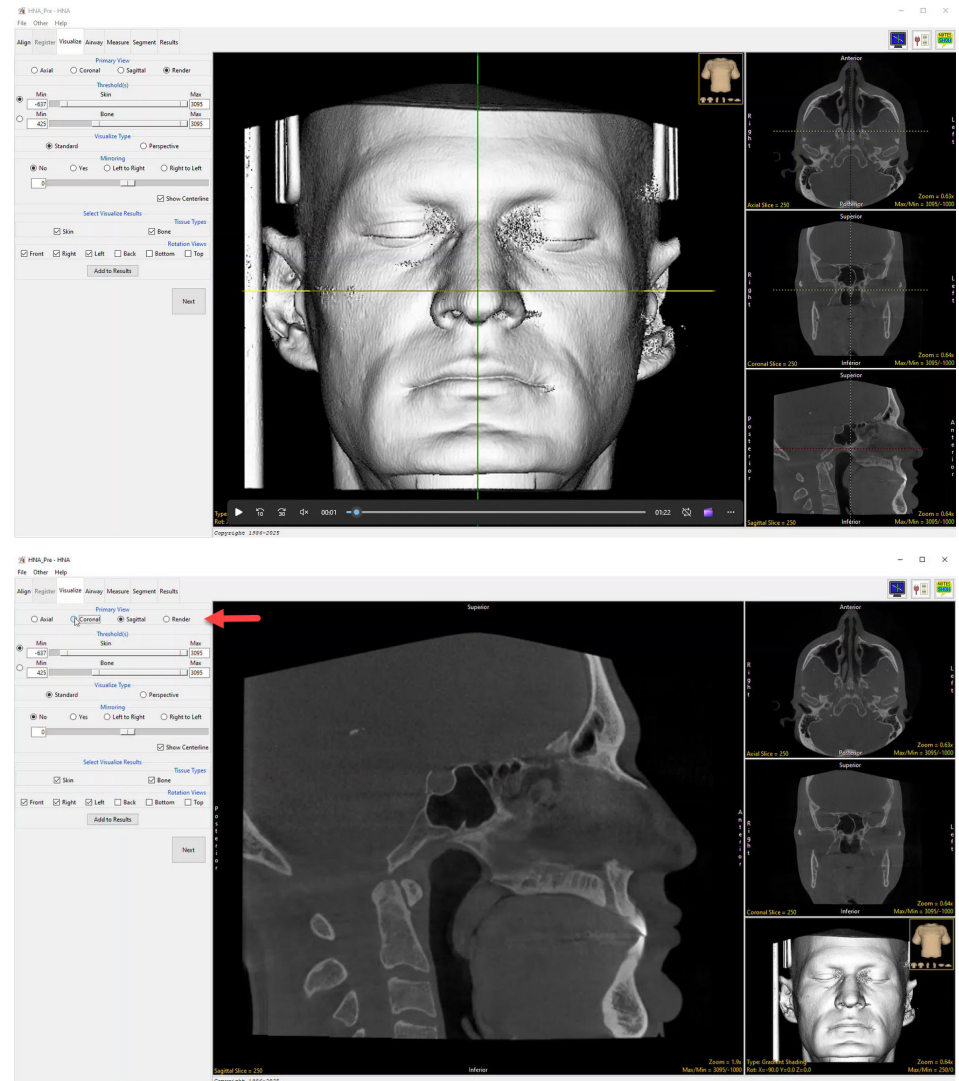


Visualize

The Visualize tab in the HNA module is designed to provide an assessment of the previous alignment step and to explore and record various visualizations or views of the subject. If the alignment is not satisfactory, realignment can be performed by simply going back to the Align tab.



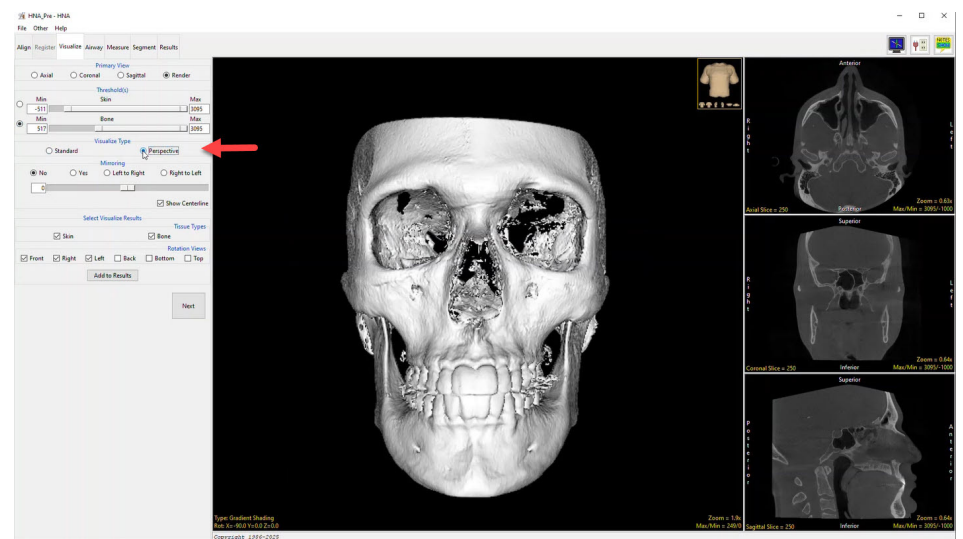
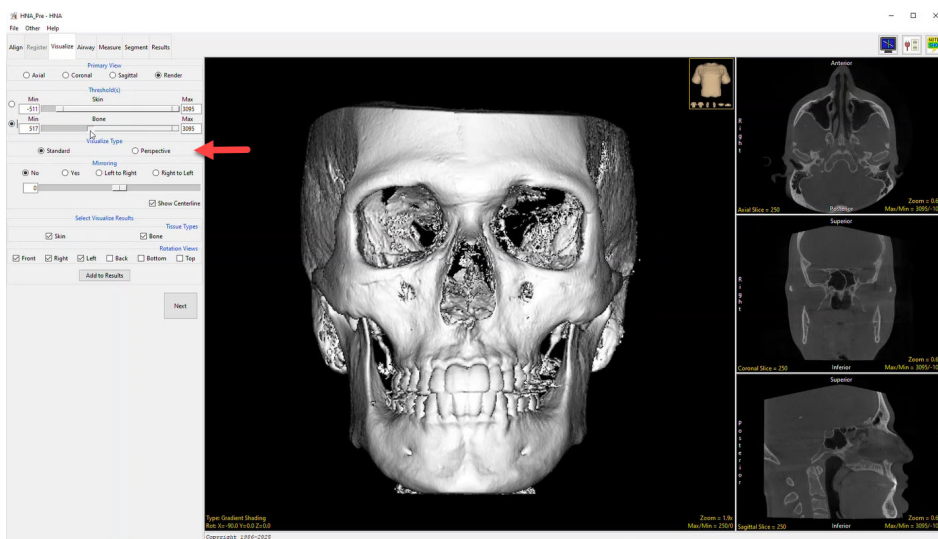
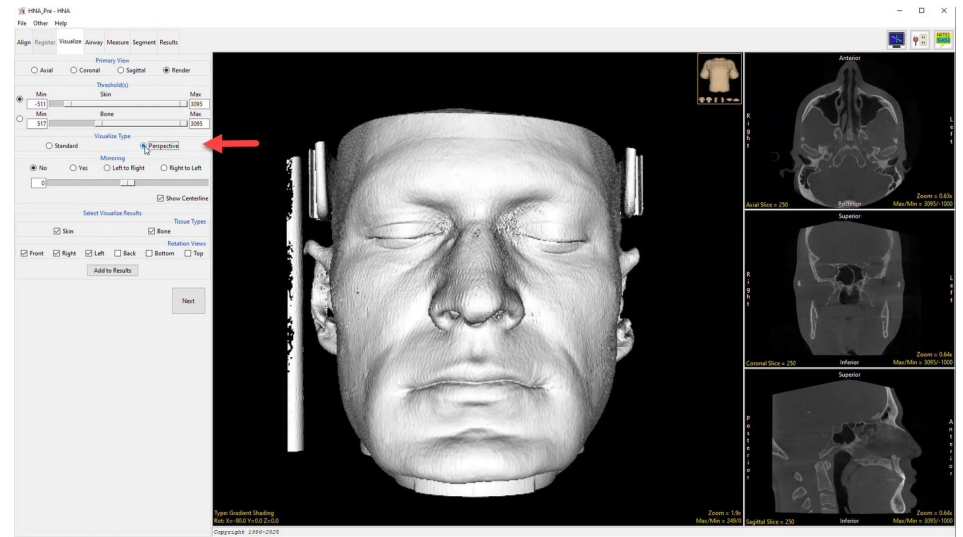
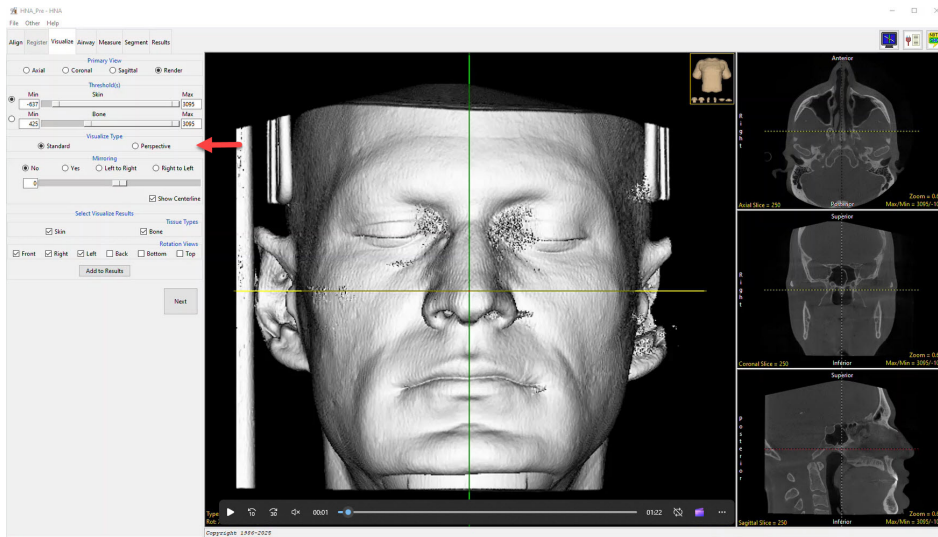
The primary image in Visualize is set to the rendering by default, but any of the other image panels can be set to primary with the Primary View radio buttons. Based on image grayscale characteristics, the threshold values for the skin and bone visualizations are preset, but these can be adjusted to improve the renderings.





Visualize: Standard and Perspective Views

Visualizations can be viewed with standard parallel ray casting or with a more realistic perspective view by selecting the desired Visualize Type radio button.





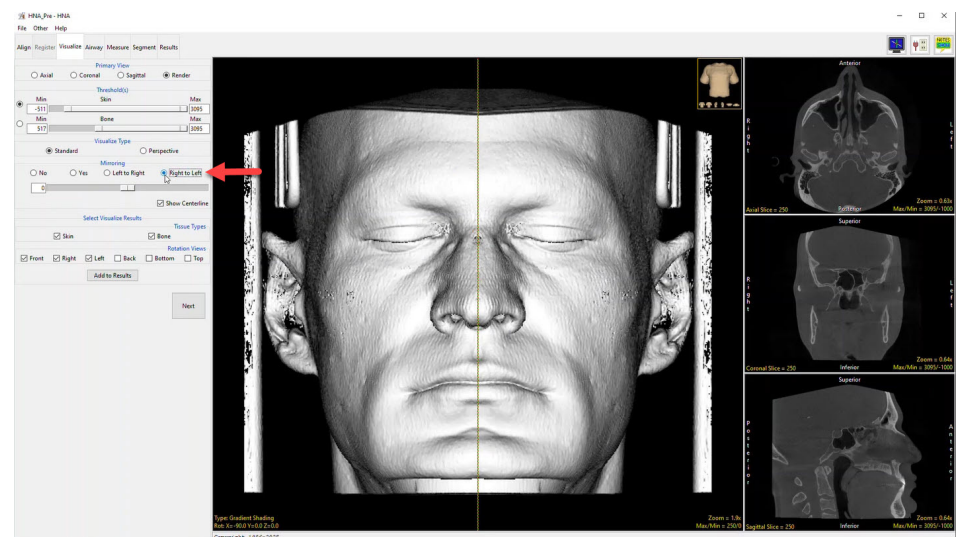
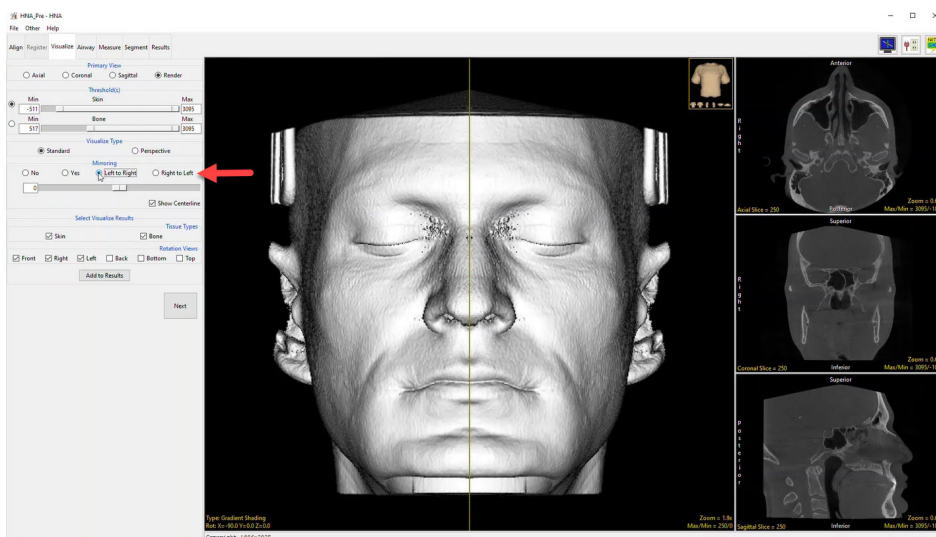
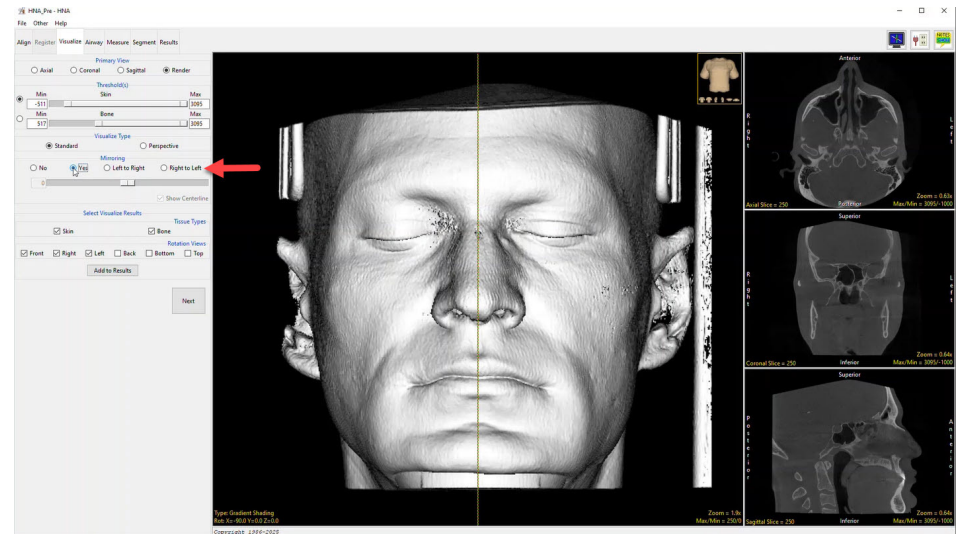
Visualize: Mirroring

The visualizations can be displayed with various mirroring options using the mirroring radio buttons and the center line adjustment slider.

Selecting the Yes button simply reverses the sides so the left side is moved to the right side and the right is moved to the left creating a true mirrored image.

If left to right is selected, the left side is kept as is but the right side is replaced by the mirrored image of the left side creating a perfectly symmetrical image with both sides being generated from the left half.

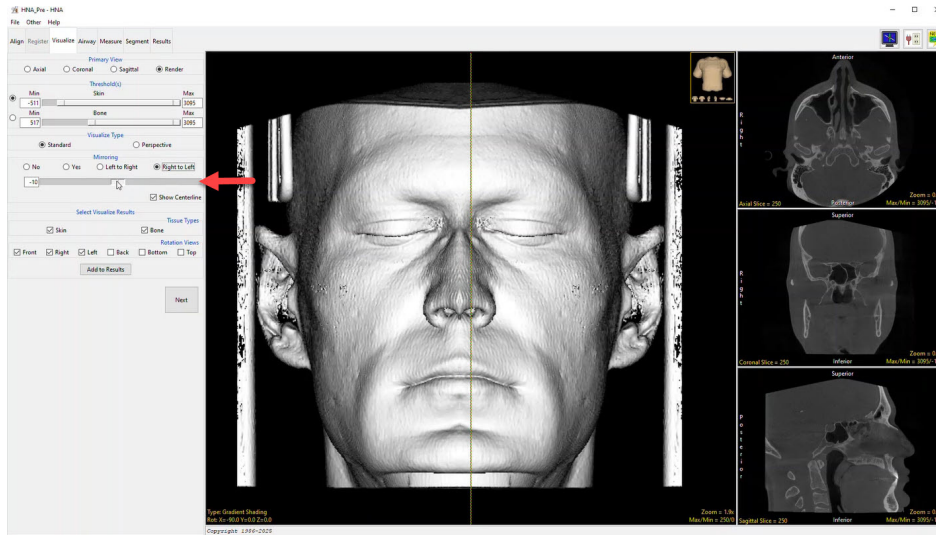
Likewise, the right to left option creates a symmetrical image with both sides generated from the right half.



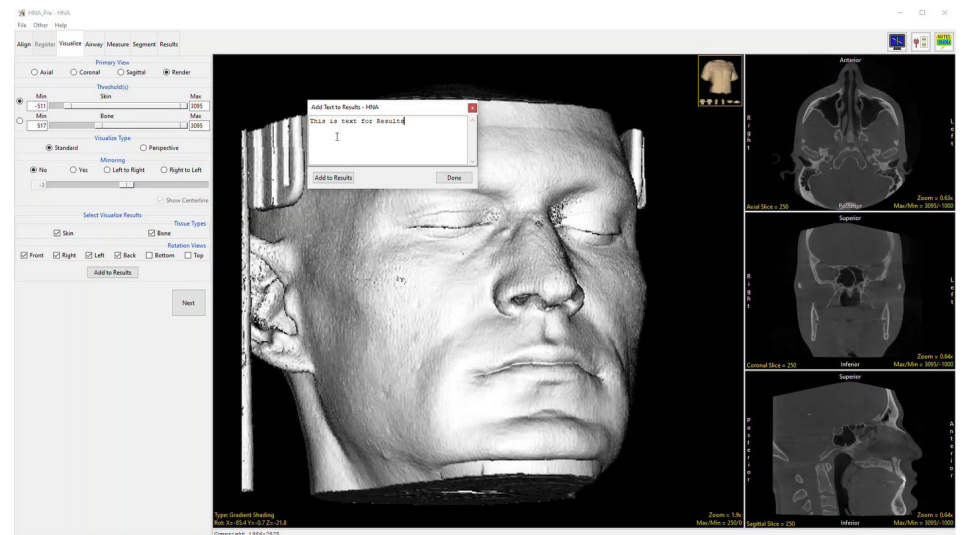
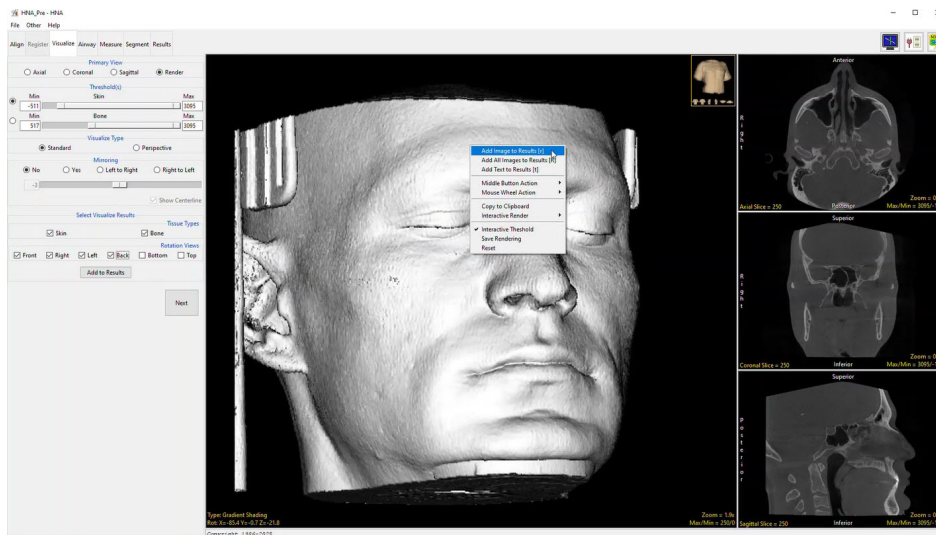


Visualize: Slider Adjustments and Add to Results

If the original image wasn't perfectly centered, the slider may need to be used to adjust the mirrored images for a more realistic rendering. The Showed Center Line checkbox allows the user to toggle on and off the center line of the mirrored images.



The Select Visualize Results section of the control panel is used to select which renderings will be saved in the results document at the end of the analysis. The options include skin and bone renderings, as well as each of the six principal orthogonal views. Once the choices have been made, press the Add to Results button to include each rendering in the results document. To save any single image to the results document that isn't included in these options, right-click in the desired image and select Add Image to Results. This can be a customized rendering, perhaps after a rotation using the middle mouse button or any of the three orientation images. To save all four image panels to the results, choose Add All Images to Results.

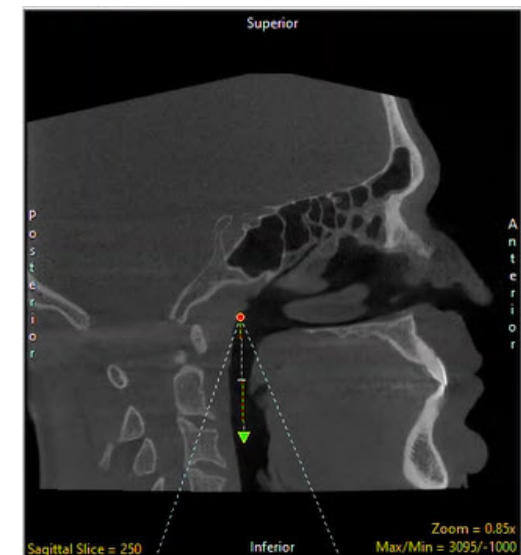
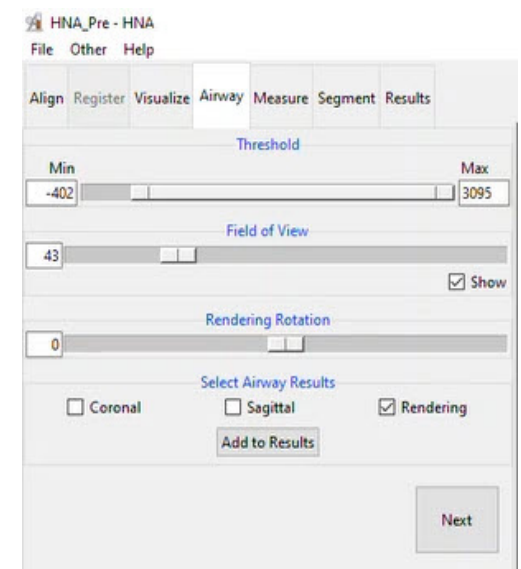
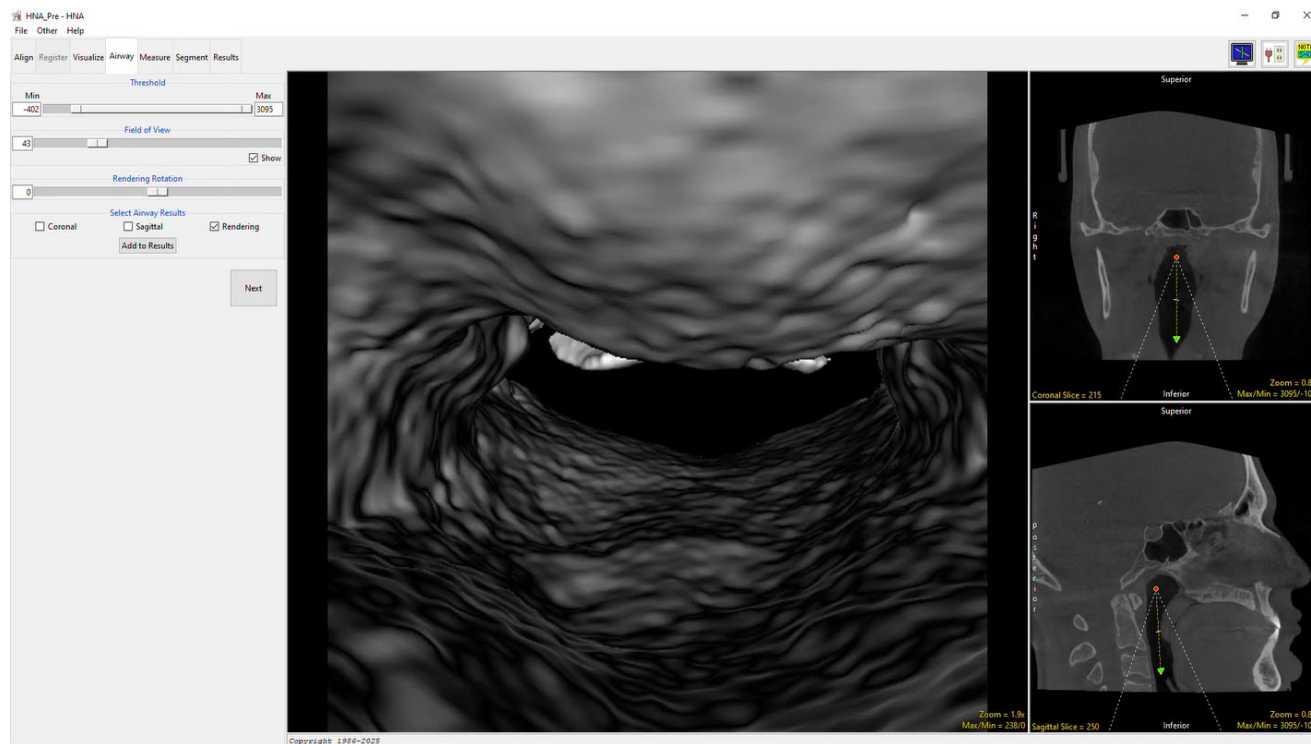


To include freeform text to the results document, right-click in one of the image panels and select Add Text to Results. This pops up a text box to enter the desired text. Once the visualized steps are complete, press the Next button to proceed to the Airway tab.



Airway

The Airway tab in the HNA app is designed to provide an internal rendering or endoscopic view of the airway.



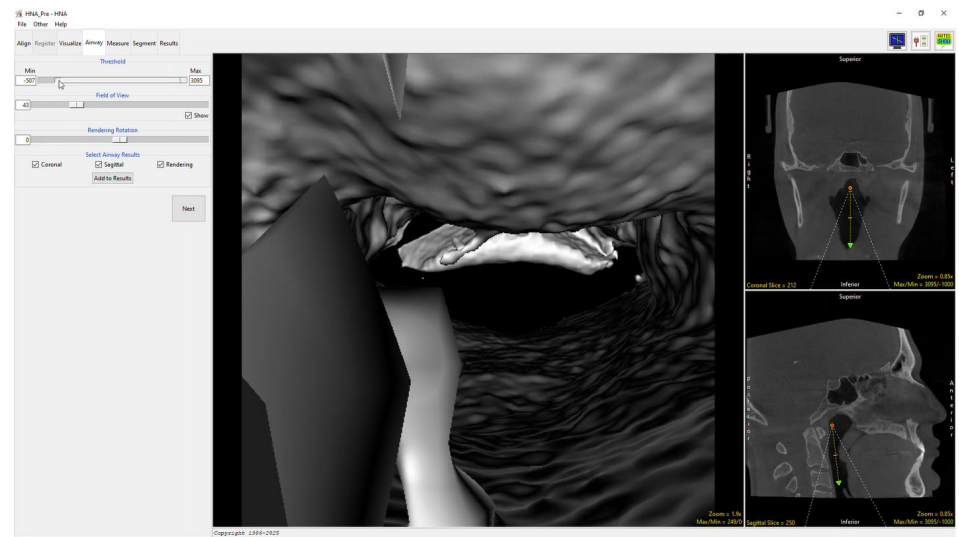
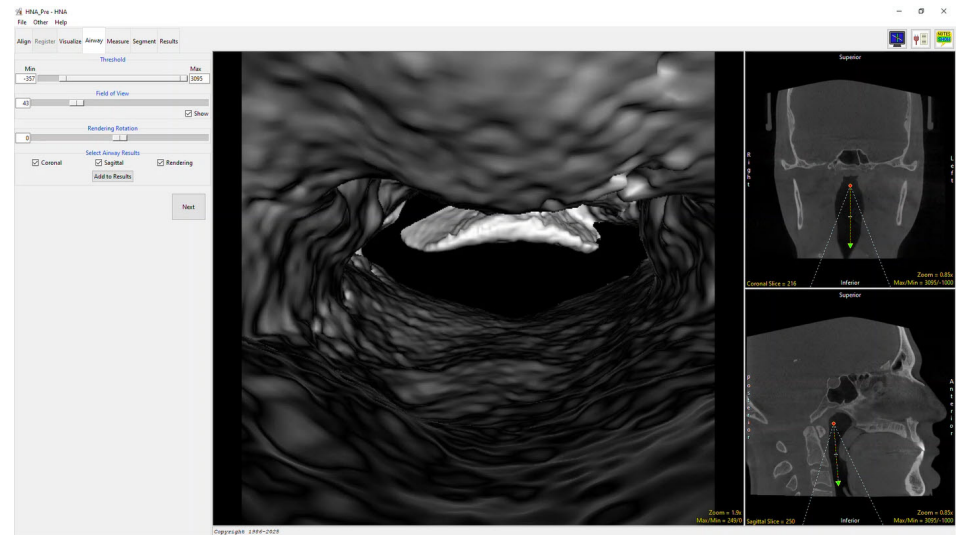
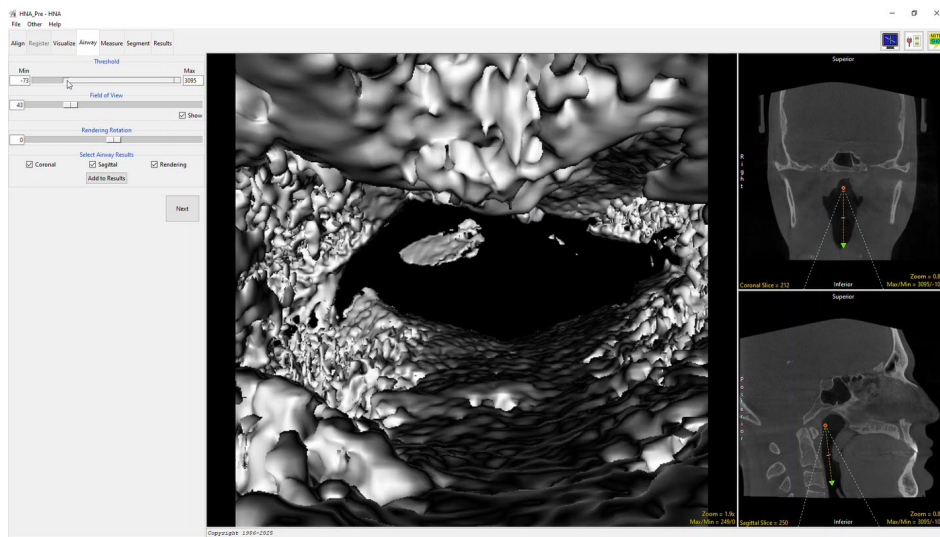
The controls on the left and the image panels on the right are used to adjust what is being viewed in the airway rendering. The arrow displayed in both the coronal and sagittal images defines the direction of the view. The small red circle at the top of the arrow represents the location of the camera or eye, and the green triangular tip of the arrow represents what is being looked at. Each icon can be moved independently in either of the two image panels to obtain the desired view. To move the entire arrow, keeping the length and direction unchanged, use the small handle at the middle of the arrow. Note, if the image was centered properly in the align step, arrow adjustments in the coronal view are rarely needed.



Airway: Thresholding

Once the arrows are placed in the desired position, the threshold slider in the control panel can be used to adjust the rendering. In case there are too many voxels included, causing excess tissue to be rendered, or in case there are too few voxels included, which can cause holes in the rendering.

Note, the min threshold is the one used most often to improve the rendering. The max end of the slider should be set all the way to the right and rarely needs to be changed.

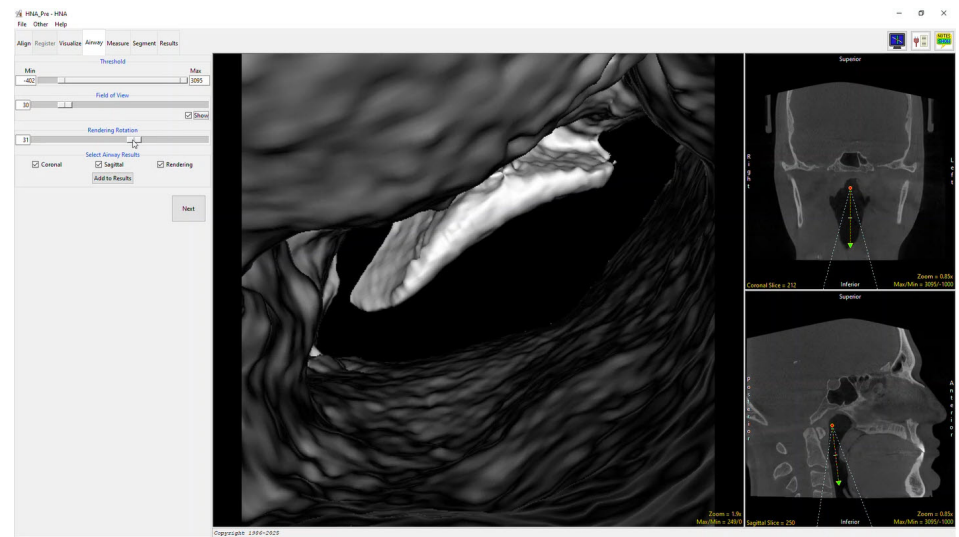
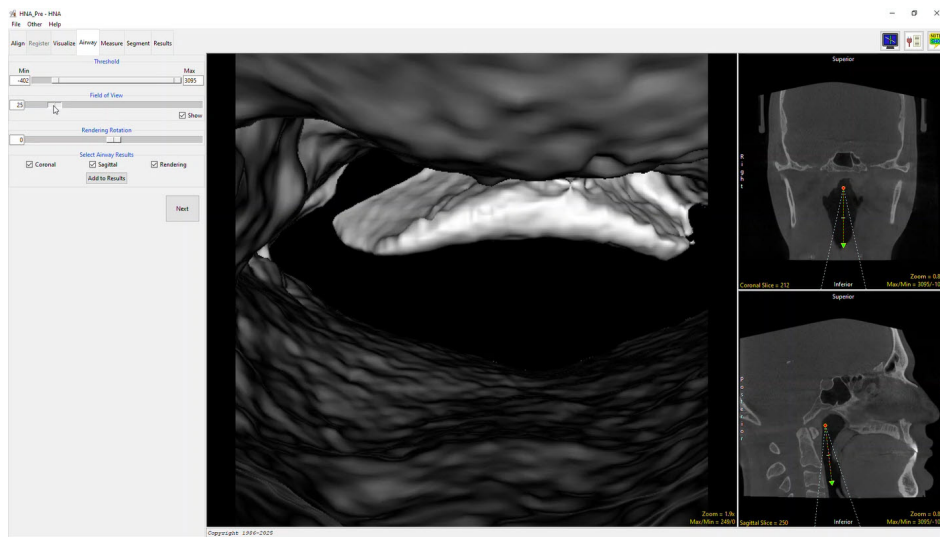
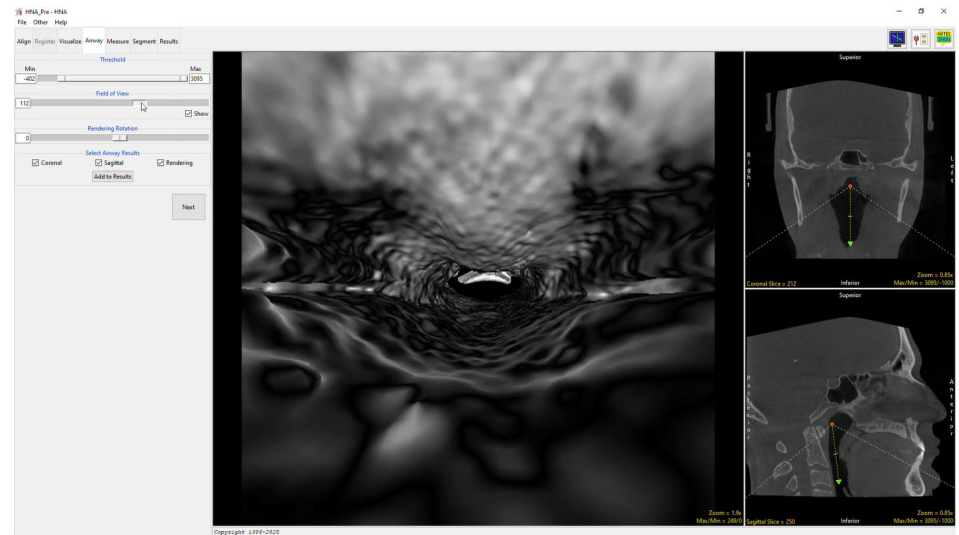




Airway: Field of View and Rotation

Adjust the field of view slider to change how much of the rendering will be in sight. Decreasing the field of view narrows the scene, making distant objects appear larger. Increasing it opens the view, making the rendering appear further away.

To change the horizon of the view, adjust the rendering rotation slider.

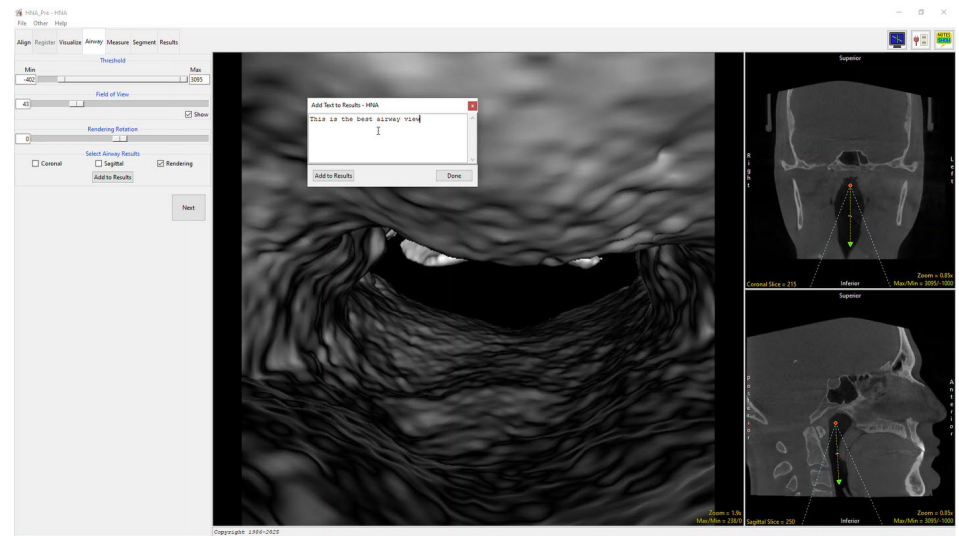
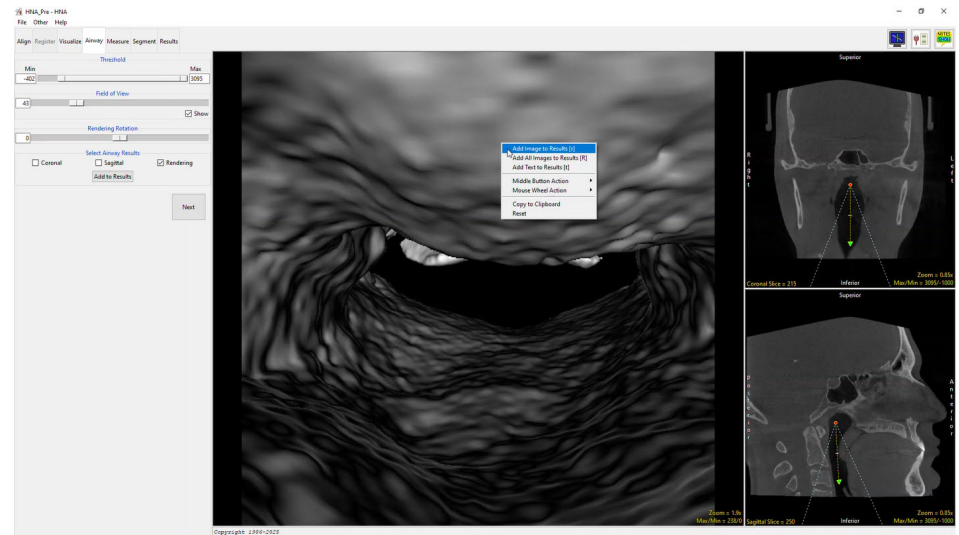
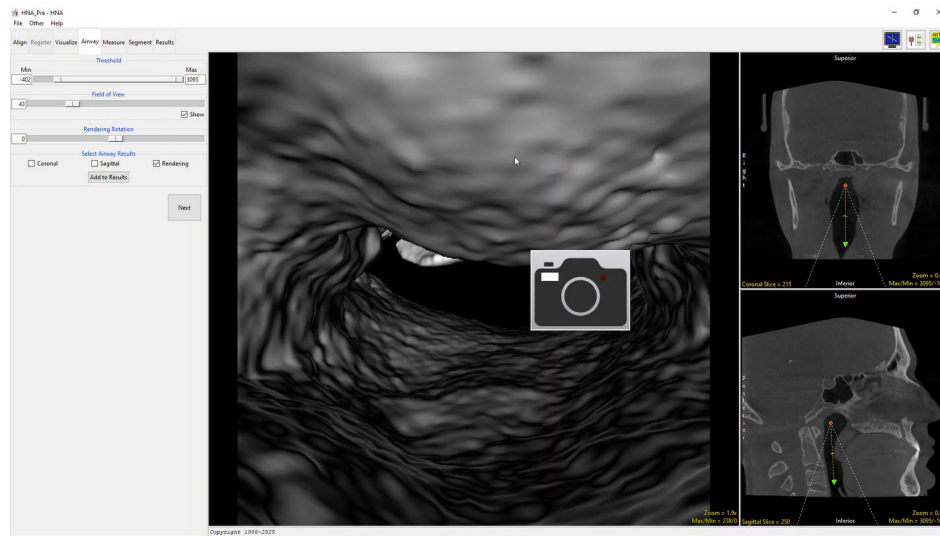




Airway: Add to Results

The coronal, sagittal or rendering panel display can be added to the results by clicking the Add to Results button in the Select Airway Results section. Additionally any image or set of images can be captured and saved to the results by selecting the Add Image to Results or Add All Images to Results option respectively, from the right-click menu when the mouse is on an image, and a camera icon will appear on the screen to confirm the request. Text can also be added by selecting the Add Text to Results option from the right-click menu.

After all images and text have been added to results, press the Next button to move on to the Measure tab.





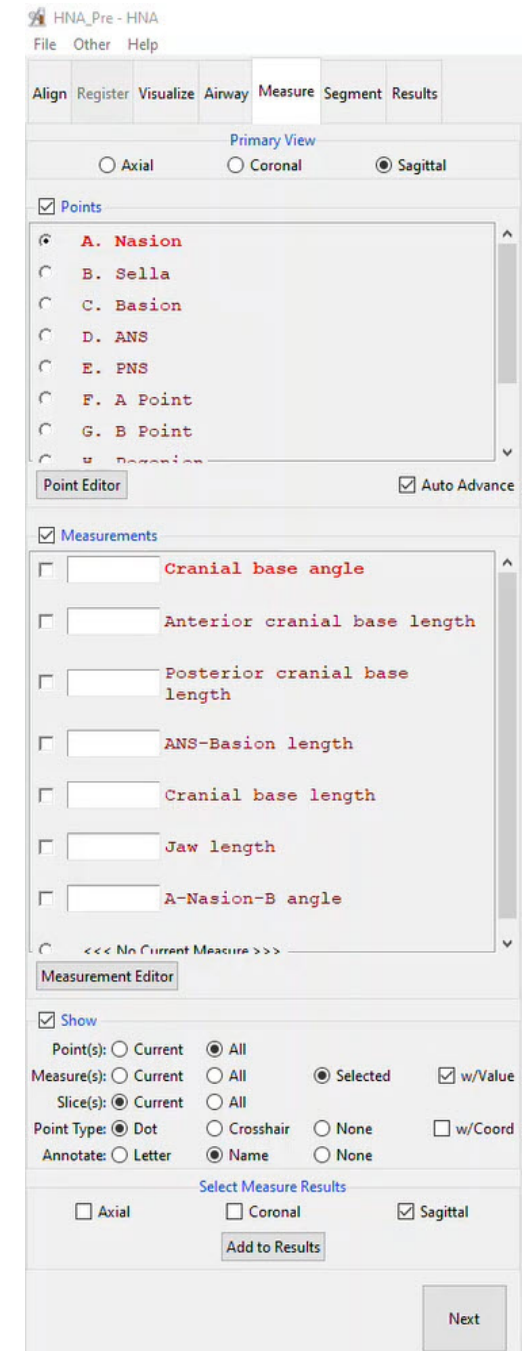
Measure

The Measure tab in the HNA app is designed to perform quantitative analysis of the head and neck, using standard Cephalometric landmarks, which are placed as points on the image.



Once the points are placed, the pre-defined distances and angles are automatically calculated. The analysis can be customized by adding additional landmarks and 2D or 3D measurements.

The left side of the Measure tab includes a list of points, which by default are the 10 most common Cephalometric landmarks, and the 7 most common measurements based on these landmarks, along with options to control how the points and measurements are displayed and what results are saved in the Results document. Editors are provided to add, delete or change points and measurements.





Measure: Placing Points

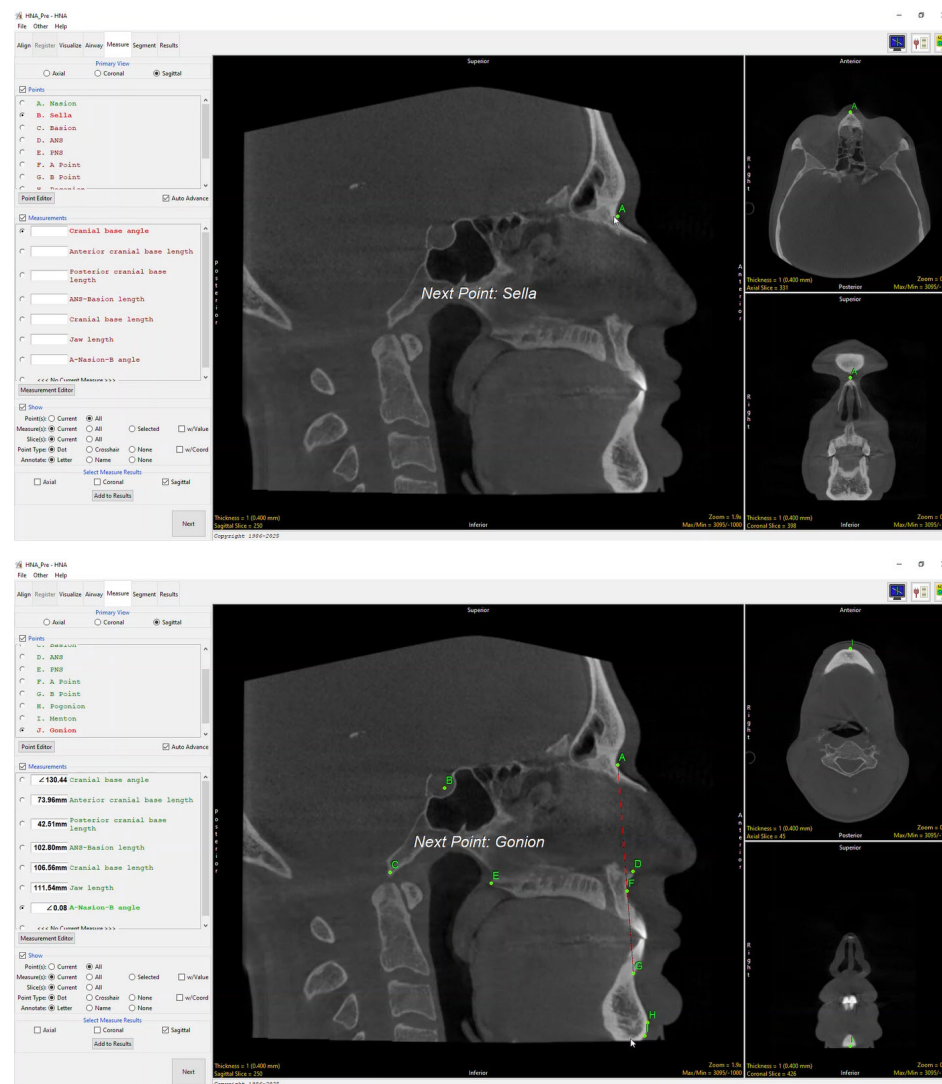
The Primary image is set to Sagittal by default but either of the other two image panels can be swapped in with the Primary View radio buttons at the top of the Control Panel. The landmarks to be placed on the images are listed in the Points section near the top portion of the control panel.

Typically, all landmark points are placed on the same slice in the Sagittal image but may be placed on any slice in any of the three orientation images. The selected point in the list indicates which one is to be placed next, using a left mouse click on the image. If the Auto Advance option at the bottom right of the list is checked, the point selection will automatically change to the next one in the list, providing a simple, efficient way to place all the landmark points.

If any points need to be moved, they can be grabbed in the image with the left mouse and repositioned to a new location.

To remove a point already placed, move the cursor over the top of it, right-click, and select Reset Point. To remove all points already placed, move the cursor over any one of them and select Reset All Points

For added point placement guidance, the image thickness can be changed by clicking on the yellow "Thickness" text in the lower left corner of the image panel. When the cursor changes to the Thickness icon, use the mouse to increase or decrease the number of slices included in the MIP (Maximum Intensity Projection) image.

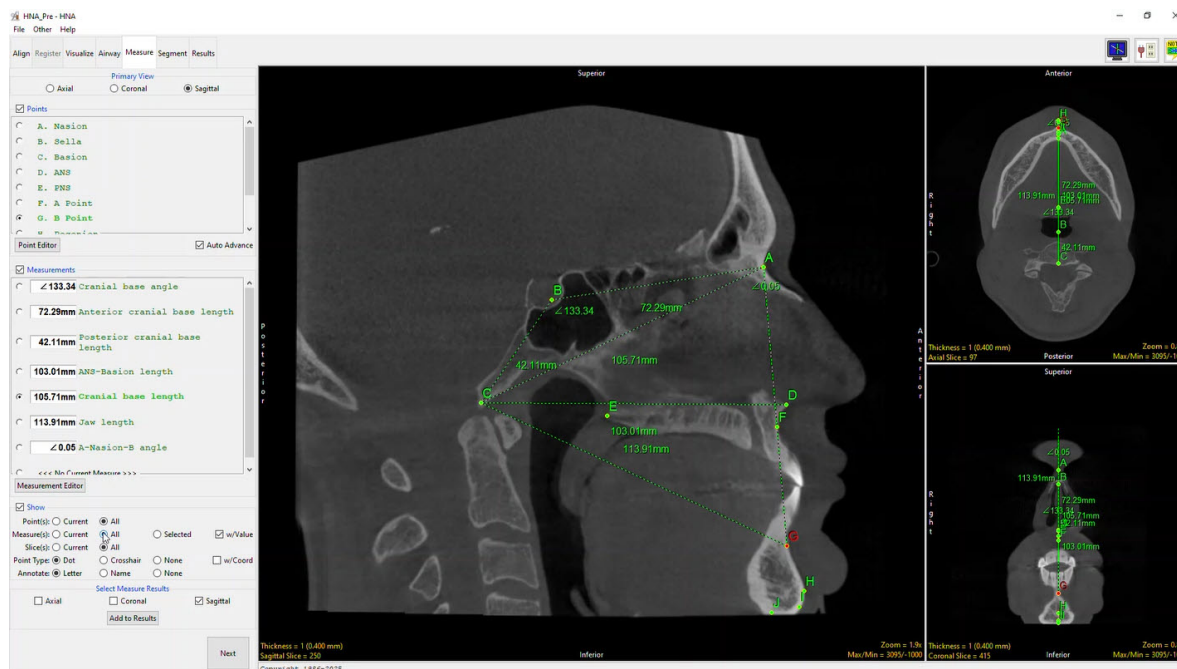




Measure: Defined Measurements and Display Options

The list of defined landmark-based measurements is shown in the Measurements section near the middle of the Control Panel. As the landmark points are placed, the measurements are automatically calculated and displayed in the list. Options for displaying the calculated values on the images and in the Results are described below:

To hide the Measurements list from the Control panel, the checkbox at the top right of the Measurements section can be unchecked. To add, remove, or change measurements in the list, press the **Measurement Editor** button, which pops up a Measurement Editor window.



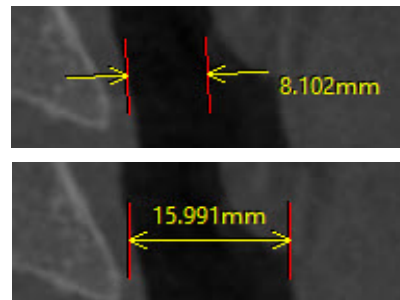
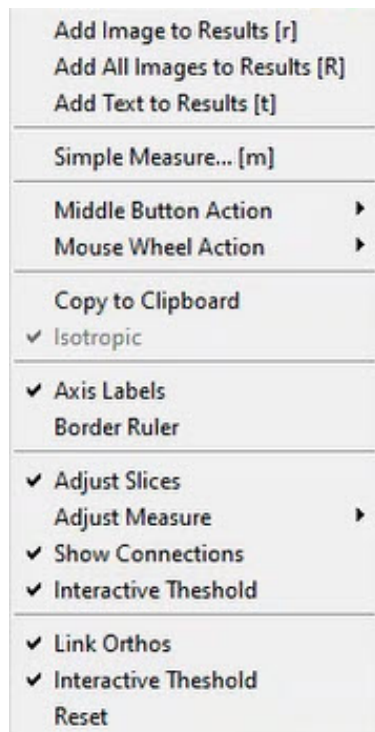
The **Show** section near the bottom of the Control panel provides a way to customize how the points and measurements will be displayed. The **Point(s)** options provide a way to toggle between showing all points on the images, or just the Current point. The **Measure(s)** options provide a way to toggle between showing all measurements on the images, or just the one selected in the Measurements list above. To display more than one but not all measurements on the images, the Selected option must be chosen, which changes the Measurements above from a single selection list to multi-selection list. Each Measurement selected in the list will be displayed on the images. To include the numerical value of the measurements, ensure the “w/Value” box is checked. If the **Slice(s)** option is set to “Current”, only the points and related chosen measurements on the currently displayed slices will appear in the images. To display all points and identified measurements, the “All” option should be selected. The **Point Type** display option by default, is a dot. This can be changed to a crosshair, no indicator at all, or with coordinates (“w/Coord”). The **Annotate** options can identify each point in the images as either the assigned letter, the defined Landmark Name, or none at all. To hide the Show options from the Control panel, the checkbox at the top right of the Show section can be unchecked.



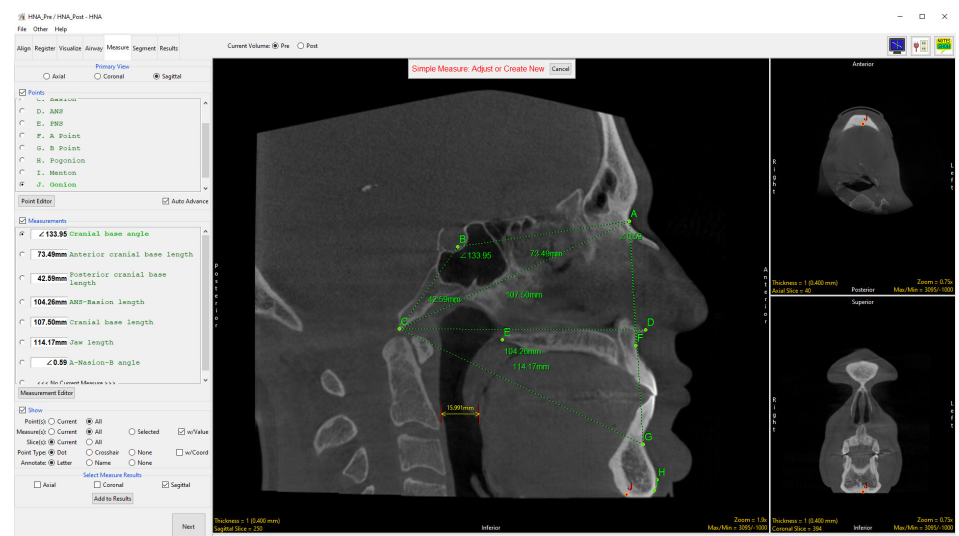
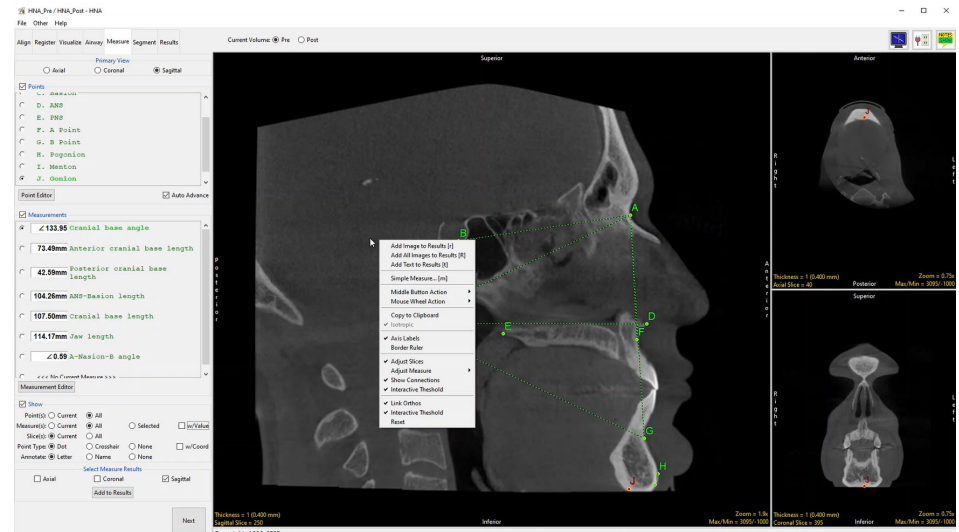
Measure: Simple Measure Tool

Although the Measure tab allows distance and angle measurements to be made automatically from the points in the Points list, there may be instances when a simple point-to-point measurement is required.

To make a single linear measurement not included in the Measurements section list, right-click in one of the images and select the "Simple Measure..." option. To make the measurement, left-click on a point in the image and drag the mouse to the desired endpoint. Either of the endpoints can be moved or an entirely new measurement can be made, which replaces the previous one.



To add the Simple Measure image to the Results, select the "Add Image to Results" option from the right-click menu. To exit the Simple Measure mode, press the Cancel button at the top of the image.





Measure: Add to Results

The Select Measure Results section at the bottom of the Control Panel offers options to include screenshots from each of the three image views. Once the choices have been made, press the Add to Results button to include the selected images and all the measurements from the Measurements section in the Results document.

In addition, any image or set of images can be captured and saved to the results by selecting the Add Image to Results or Add All Images to Results option respectively, from the right-click menu when the mouse is on an image. A camera icon will appear on the screen to confirm the request. Text can also be added by selecting the Add Text to Results option from the right-click menu.

After all images and measurements have been added to results, press the Next button to move on to the Segment tab.

☒ Show

Point(s): ☐ Current ☒ All

Measure(s): ☐ Current ☒ All ☐ Selected ☒ w/Value

Slice(s): ☒ Current ☐ All

Point Type: ☒ Dot ☐ Crosshair ☐ None ☐ w/Coord

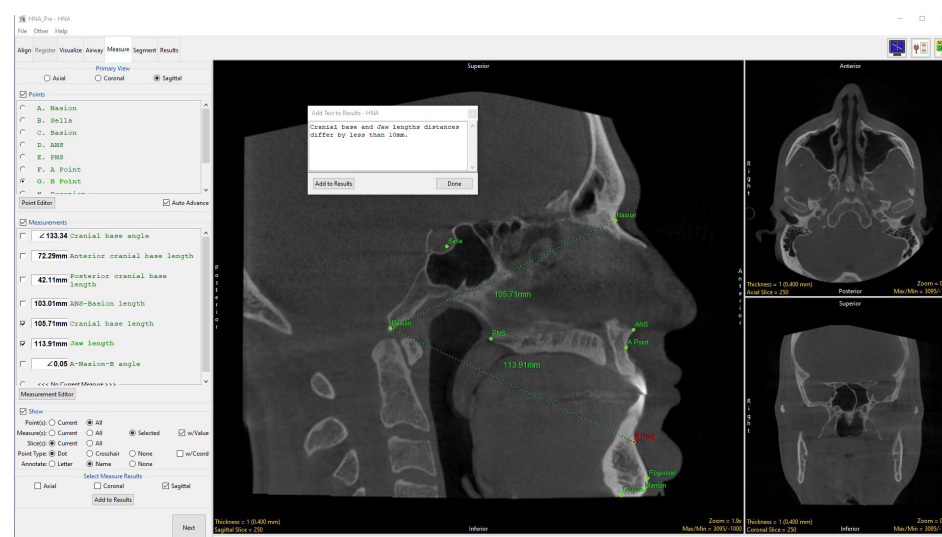
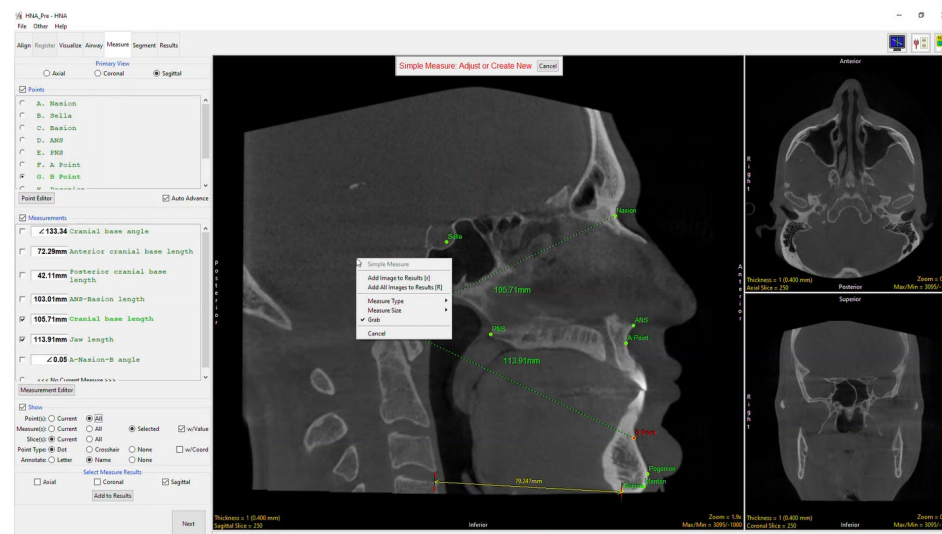
Annotate: ☒ Letter ☐ Name ☐ None

Select Measure Results

☐ Axial ☐ Coronal ☒ Sagittal

Add to Results

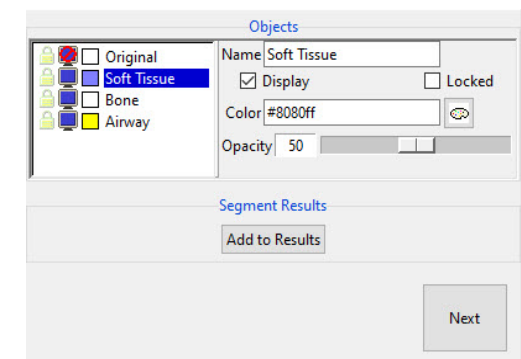
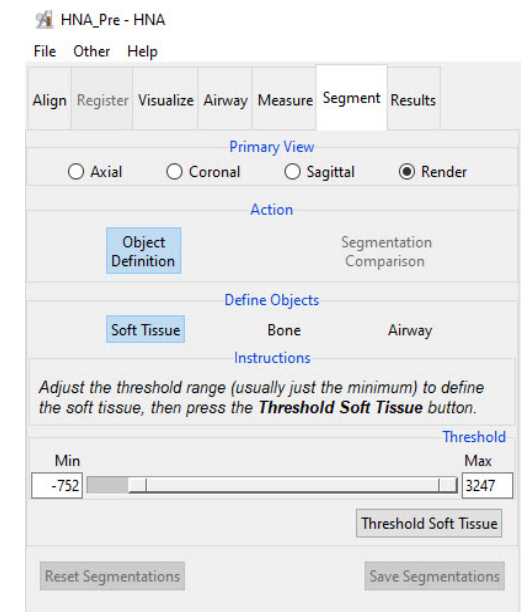
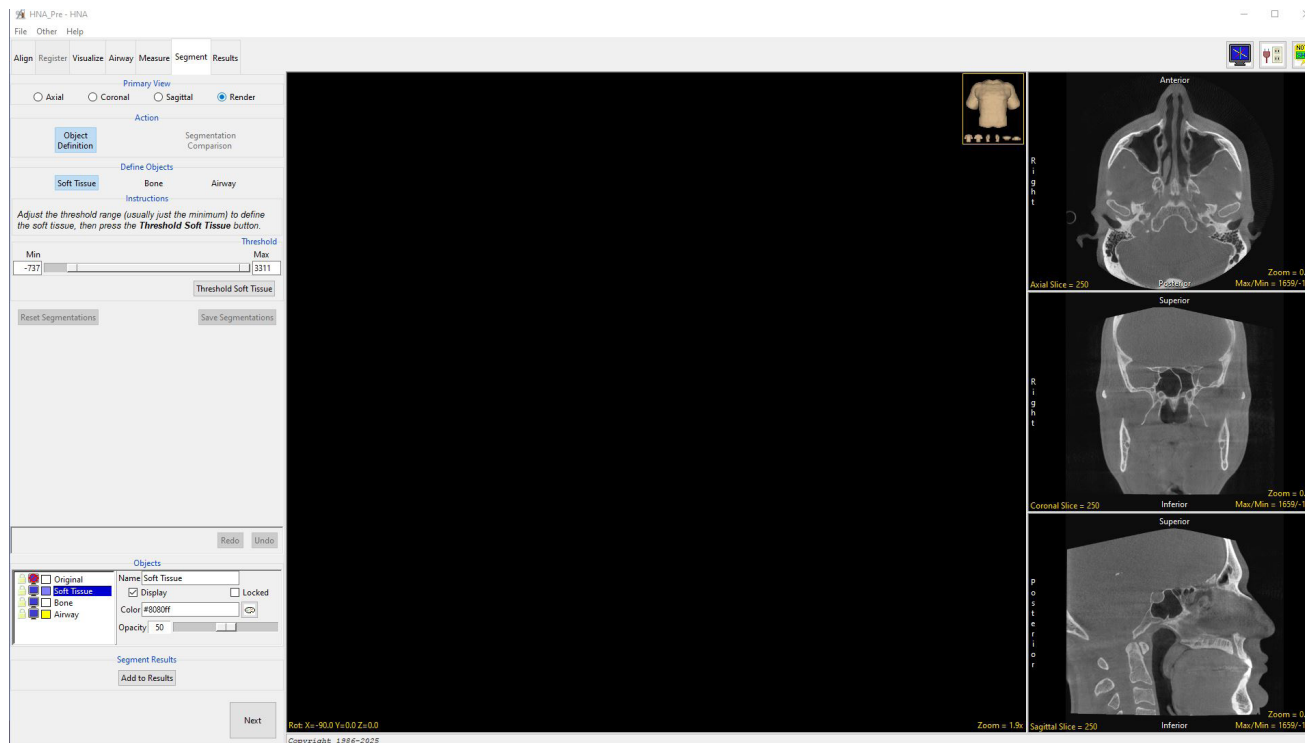
Next





Segment

The Segment tab in the HNA app is used to efficiently define the three most important regions of interest in head and neck analysis scans, soft tissue, bone, and airway. Once defined, the segmented objects are used to generate various renderings from a single scan or from pre and post interventions scans which can be combined to show changes that have taken place over time.



The Primary view is set to the Render panel by default but any of the three orthogonal image panels can be swapped in with the Primary View radio buttons at the top of the Control Panel.

Initially the Render panel is dark, as no objects have yet been defined. As the Soft Tissue, Bone and Airway objects get defined, the Objects section at the bottom of the Control Panel can be used to determine how these objects are displayed in the Render panel, including options for changing color and opacity.



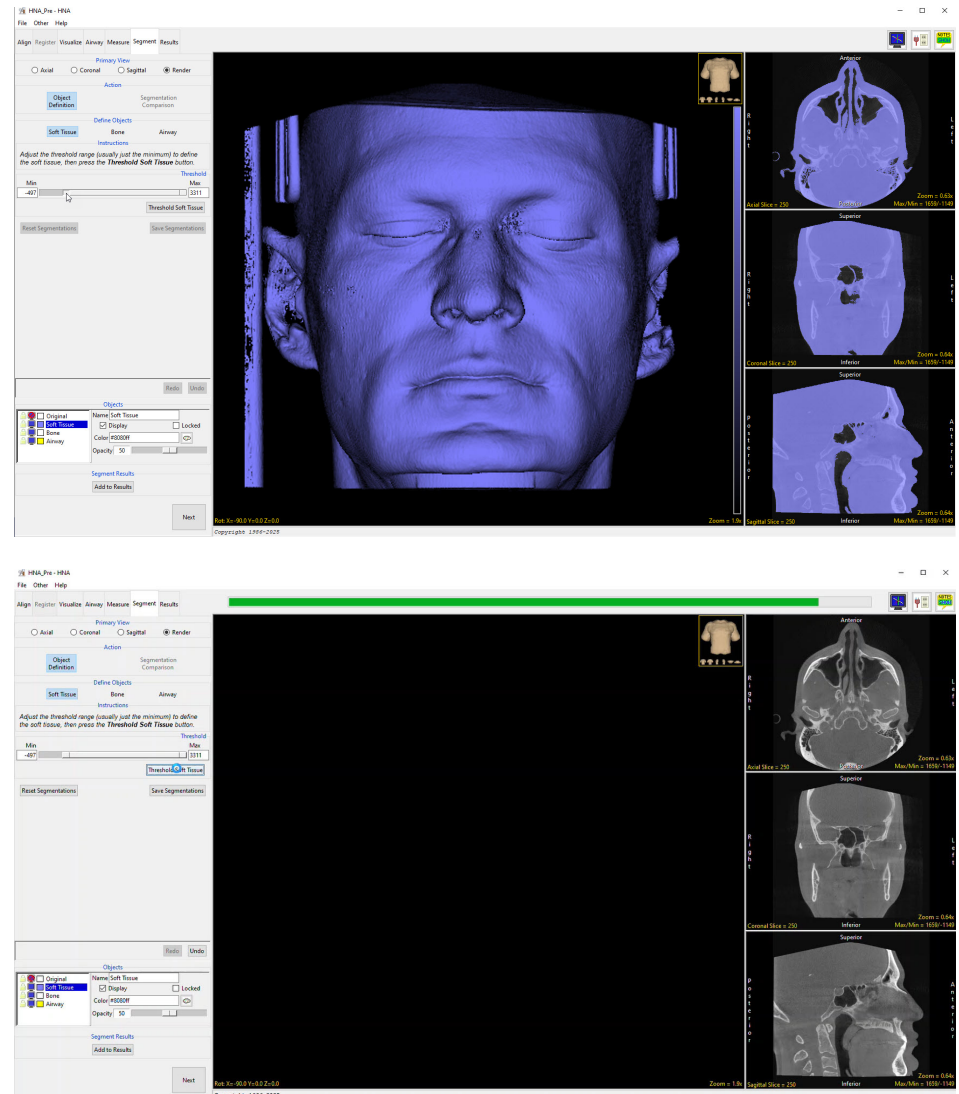
Segment: Defining the Soft Tissue Object

In Segment we define the regions of interest in the following order: soft tissue, bone, and airway. By default, the Object Definition button in the Action section is selected. The Segmentation Comparison option is only available when HNA is opened with both pre- and post-intervention scans selected.

The Define Objects section appears while the Object Definition option is selected in the Actions section just above. As stated, the recommended object segmentation sequence is the definition of the soft tissue first, then the bone and finally the airway, so the Soft Tissue option is initially selected by default.

To define the Soft Tissue, a threshold slider is used, and the Min value is typically the only one that needs to be adjusted. The app calculates what is believed to be an appropriate Min value which can be viewed and adjusted with the left mouse button pressed on the Min end of the slider. With the mouse, grab the Min end of the threshold slider and slide it to the right until the soft tissue is rendered as desired. When the mouse button is released, the rendering effect disappears.

To create the segmentation and have the rendering stay in the Render window, press the Threshold Soft Tissue button. A green progress bar will appear at the top of the interface and when complete, the soft tissue rendering will appear in the Render window, and the Define Object option will automatically progress to Bone. If the Soft Tissue object needs to be adjusted, press the Undo button below and then reselect the Soft Tissue option in the Define Objects section.



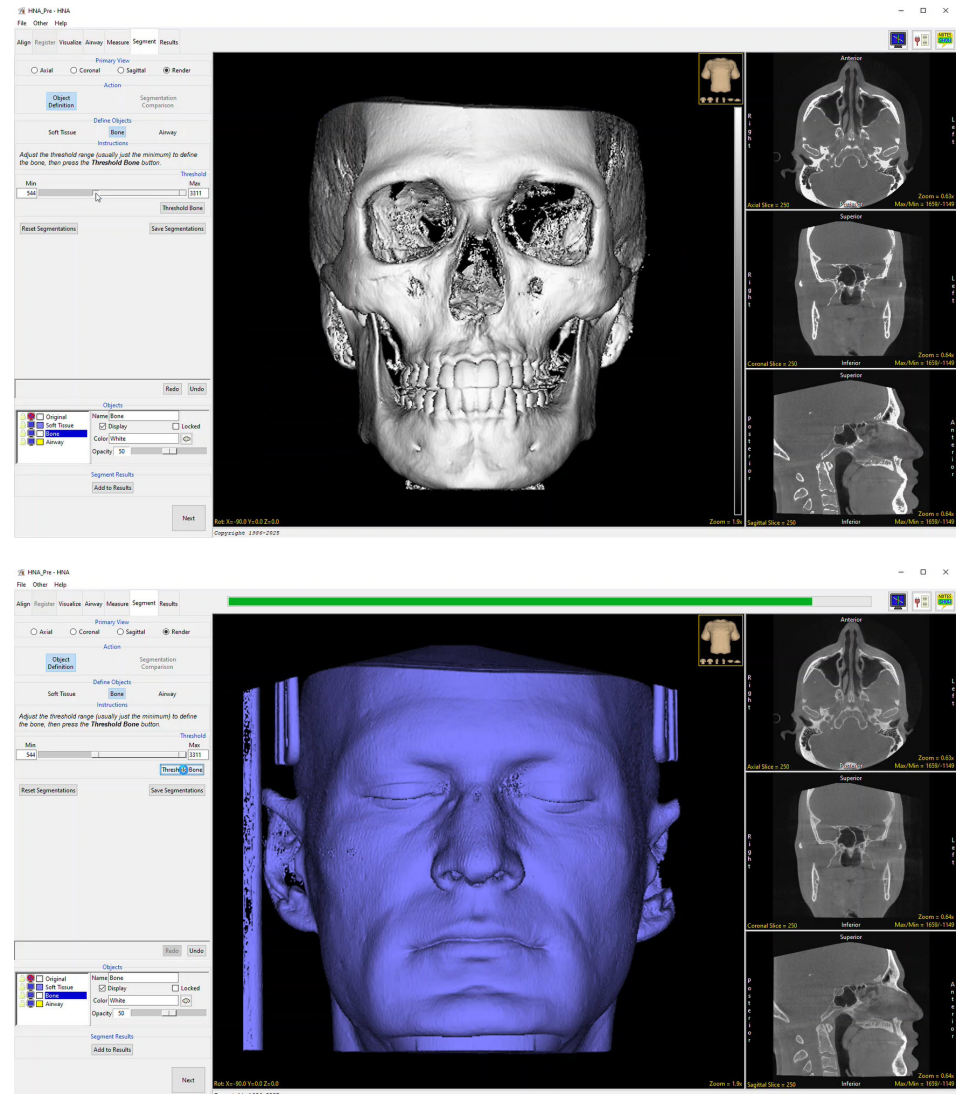


Segment: Defining the Bone Object

The second segmentation step is the definition of bone. Having completed the previous step of segmenting the soft tissue, the Define Object option automatically progresses to Bone.

To define the Bone, the Min value of the threshold slider is typically the only one that needs to be adjusted. With the mouse, grab the Min end of the threshold slider and slide it to the right until bone is rendered as desired. Once again, the Max slider should not need to be adjusted. Note, when the mouse button is released, the rendering effect disappears.

To perform the segmentation, press the Threshold Bone button. A green progress bar will appear at the top of the interface and when complete, the bone rendering will appear in the Render window, and the Define Object option will automatically progress to Airway. If the bone object needs to be adjusted, press the Undo button below and then reselect the Bone option in the Define Objects section.





Segment: Defining the Airway Object

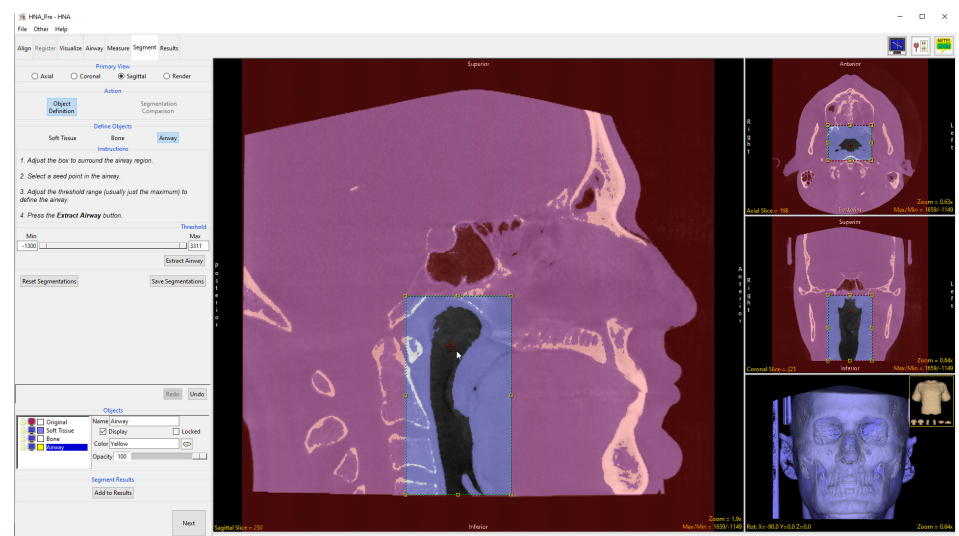
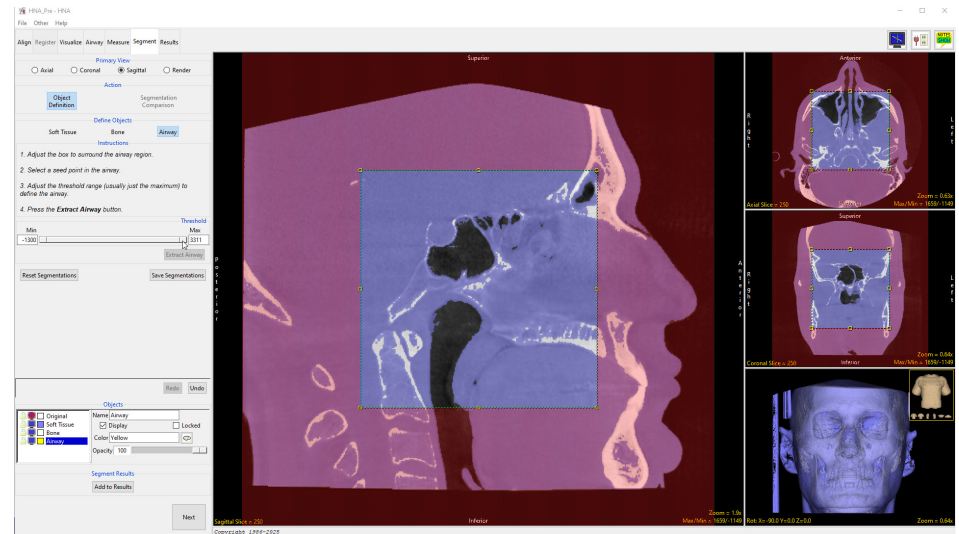
The third and final segmentation step is the definition of the airway. With the previous steps of soft tissue and bone having been completed, the Define Object option automatically progresses to Airway. While the previous two objects were segmented using simple thresholding, the airway requires a segmentation process known as object extraction.

The primary view automatically changes to Sagittal, as this orientation is the easiest to view and define the airway. The Render view, which in the previous two steps was the Primary View by default, will now appear as one of the three other views on the right side of the interface.

There are three stages to defining the airway, which are: adjusting the subregion box; selecting a seed point for the object extraction; and adjusting the threshold range.

First, adjust the subregion box on the Sagittal view until it encloses the airway. To do this, locate the “handles” on the sides and corners of the box, and click and drag these handles until the airway region is fully enclosed. The left and right sides of the box in the Coronal view should also be moved in to more closely enclose the airway region. To see how far to move them, scroll through the slices of the Coronal images using the middle mouse wheel.

Second, place a seed in the airway on the sagittal view using the mouse button. To move the seed, grab it with the left mouse and drag it to the desired location. To remove it, hover the mouse over the seed, right-click and select Delete.

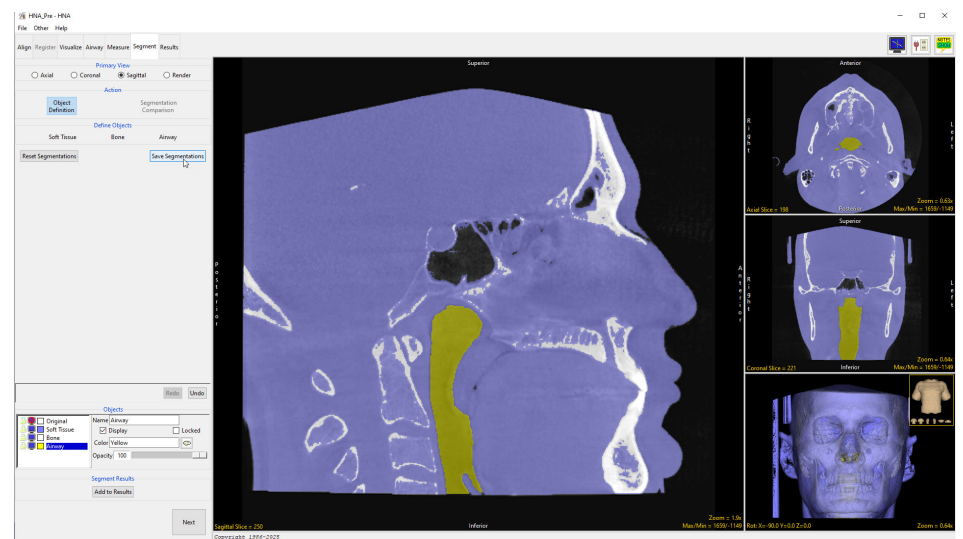
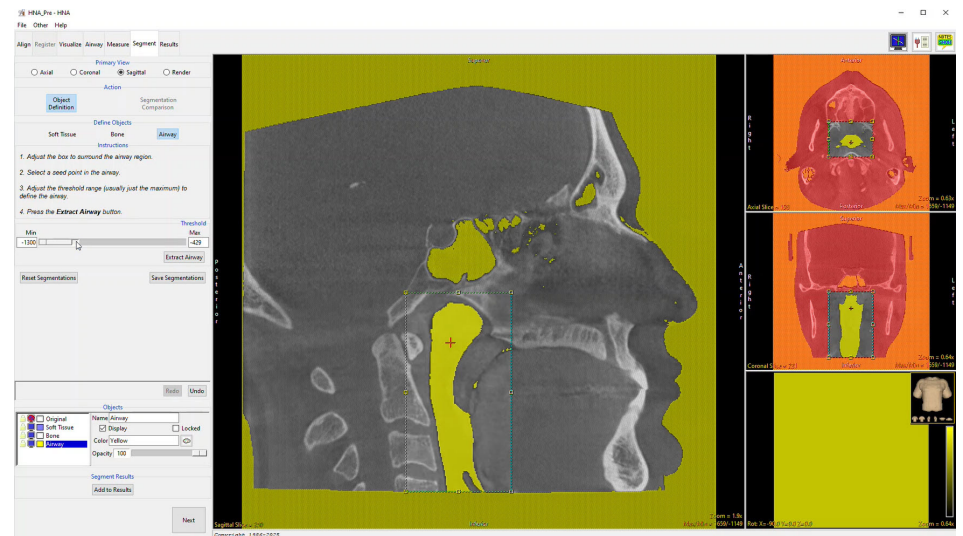




Segment: Defining the Airway Object

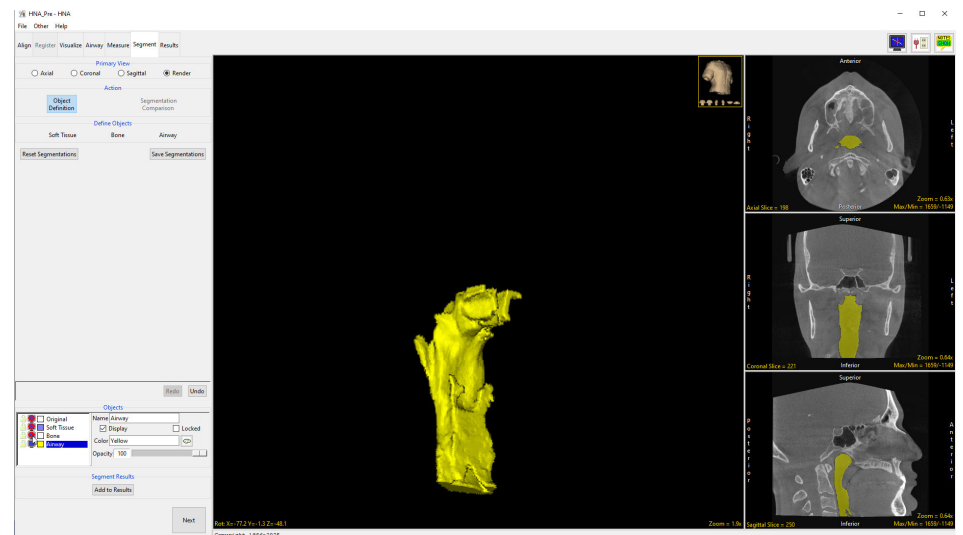
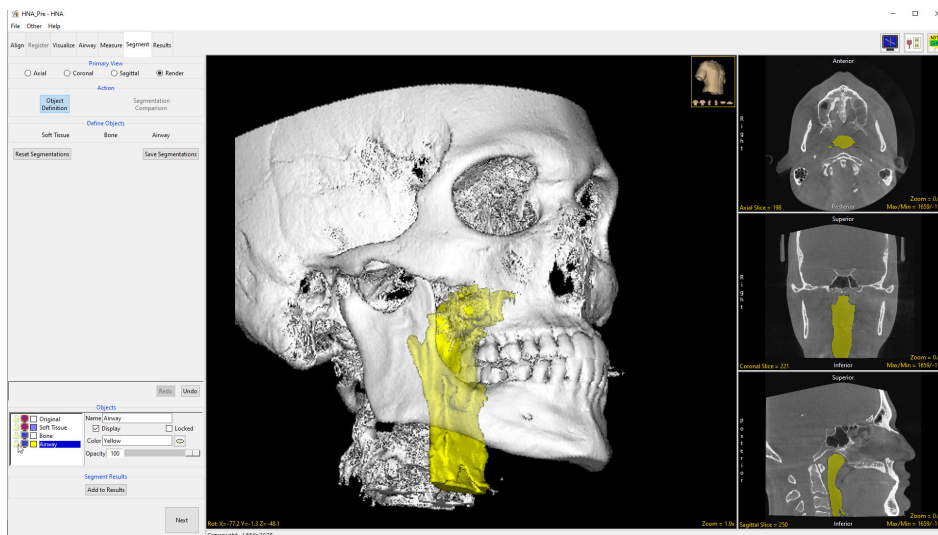
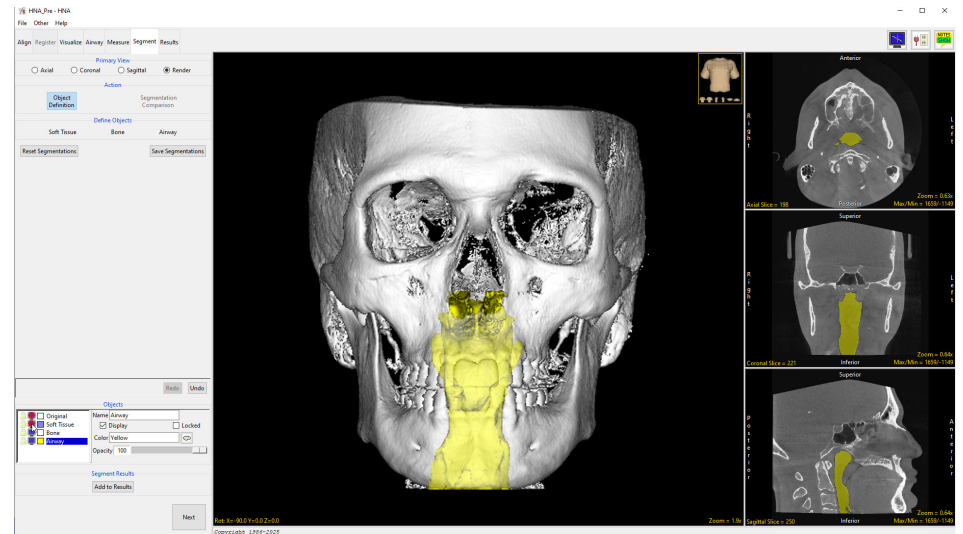
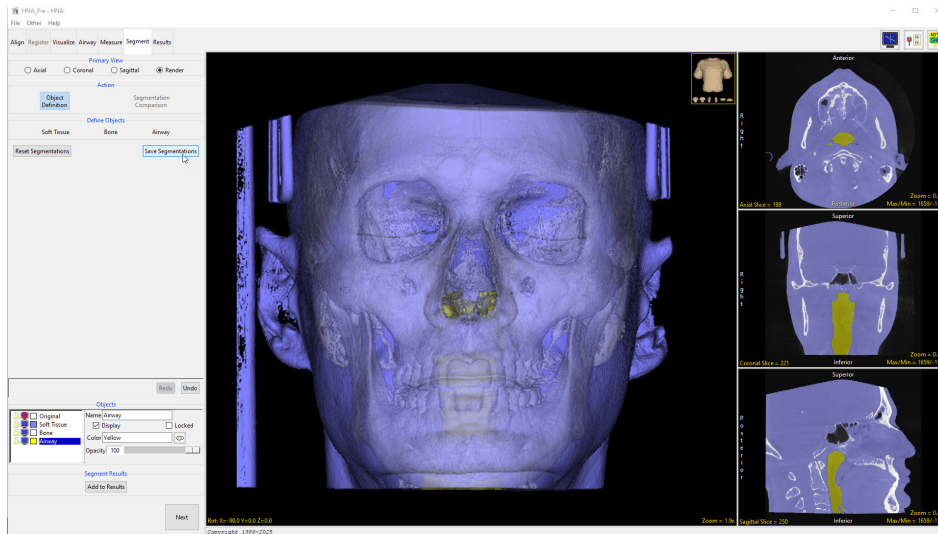
When the seed is placed in the airway region, initially all voxels over the entire threshold range will be displayed. To isolate the voxels related only to air, which includes the airway, move the Max end of the threshold slider to the left until the airway is appropriately identified, which is indicated by all air-related voxels changing to the same shade. The Min slider should not need to be adjusted. As with the previous segmentation steps, when the mouse button is released, the shading effect disappears.

To perform the segmentation, press the Extract Airway button. A green progress bar will appear at the top of the interface and when complete, the Airway object will appear in the Sagittal window. Note that although other voxels were shaded as air when the threshold slider was being adjusted, only those in the region bounded by the subregion box were extracted as the Airway object. If adjustment is needed, press the Undo button and then reselect the Airway option in the Define Objects section.



Segment: Reviewing the Soft Tissue, Bone and Airway Objects

At this point, all three objects, soft tissue, bone and airway, will be defined and can be reviewed in any of the four image panels. Reviewing may include toggling Transparency on or off using the Render window right-click option, hiding and displaying objects using the display icon next to the object name in the object control panel, changing the Opacity of objects in the object control panel if Transparency is toggled on, and rotating the rendering using the middle mouse button (i.e. pressing the mouse wheel).

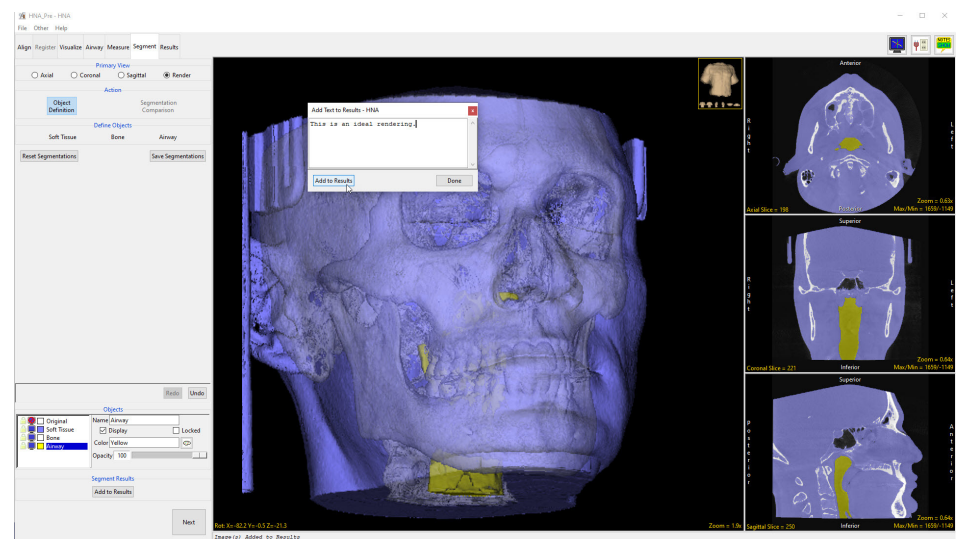
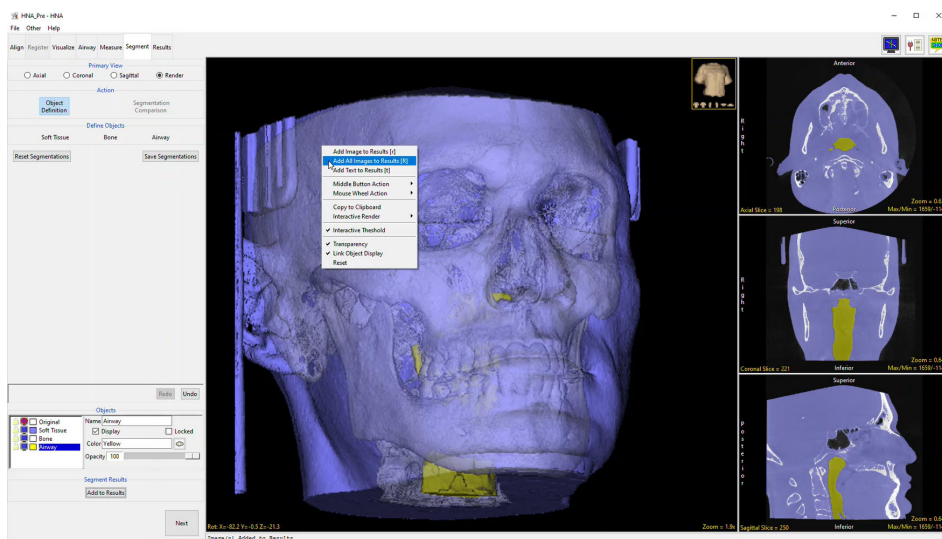
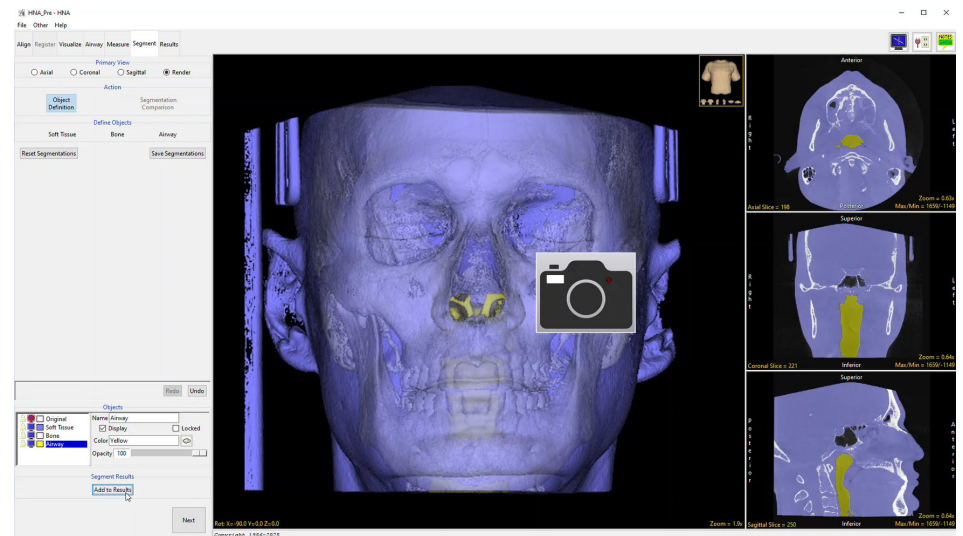




Segment: Save Segmentations and Add to Results

After the segmentation of soft tissue, bone and airway are complete, ensure that the Save Segmentations button is pressed. This action saves the three segmentations as an object map which is linked to the HNA data set being examined, for future use. Specifically, when the same data is later reloaded into the HNA app, when the Segment tab is selected, the option will be offered to load the previously saved segmentations or start a new one.

The segmentations represented in the four image panels can be added to the results by clicking the Add to Results button in the Segment Results section. Additionally any image or set of images can be captured and saved to the results by selecting the Add Image to Results or Add All Images to Results option respectively, from the right-click menu when the mouse is on an image. A camera icon will appear on the screen to confirm the request. Text can also be added by selecting the Add Text to Results option from the right-click menu.





Dual Scan Analysis

Using Pre- and Post-Intervention Data

This User's Guide has thus far focused on the head and neck analysis of a subject at a single point in time. A key function of the Head and Neck Analysis app is that it allows the comparison of head and neck data at two points in time, allowing differences to be observed between scans before and after a certain intervention.

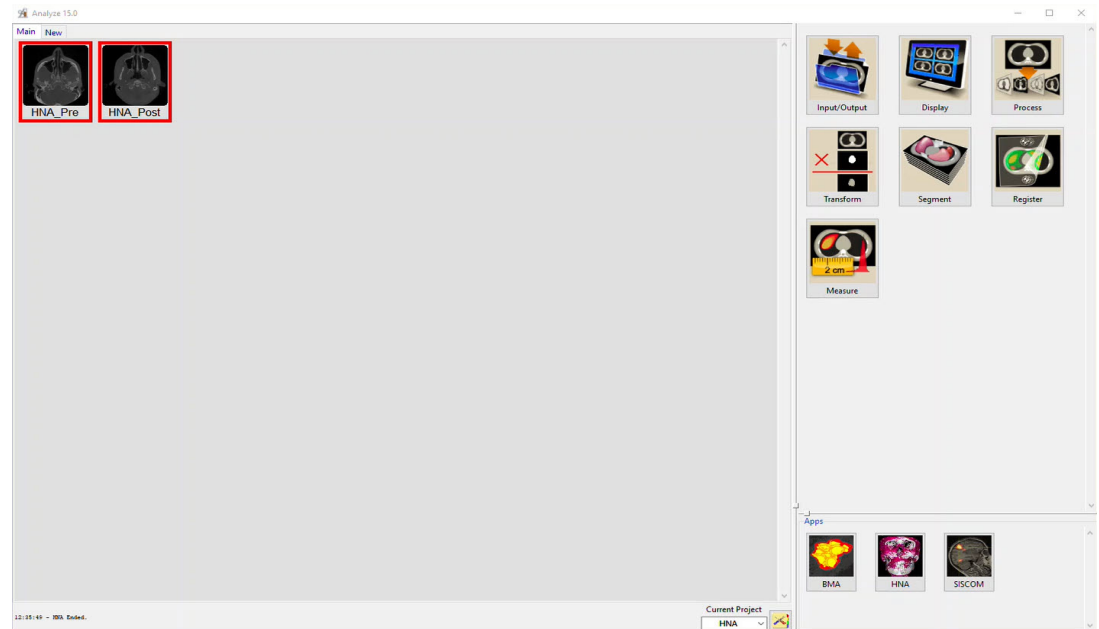
To analyze a pre- and a post-intervention scan at the same time for comparison purposes, the HNA App can be started after two volumes (pre- and post-intervention) have been loaded and selected in the Analyze 15.0 workspace. The Pre should be clicked on first and then the Post is selected with Ctrl-left mouse button. Once the two scans are selected, the HNA App can be opened.

For dual scans, the sequence of analysis is as follows:

- Align
- **Register**
- Visualize
- Airway
- Measure
- **Segment with Segmentation Comparison**

Steps in bold are only available for dual scan analysis.

- **To load Pre- and Post- Intervention data** into the Analyze 15.0 workspace, first press the Input/Output button on the right-hand side of the interface, navigate to the desired image dataset on the disk and load it. The volume will appear in the workspace.



- **To analyze Pre- and Post- Intervention images with the HNA app** first select the Pre- volume in the workspace, then select the Post- volume using the middle mouse button (i.e. pressing the mouse wheel). When both volumes are selected, click on the HNA button in the lower right-hand side of the interface.



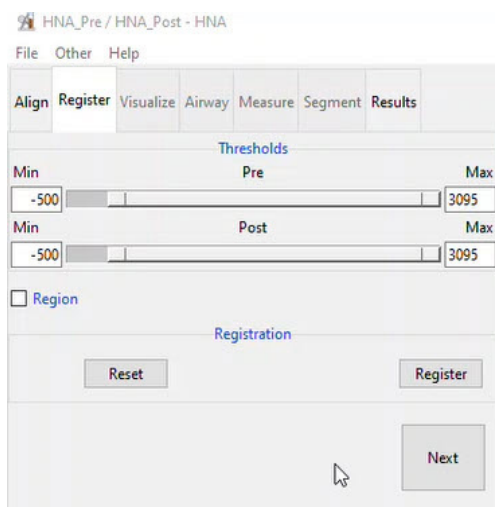


Register

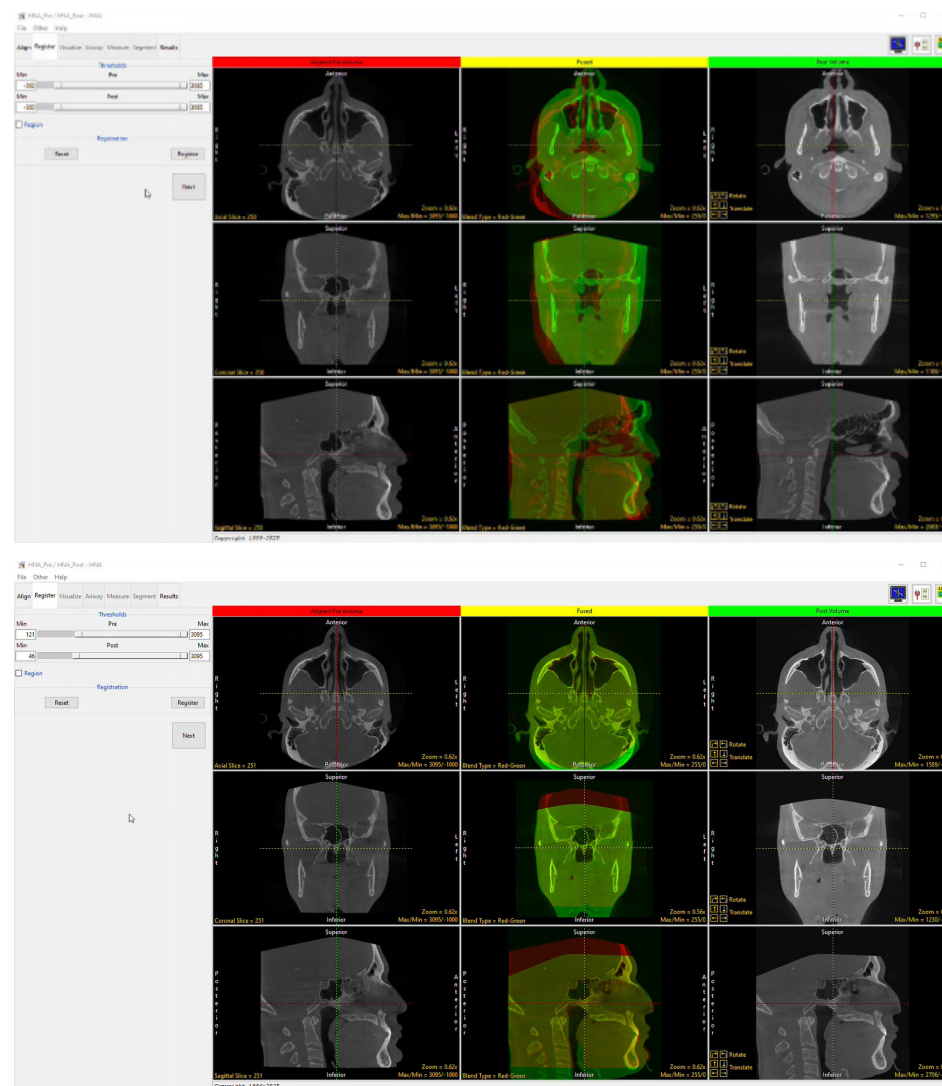
Following an alignment step of the Pre volume using Align, the next step is Register, which co-registers the Post volume to the Pre volume, so that meaningful comparisons can be made between the two scans before and after an intervention.

In medical imaging, registration is the process of aligning two scans of the same subject taken at different times, in this case, the pre-intervention and post-intervention volumes. To achieve this, the Post volume is transformed (translated/rotated) so that the regions of the Post volume that have not changed over time are precisely aligned with the same regions of the Pre volume. If the registration is completed satisfactorily, the two volumes will be aligned and only the regions that have changed between scans will be detectable.

To Register the Post volume to the Pre, simply press the Register button in the Registration section near the middle of the control panel. This action in most cases should produce an accurate co-registration, and the Next button can be selected.



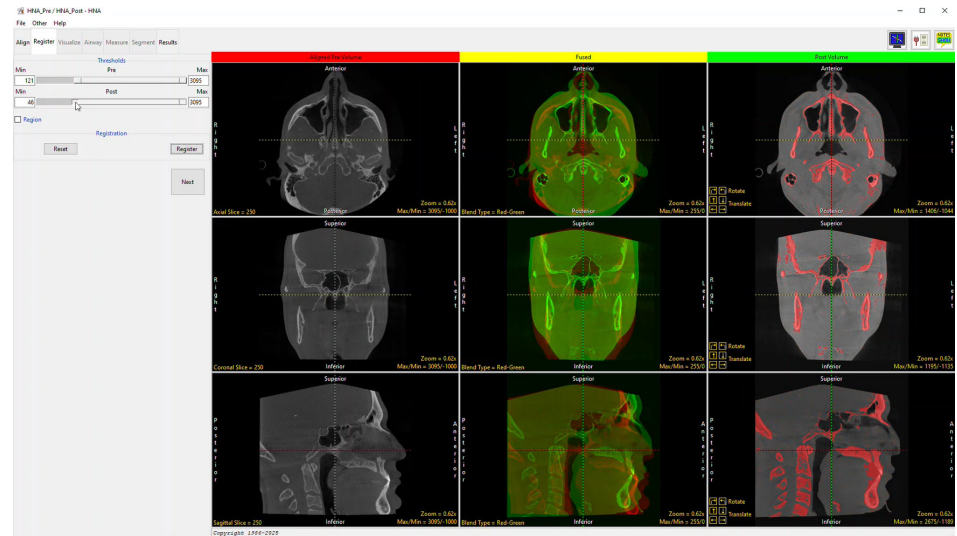
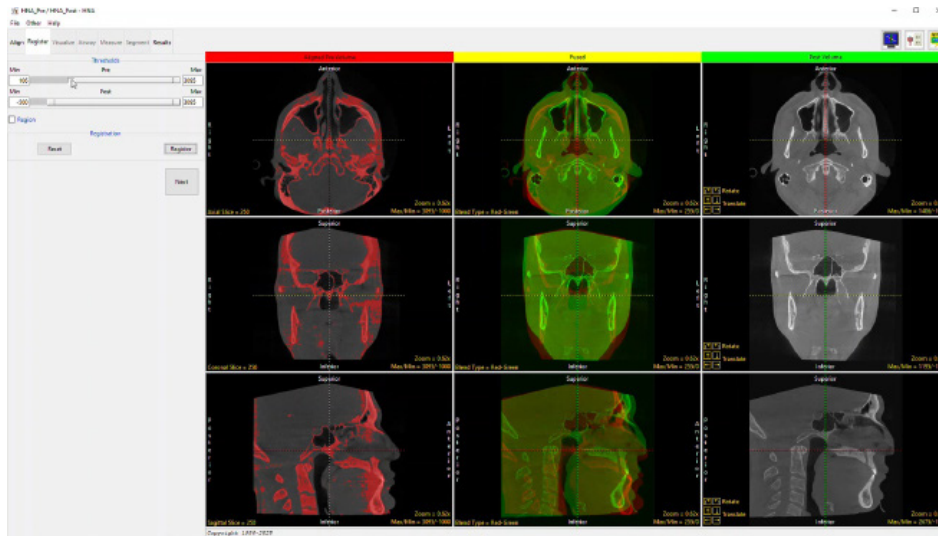
However, if the registration result is not satisfactory, additional steps can be taken which are shown on the following pages.



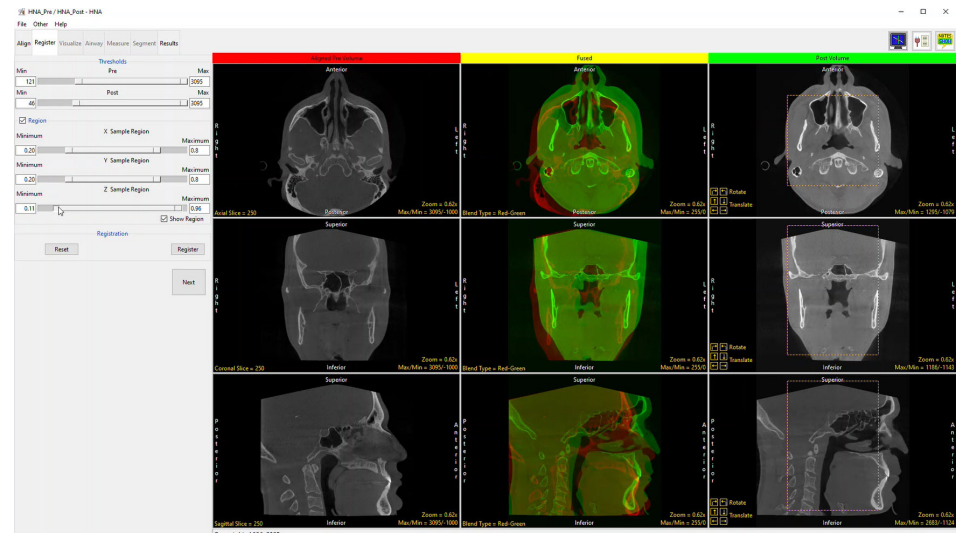
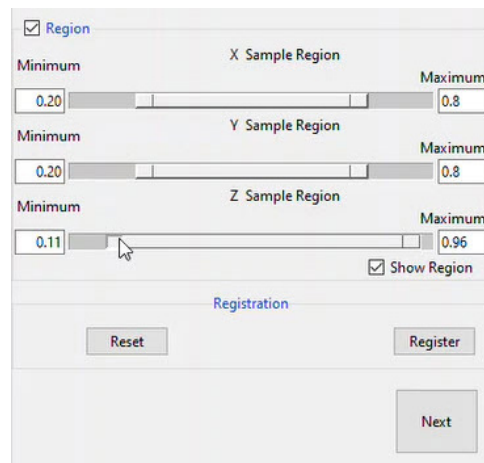


Register: Thresholding and Subregioning

If the automated registration is not satisfactory, adjusting the Thresholds for each of the volumes to include less of the image may help. To do this, move the Min handle of the threshold slider to the right for each volume so only bone is highlighted in red. Then press the Register button to perform the registration.



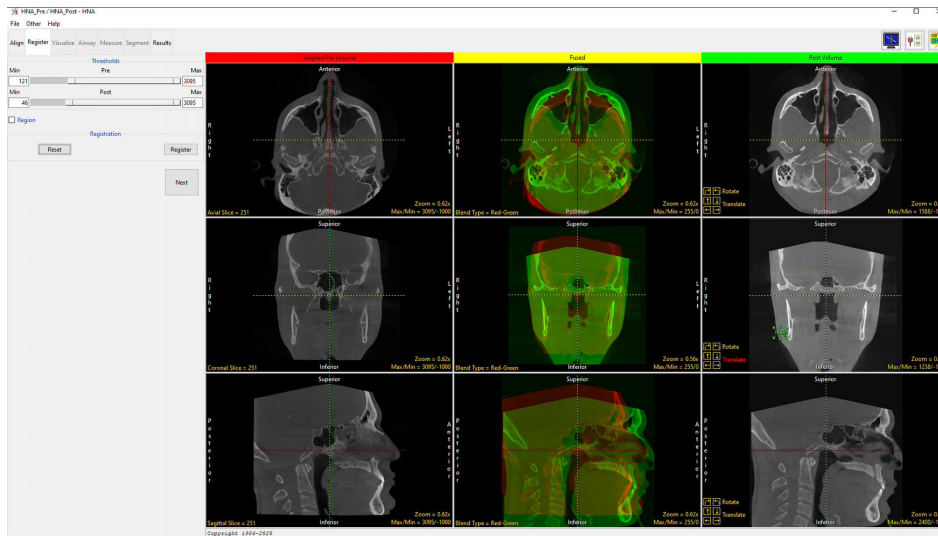
Another way to provide an acceptable registration result is to subregion the Post volume which restricts registration to only that portion of the volume. The controls for this appear when the Region box is checked. Use the X, Y and Z sliders to define the subregion, then press the Register button to perform the registration.





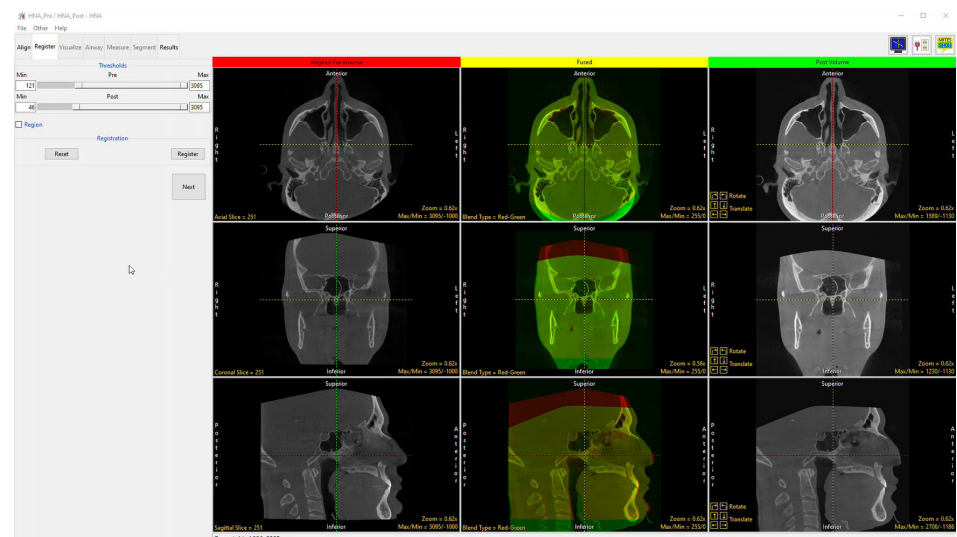
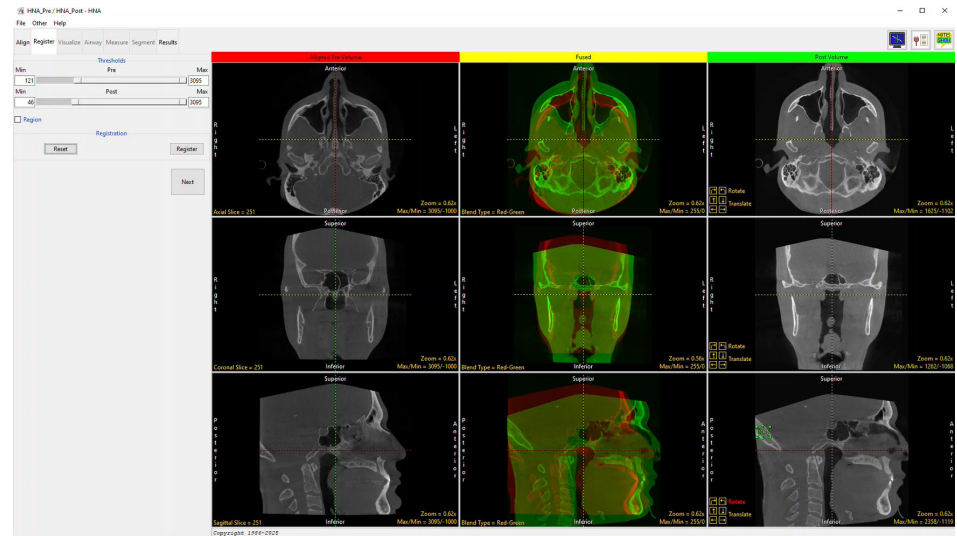
Register: Rotation and Translation

If previous steps have not resulted in a satisfactory registration, manually translating and/or rotating the Post volume to get the two volumes closer to co-registration may help the automated registration process. Use the translate and rotate buttons in the lower left corners of the three Post volume images on the right of the interface to manually adjust the registration.



To translate or rotate using the mouse, click the yellow “Rotate” or “Translate” text and then press and hold the left mouse button to adjust the Post volume. To incrementally reposition the Post volume, click the icons to the left of the Rotate and Translate text. Note, the rotation and translation incrementation can be changed with a right-click over the icons.

At any time, the Reset button can be pressed to undo all previous registrations and start over. Once the registration appears satisfactory, either automatically or through making these adjustments, press the Next button to proceed.



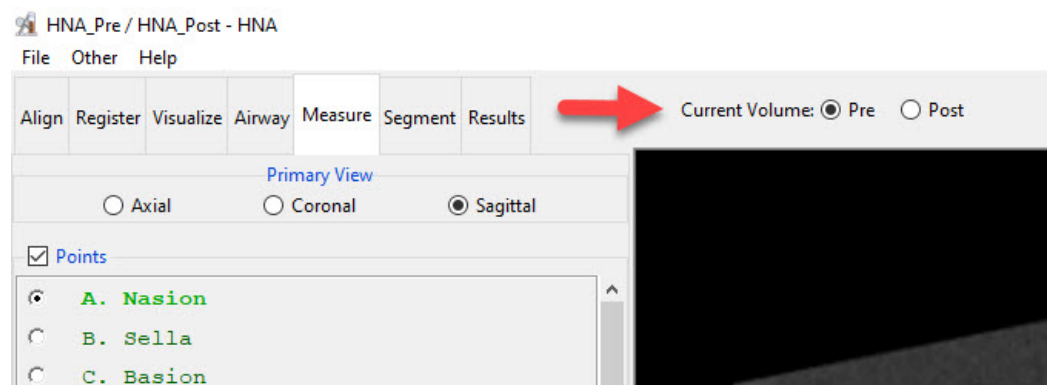
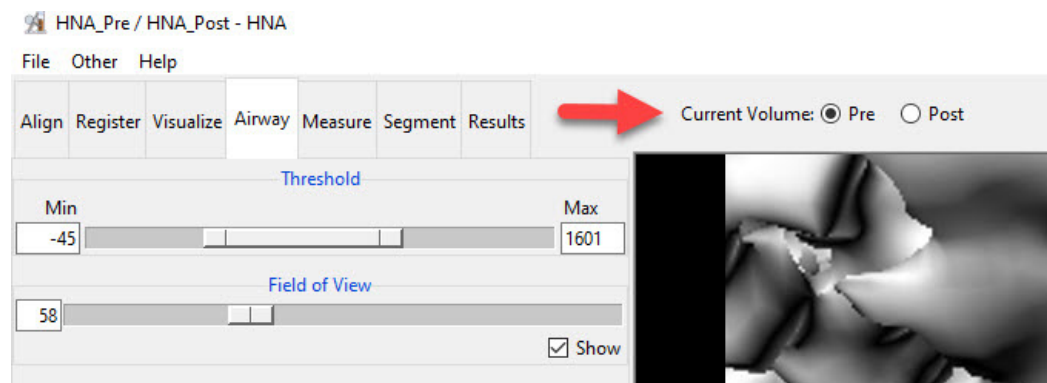
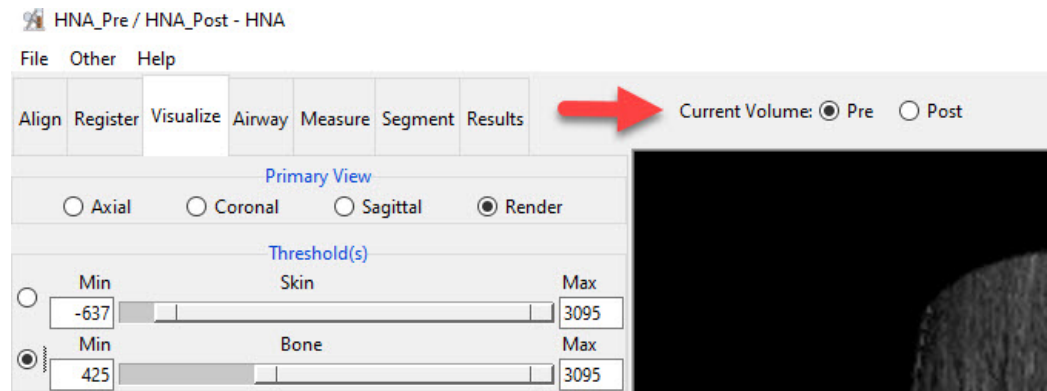


Visualize/Airway/Measure for Dual Scans

After co-registering the Post volume to the Pre volume, pressing Next will progress the app to the Visualize tab. For this and all of the remaining steps in the HNA analysis of dual scans, both the Pre and the Post volumes must be analyzed separately. To facilitate this and to help users keep track of which volume is being studied, a Current Volume button is shown at the top of the interface to the right of the function tabs, where Pre or Post can be selected.

Note that toggling between Pre and Post is a useful technique to verify alignment and registration and also provides another way to visualize post-intervention changes.

In summary, the Visualize, Airway and Measure tabs are used in the same way for Dual Scan analysis as they are for Single Scan analysis described on Pages 7-19, with one exception: the volume to be analyzed, either Pre or Post, must be selected as the Current Volume.

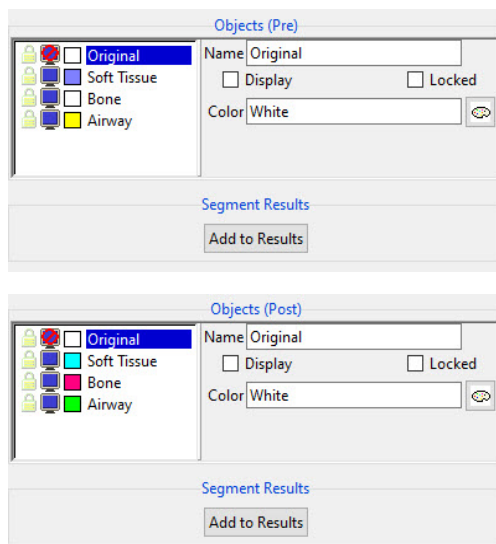




Segment for Dual Scans

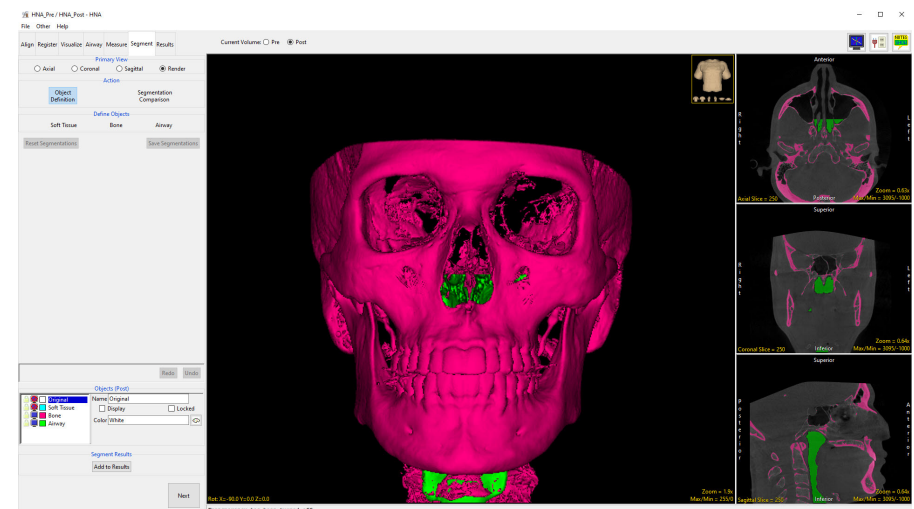
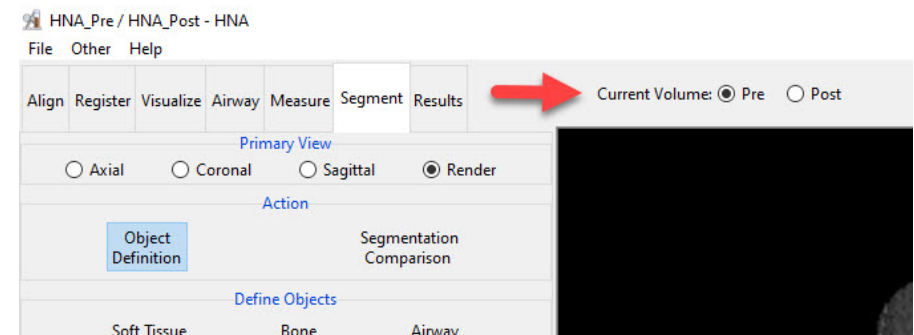
As with the previous steps in the HNA analysis of dual scans, when the Segment step is reached, both the Pre and the Post volumes must be processed separately. The same Current Volume button is shown at the top of the interface where Pre or Post can be selected. Additionally, a Segmentation Comparison action button in the Segment tab is enabled. Before being able to compare segmentations, the Soft Tissue, Bone, and Airway objects must be defined for both the Pre and Post volumes. If the trio of objects, collectively referred to as the Object Map, had been previously defined for either or both volumes, an option to use them or redefine the objects is offered at the beginning of the Segment step. Only after both Object Maps have been defined can the Segment Comparison option in the Actions section be selected.

If the Pre volume objects need to be segmented, define the Soft Tissue, Bone and Airway objects as described in the Segment section starting on page 20. Do the same if necessary for the Post volume. At this point, two object maps will be presented, one for the Pre volume and



one for the Post volume. All of the six objects in the two object maps are listed in the Objects section at the bottom of the Control Panel and can be used to determine how these objects are displayed in the Render panel, including options for changing color and opacity

if Transparency is turned on (the toggle for Transparency is a right-click option when the mouse is in the render window). With all the objects now defined for both the Pre and Post volumes, the object maps can be compared using the Segmentation Comparison function.

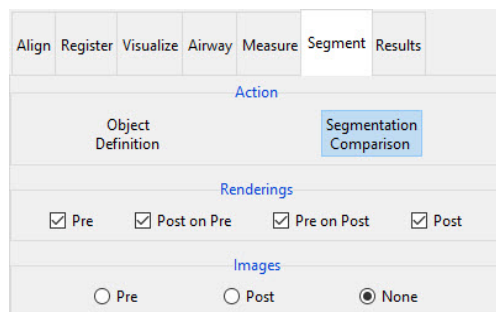




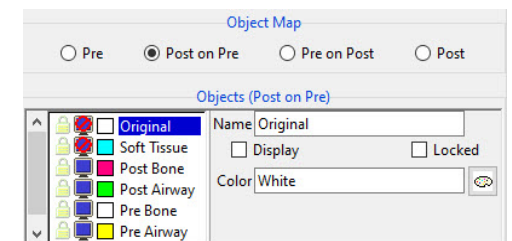
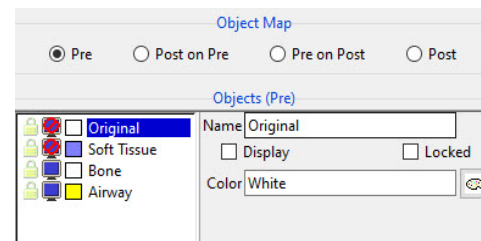
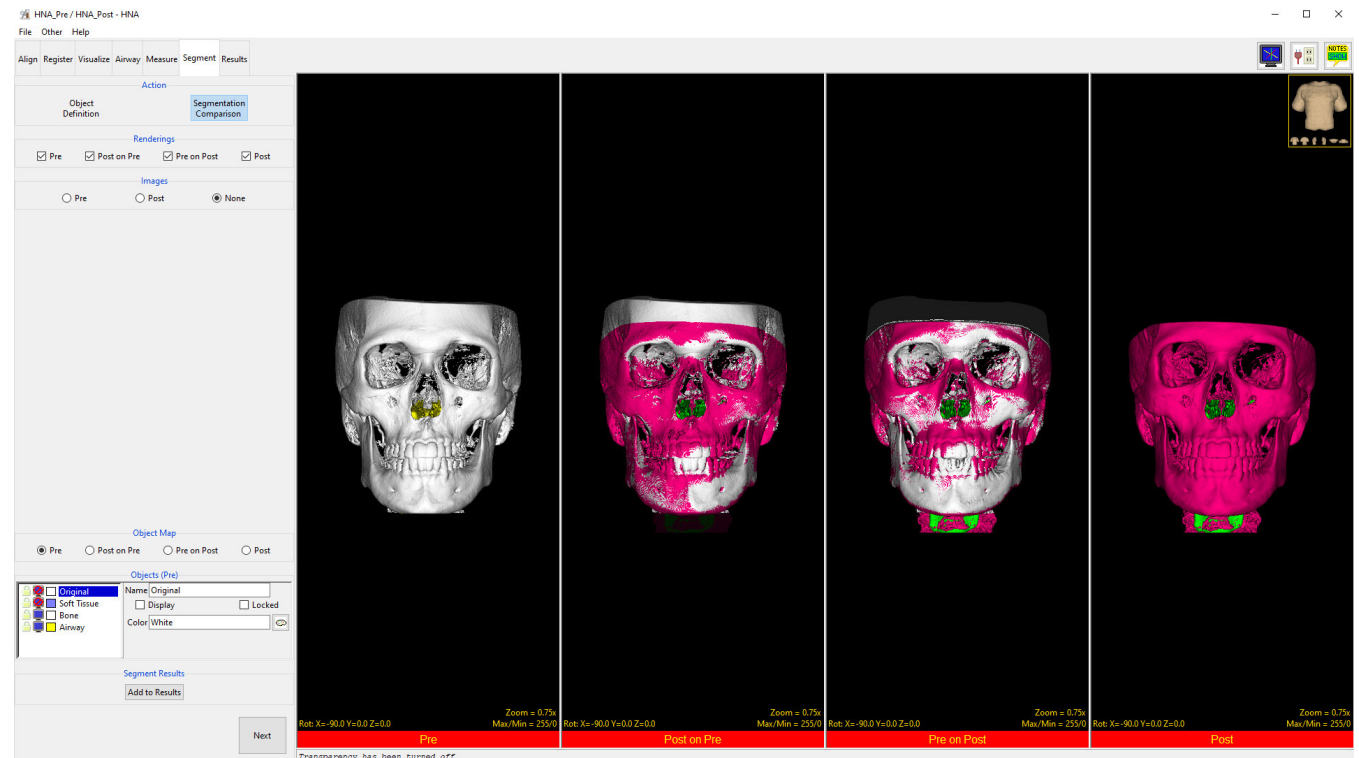
Segmentation Comparison

Selecting the Segmentation Comparison action button will display a selection of renderings generated from the two object maps that have been defined for the Pre and Post volumes. The Renderings section provides checkboxes to choose which comparison renderings to display. By default, all four renderings are selected, with only the bone and airway objects displayed for each. The Post on Pre

option displays a rendering of the Post objects superimposed onto the Pre objects. Pre on Post displays a rendering of the Pre objects superimposed onto the Post objects.



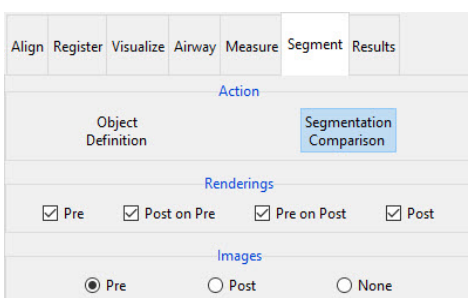
Although the Soft Tissue display in the object map section can be toggled on, that would obscure the other two objects, so it is usually kept toggled off for Segmentation Comparison. If more than one rendering is selected in the Renderings section, an Object Map section is displayed above the Objects list section, which is used to select which object map to display. The Object Map selected will not affect the display of the renderings, only the Pre or Post images discussed on the next page.



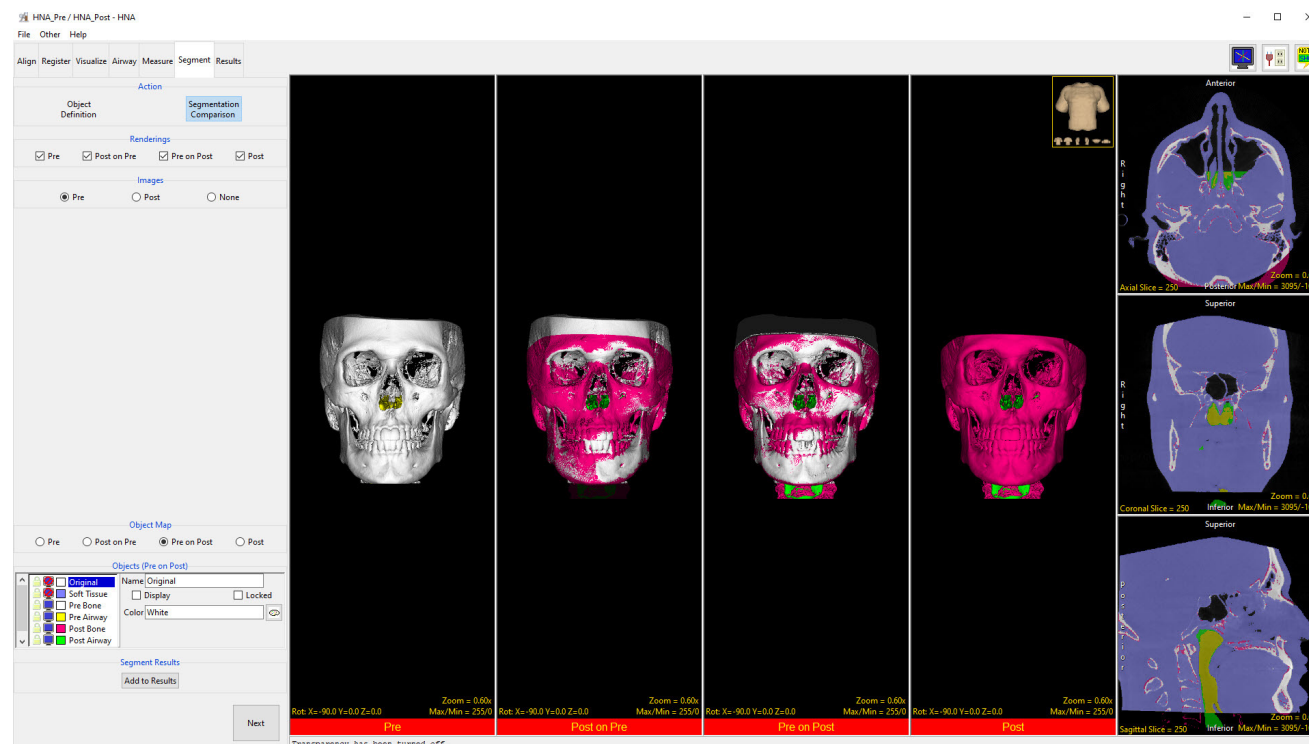
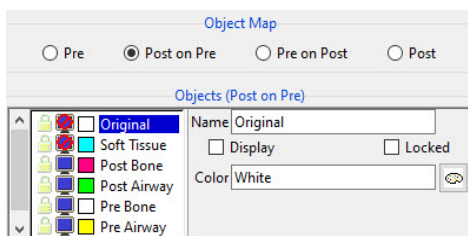


Segmentation Comparison: Viewing Object Maps on Images

The Images section of the control panel provides a way to display the set of Axial, Coronal, and Sagittal image panels for either the Pre or Post images, down the right hand side of the interface. By default, the Images section is set to None, and only the selected Renderings will be shown on the interface. If Pre is selected from Images, the Pre images will be displayed and by default, the Pre object map will be displayed on these images. Likewise, if Post is selected from Images, the Post images will be displayed and by default, the Post object map will be displayed on these images. In the Object Map section, the Post object map can be displayed on the Pre images, and similarly, the Pre Object Map can be displayed on the Post images. If Post on Pre and/or Pre on Post Rendering are selected, the Object Maps section



will contain the Pre, Post on Pre, Pre on Post, and Post object maps, which can be selected and displayed on the the Pre or Post images.

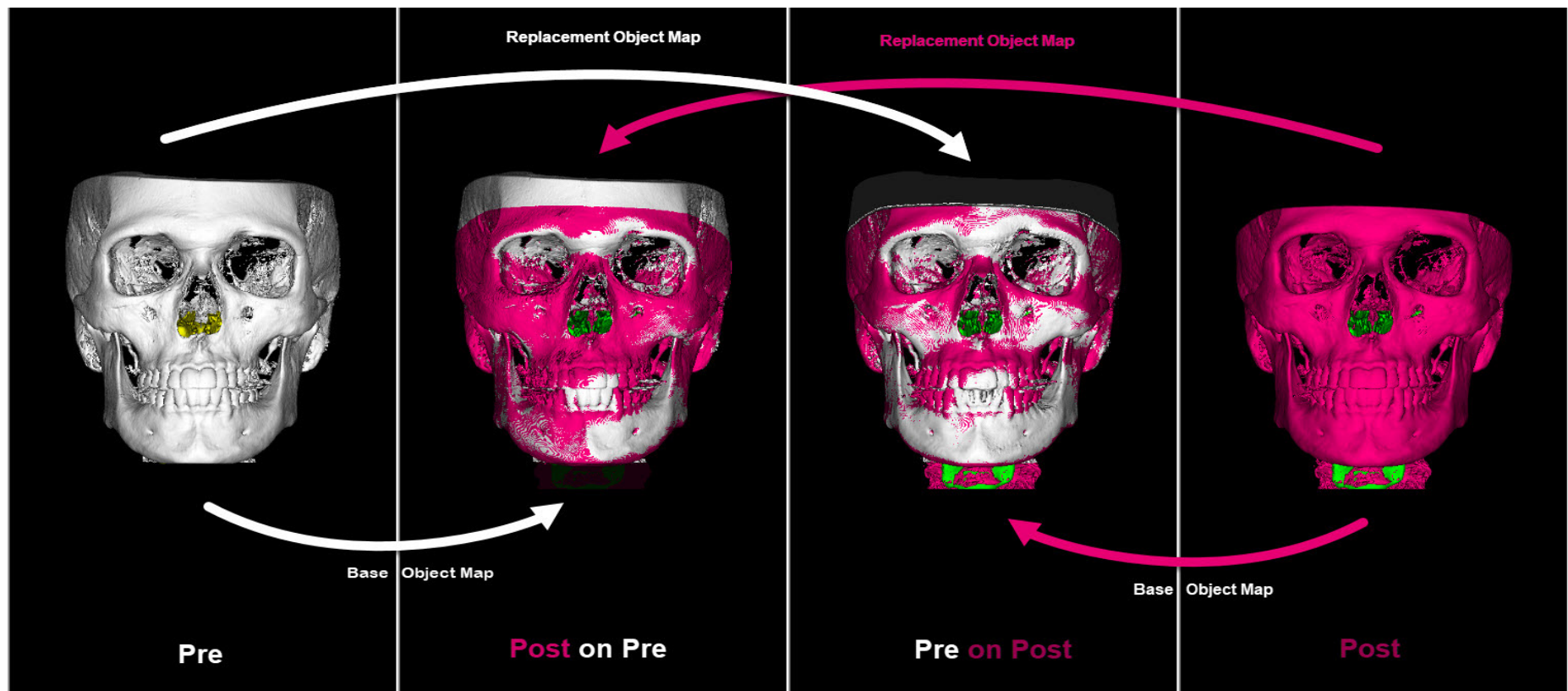


Like all of the previous function tabs, the Add to Results button will add all currently displayed renderings and images to the Results document. It can be pressed multiple times to capture multiple different combinations of renderings/images/object maps.



Segmentation Comparison: Voxels and Object Maps

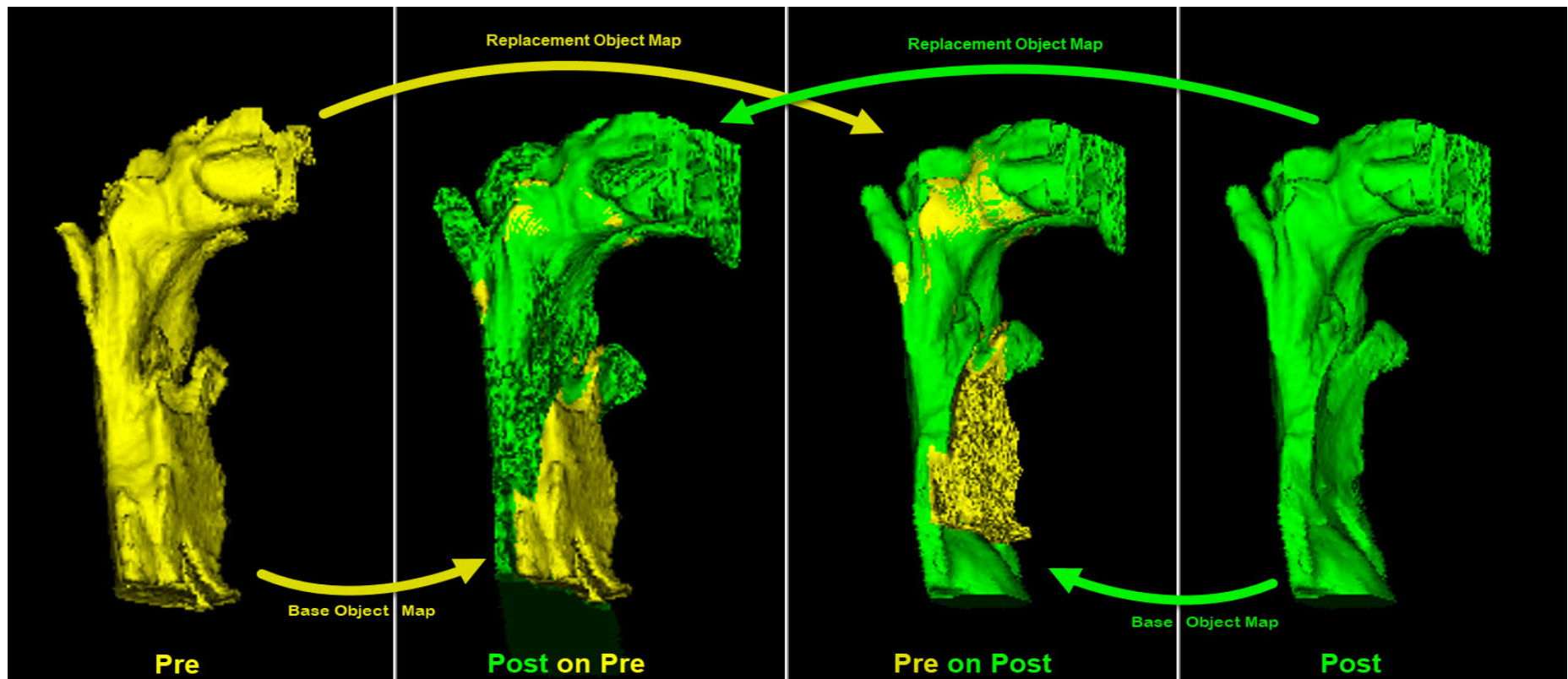
To fully appreciate what the segmentation comparison renderings are truly presenting, a clear understanding of voxels and object maps is vital. Think of a voxel (volume element) as a 3D pixel (picture element), so a voxel is analogous to a pixel in 2D imaging but with depth. A medical imaging scan is a 3D volume made up of these voxels, each of which contain the grayscale value associated with the radiodensity at that point in the scan. To create 3D renderings in HNA, objects of interest must be identified, which is what is accomplished in the Object Definition step, also referred to as the segmentation step.



The three objects of interest for HNA volumes are Soft Tissue, Bone, and Airway. These three objects are saved in what is called an Object Map. An Object Map can be thought of as a complementary volume to the loaded grayscale volume. Every voxel in the Object Map will be assigned to one of the three objects of interest or left unassigned, which makes it part of the Original object. This means every voxel in a volume can have only one object assigned to it.

Segmentation Comparison: Voxels and Object Maps

For the Post on Pre rendering, every voxel in the Post Object Map replaces the same voxel location in the Pre Object Map. For the Pre on Post rendering, every voxel in the Pre Object Map replaces the same voxel location in the Post Object Map. This is particularly evident in the Images if they are selected to be displayed. If object differences between the Pre and Post Object Maps are fairly significant (e.g. a consistent thickness difference of greater than 2 voxels), then those regions in both of the merged renderings (Post on Pre and Pre on Post) will look fairly similar. Regions of the two merged renderings that look dissimilar between them signify very slight differences between objects, and could easily be attributed to a slight variance caused by the registration process or segmentation thresholding variability.

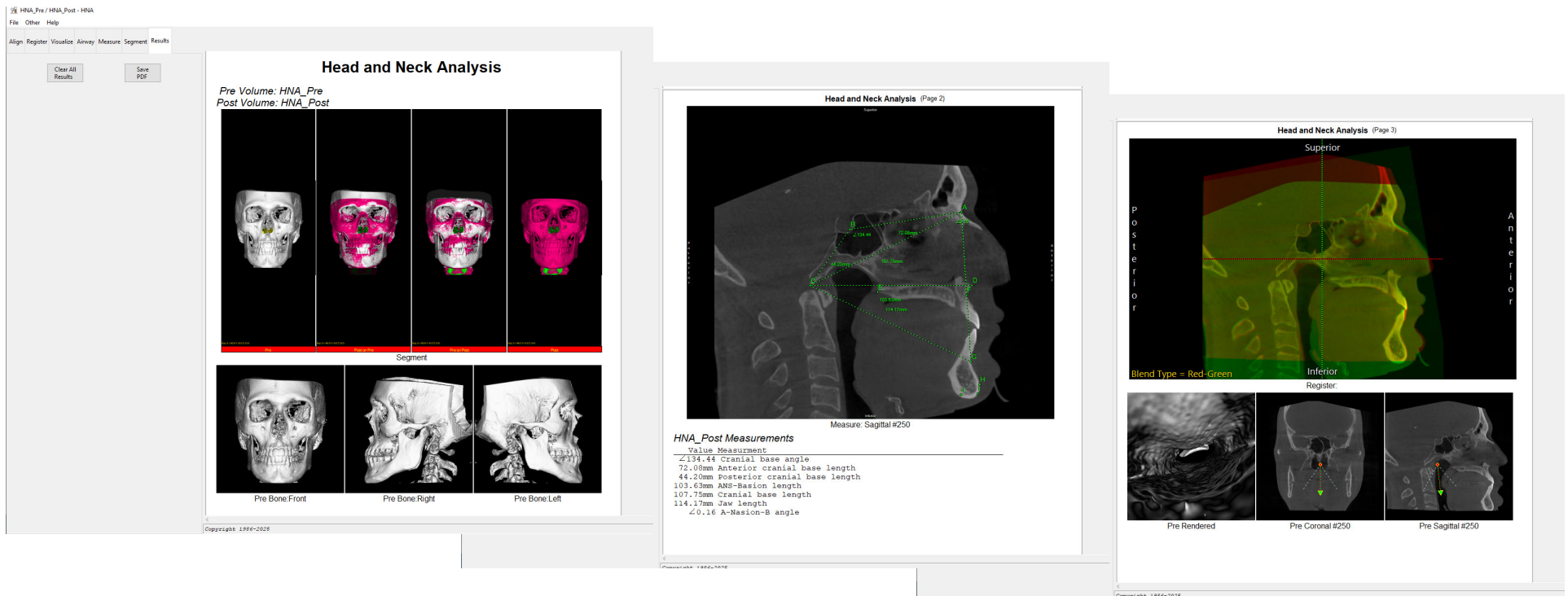


To summarize, the regions that have the same coloring in both merged renderings point to valid change between Pre and Post intervention scans. Regions that show different coloring between the two merged renderings likely represent a change that is small enough to be considered insignificant.



Results

The Results tab in the HNA app provides documentation of the results from each of the previous tabs in the form of images, measurements and notes. Information is added to the Results document from the “Add to Results” buttons found on the other tabs as well as the right-click options from any of the previous image panels.



The contents of the document can be removed using the Clear All Results button. To delete the contents of a single page, right-click on the page to be removed and select the Delete Results Page.

To save the Results document as a PDF, press the Save PDF button.

