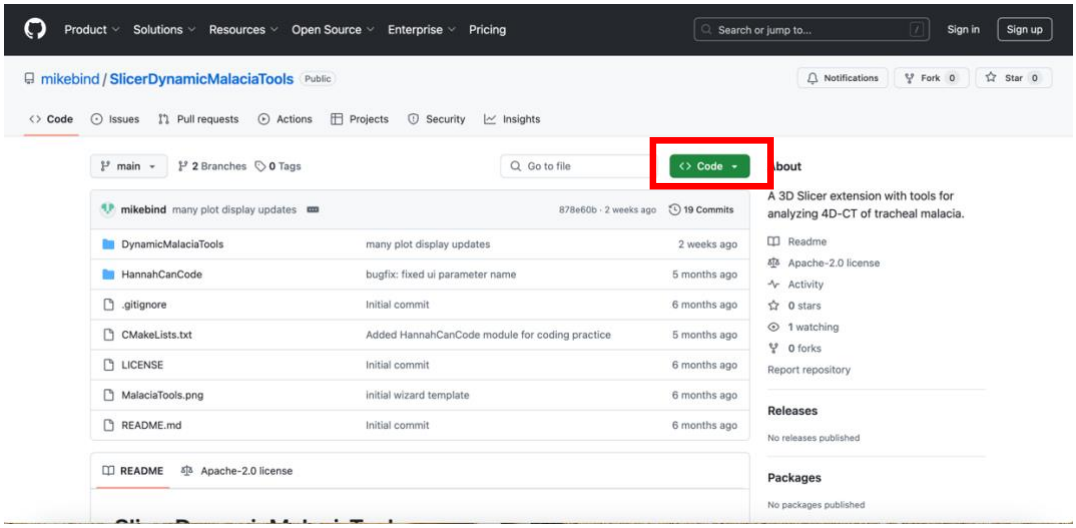
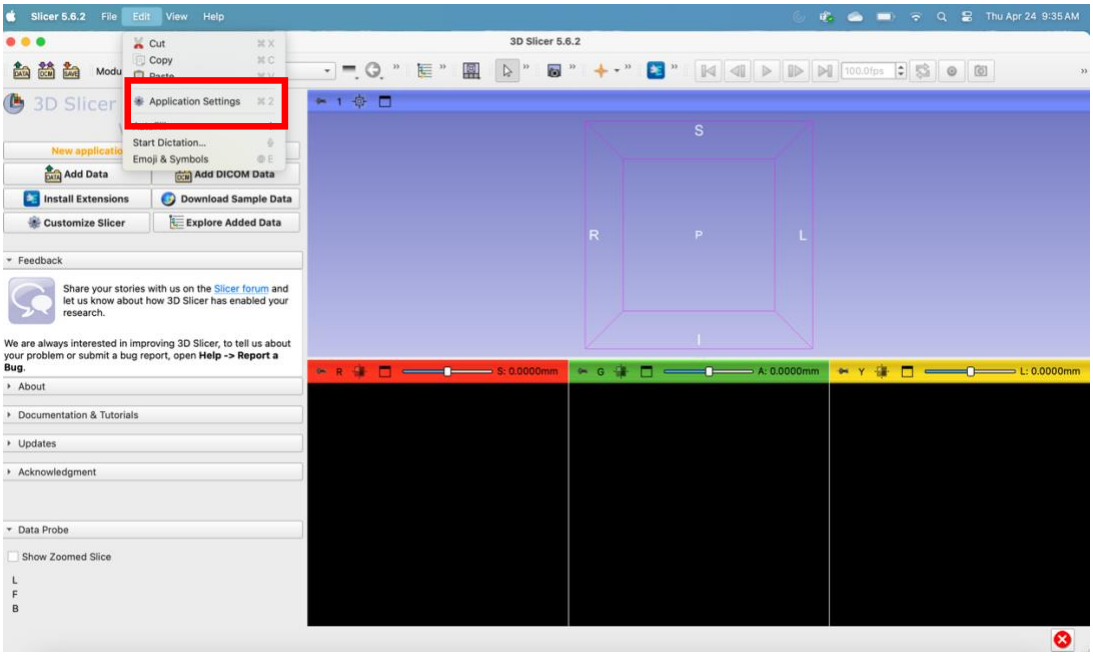
3D Slicer Dynamic Malacia Toolkit Tutorial (Installation & Use)

1. From the shared GitHub link, use the green button to download the code as a Zip file.

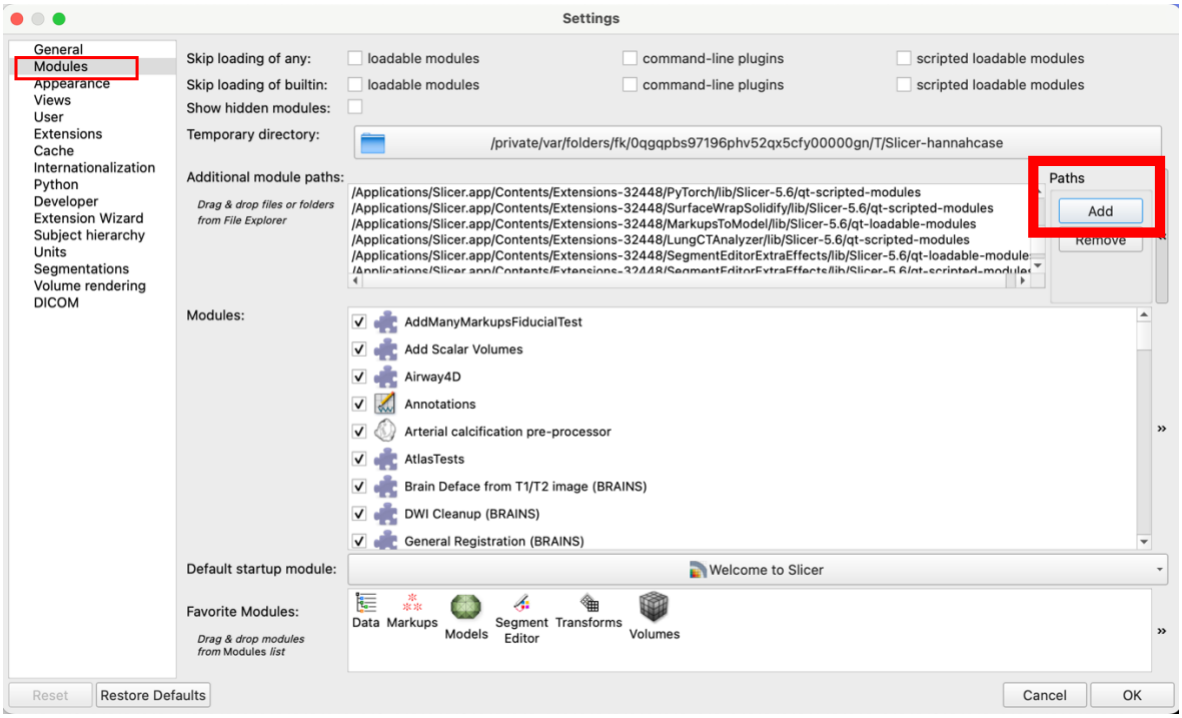


2. Unzip the file and save it in. Note: if you move this file to a different location on your computer after installing it into Slicer, this will change the path destination and it will need to be re-installed to Slicer.
3. Open Slicer and navigate to “Edit” in the top left main options bar. From here select “Application Settings”. This is where we will install the toolkit.

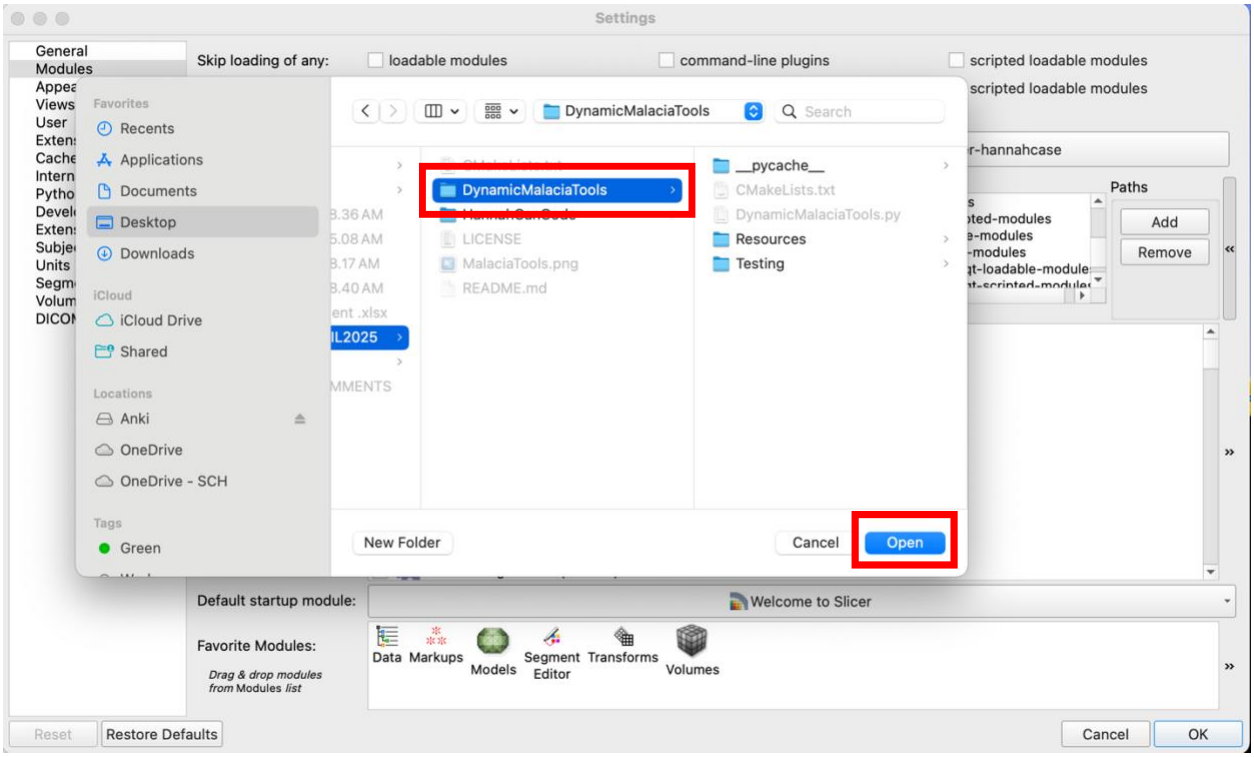


4. Once “Application Settings” is opened, navigate to “Modules” and select “Add” on the far right under “Paths”. Note: If you don’t see this option initially, click (>>) to open the

Paths console.

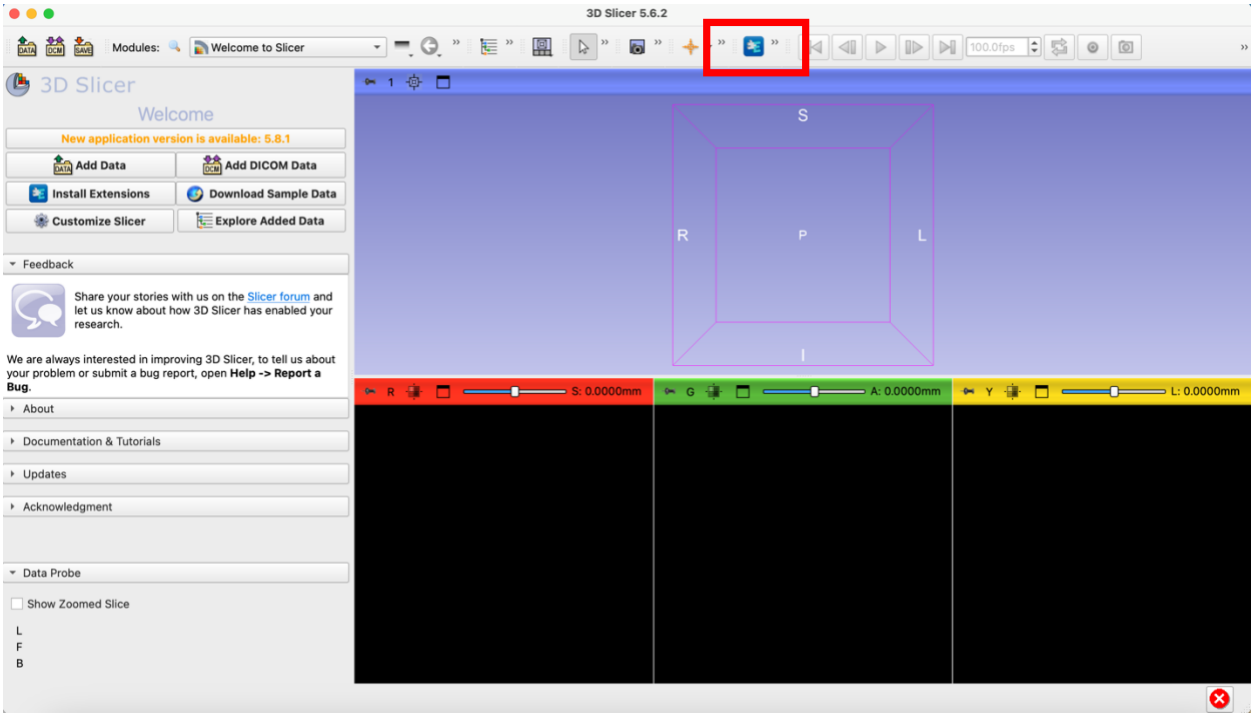


5. Once you select “Add”, navigate to the “SlicerDynamicMalaciaTools” file you saved from the GitHub download and “open” the file titled “DynamicMalaciaTools”.



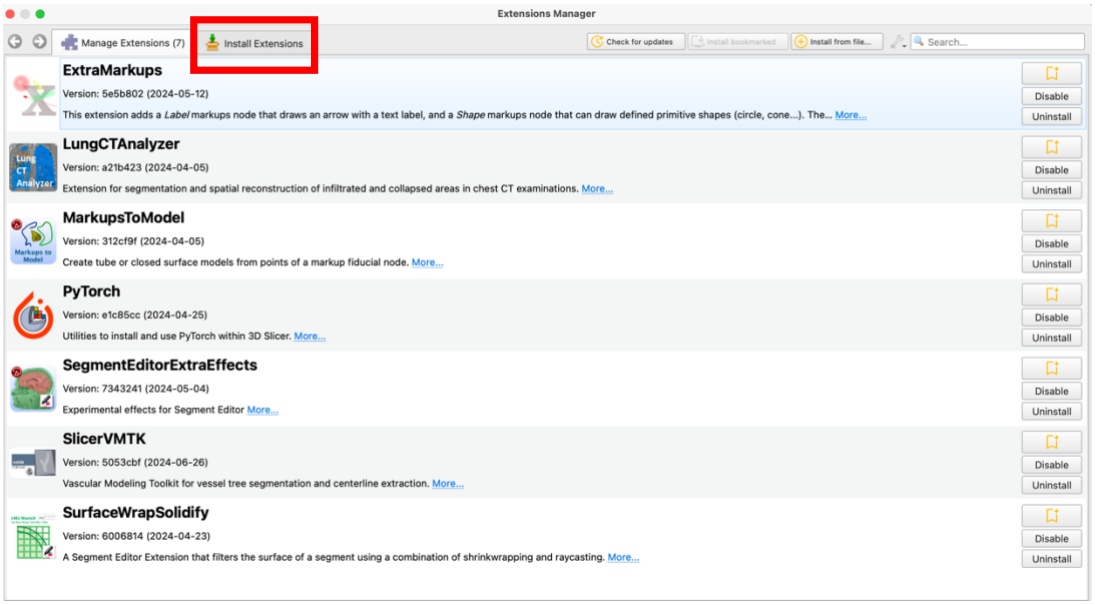
6. For the installation to take effect, you will have to re-start Slicer at this time. Prior to re-starting, there are some Extensions that are necessary for the toolkit to function

properly. To check your extensions or download new extensions, select the blue “E” from the main Slicer window.

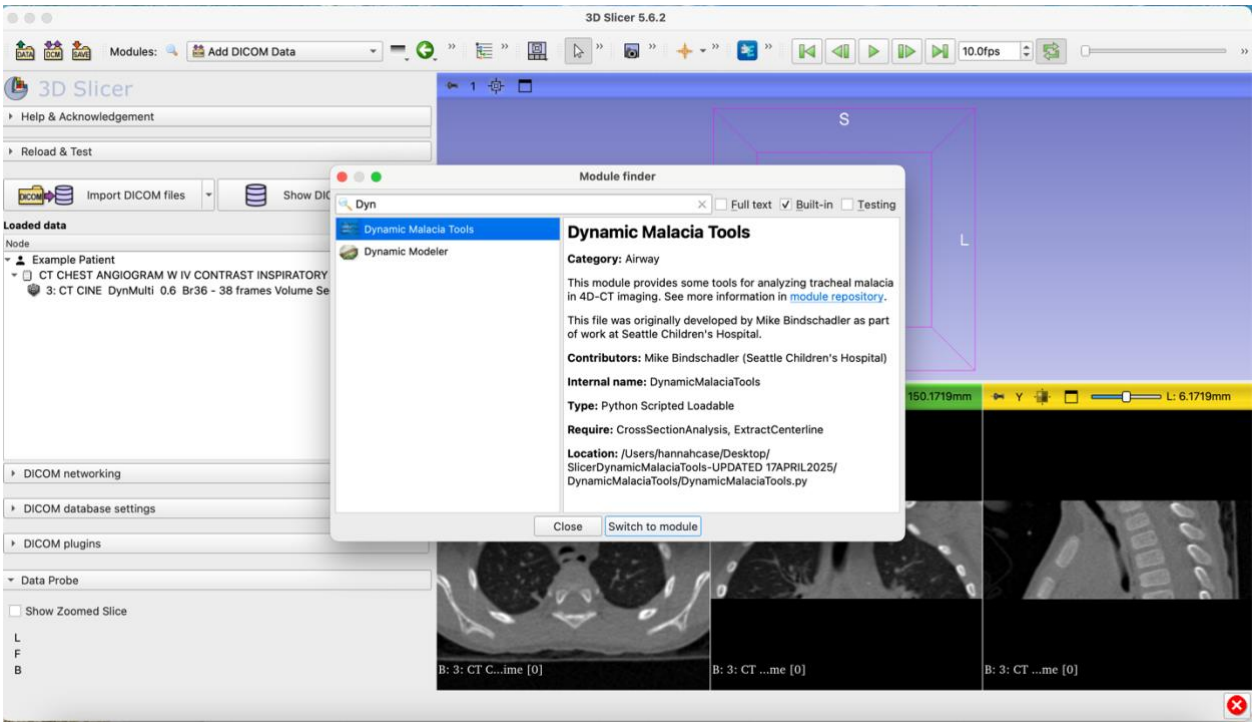


7. The following Extensions are required for the DynmaicMalaciaTool to function properly:
    - ExtraMarkups
    - PyTorch
    - SlicerVMTK

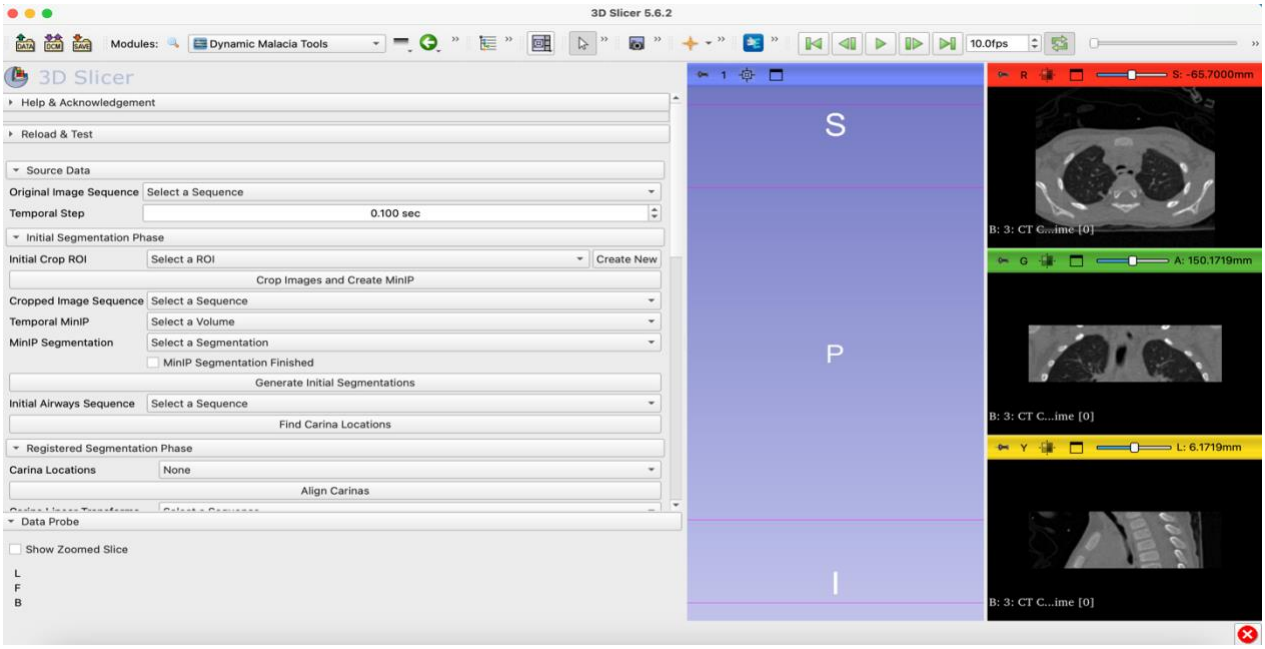
If these are not yet installed, click “Install Extensions” and use the search bar function to install them.



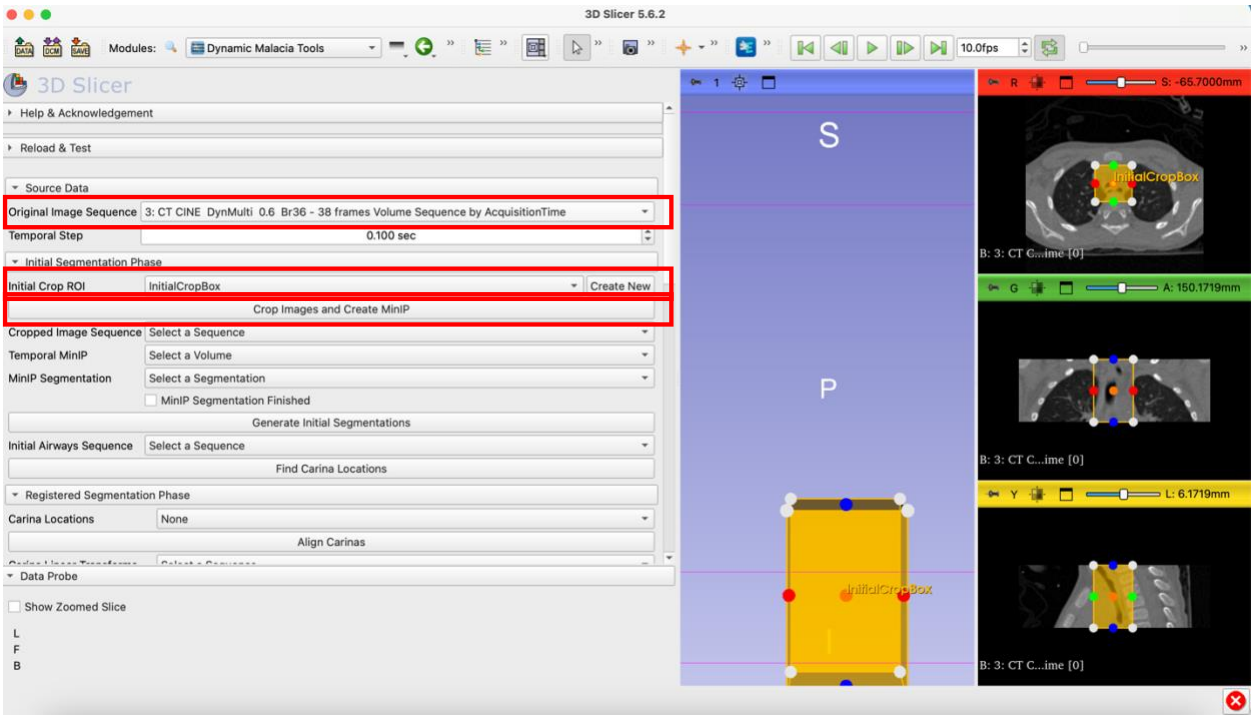
8. Once the “DynamicMalaciaTools” file and necessary extensions are installed, re-start Slicer.
9. Re-open Slicer and import the 4D CT DICOM file you wish to analyze.
10. Once the DICOM is imported, use the “Modules” search bar to find and open “Dynamic Malacia Tools”



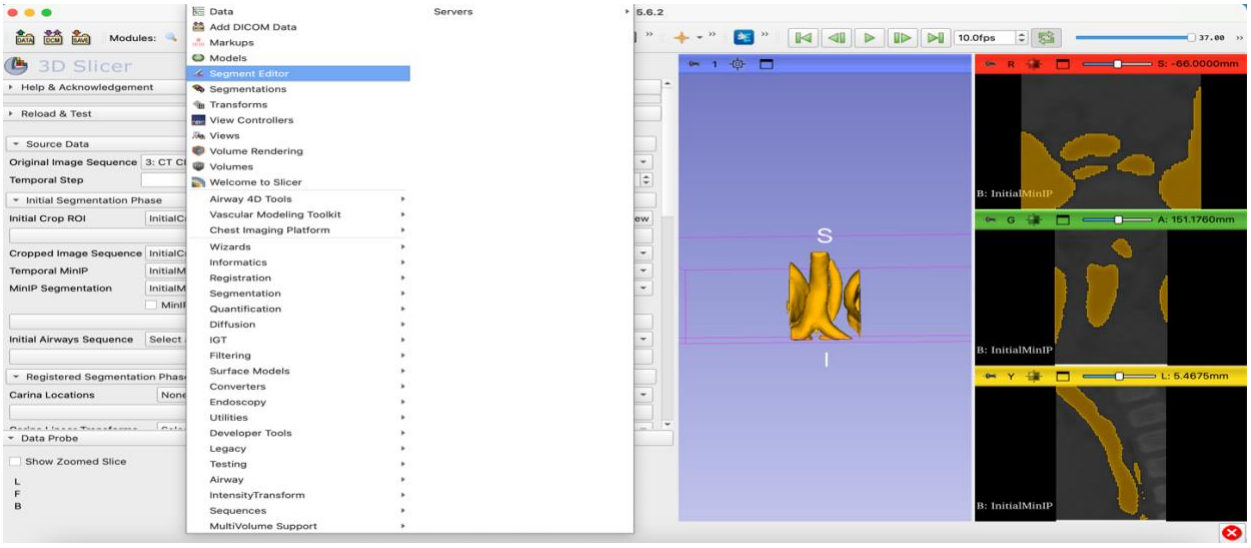
11. Upon entering the module, you will be prompted with various drop down options which you will complete sequentially to generate the dynamic airway volume segmentation and associated analysis.



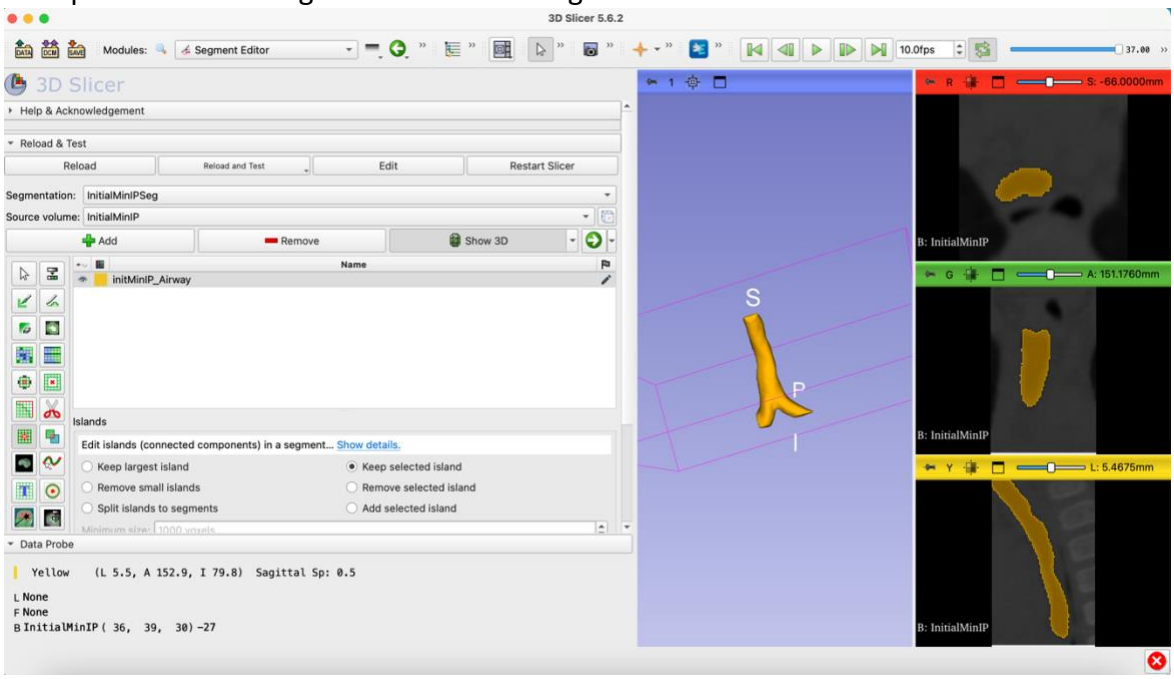
12. Under “Original Image Sequence” select the DICOM sequence previously imported. Here, it is called “CT CINE DynMulti…”.
13. Next select “Create New” for the “Initial Crop ROI” step. Here, define a boundary around the airway you wish to segment.
14. Select “Crop Images and Create MinIP” to generate the initial segmentation.



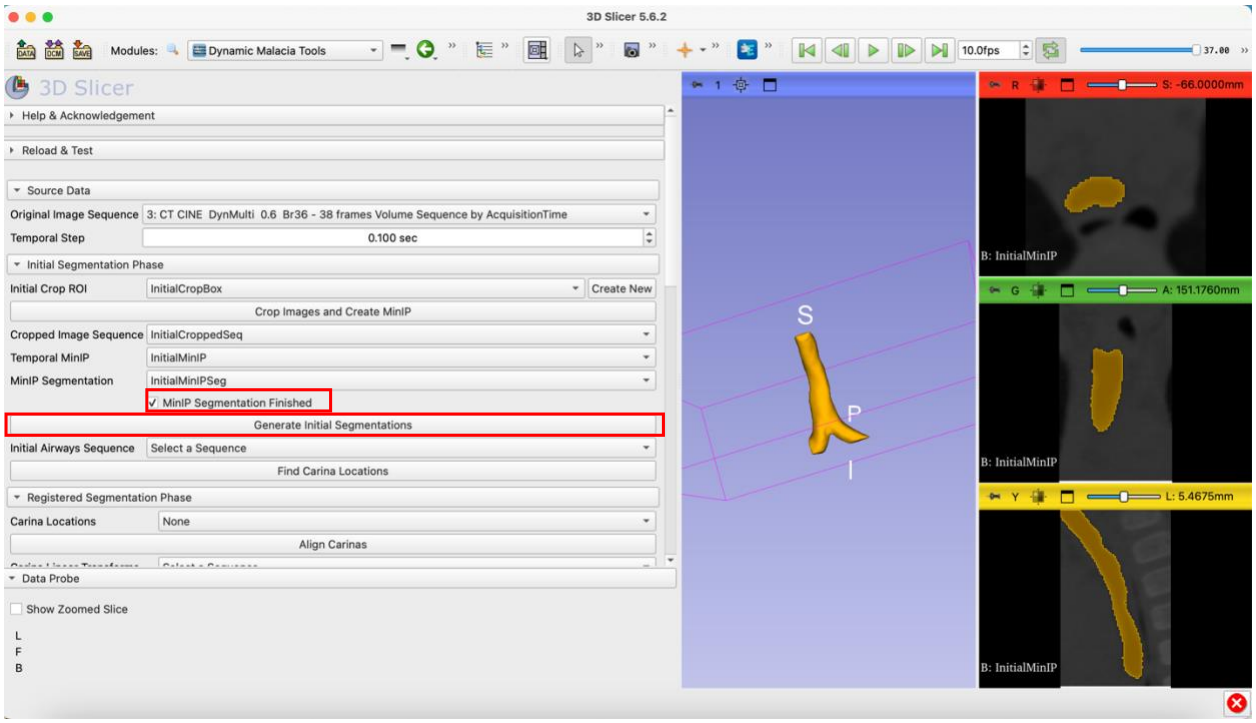
15. Once the 3D segmentation is generated, switch to the “Segment Editor” module to clean the segmentation so only the trachea is present. Note: When editing this MinIP it is important that a clearly defined carina is present for the rigid registration steps that occur next.



Example of what editing the MinIP in the Segment Editor Module looks like.

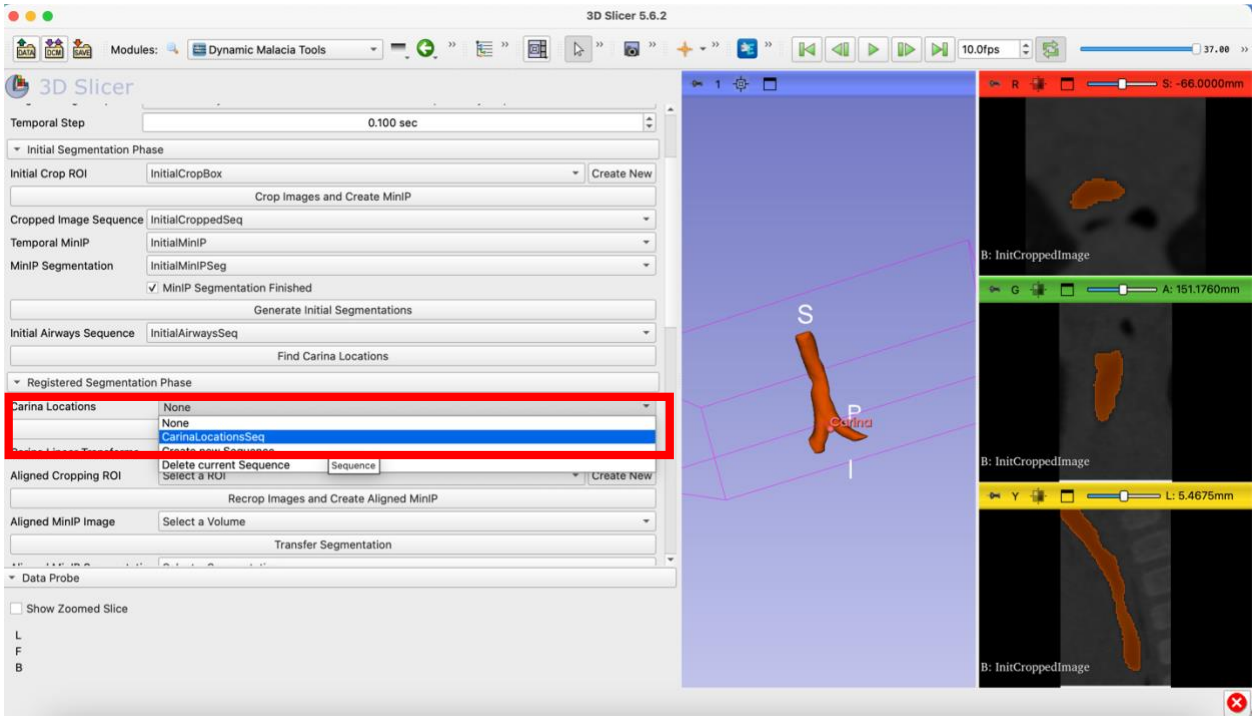


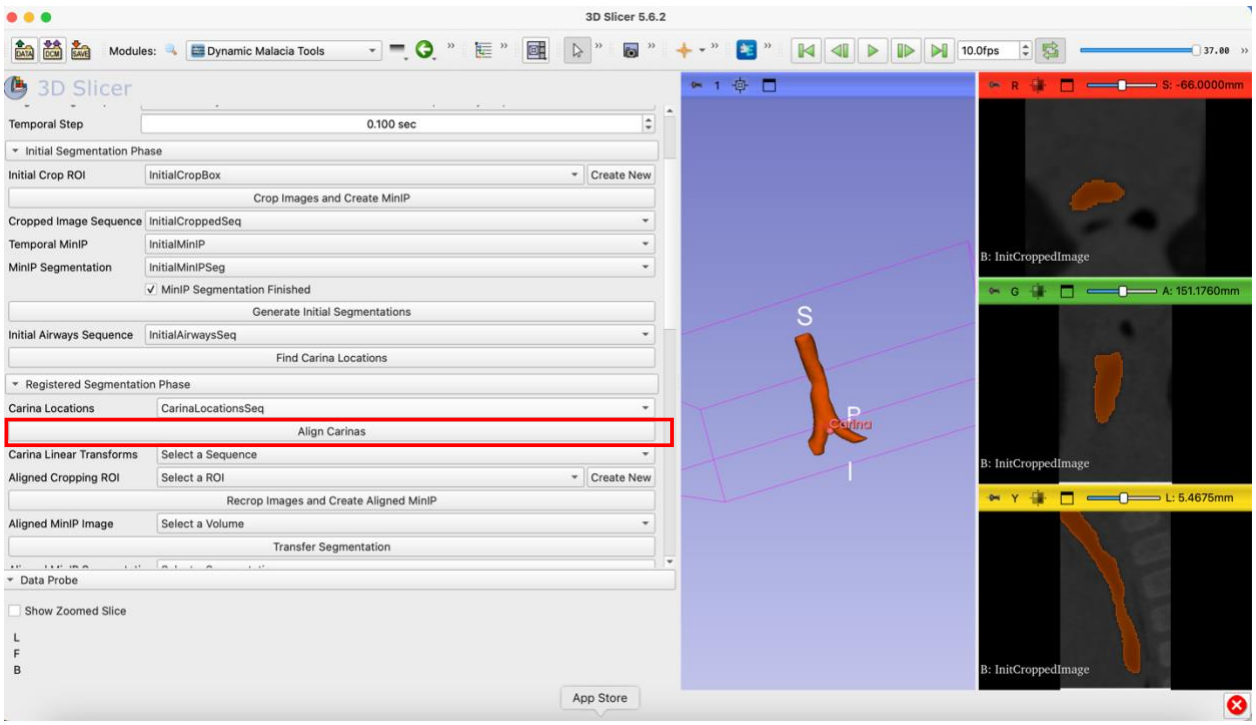
16. Once edited, return to the Dynamic Malacia Tools module. Click the check box next to “MinIP Segmentation Finished” and then select “Generate Initial Segmentations”. Note: All drop down options will auto-fill to the correct item unless otherwise specified.



17. The next several steps will complete a rigid registration to better align each frame of the dynamic sequence. To do this first, select “Find Carina Locations”. You will see a load bar as it scrolls through each frame to identify the carina.

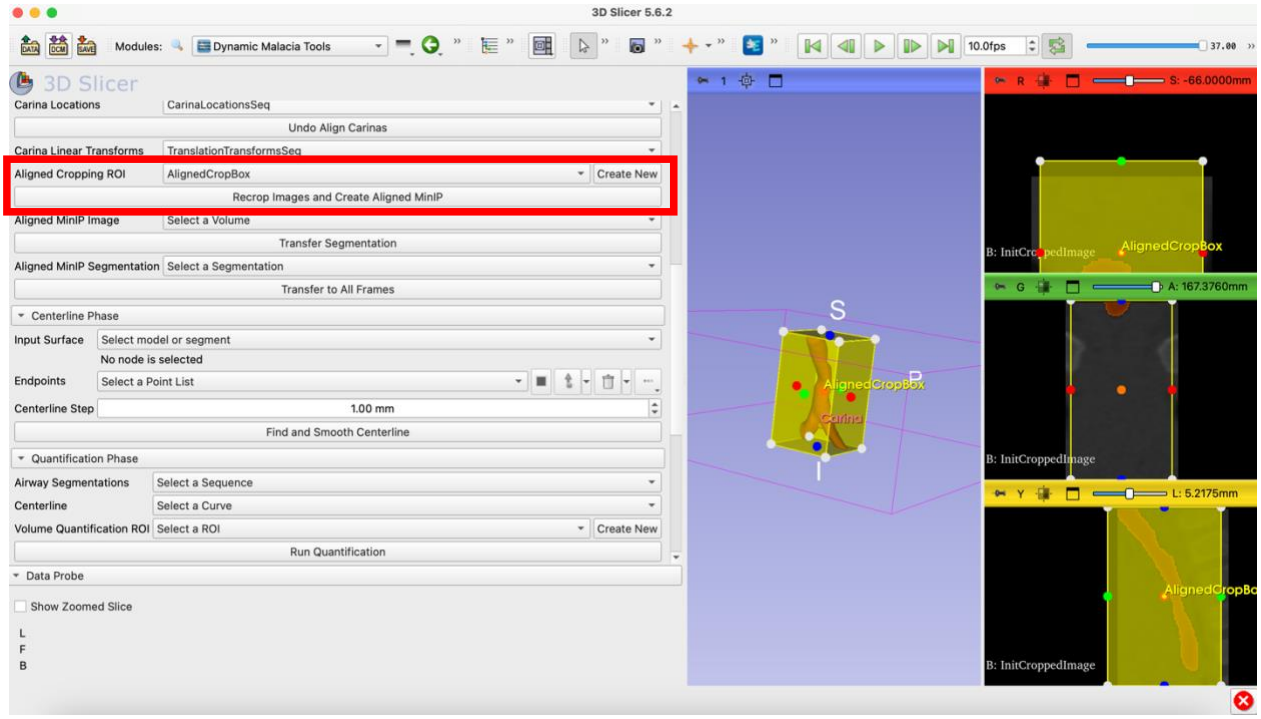
18. At “Carina Locations” click the drop down menu and select “CarinaLocationsSeq”. Then select “Align Carinas”.



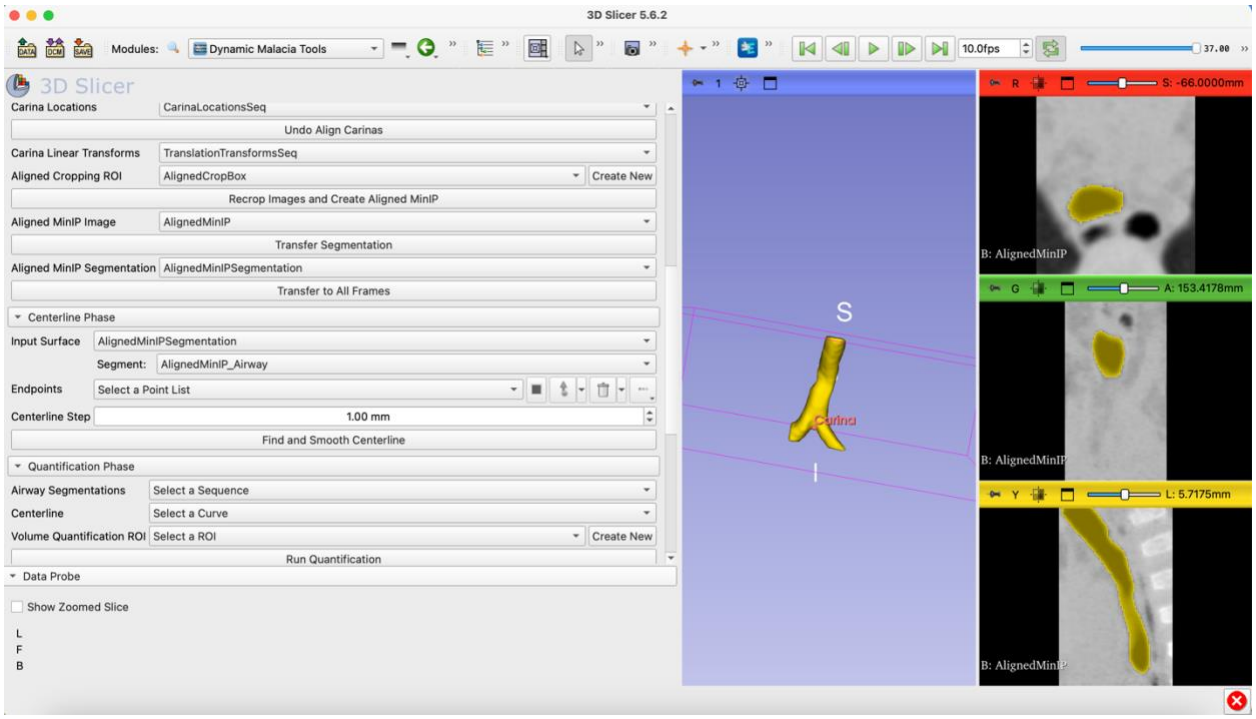


19. Once aligned, create a new aligned cropping ROI by clicking “Create New”. This will likely be the same ROI generated previously; however, if any of the airway now extends outside the ROI box, adjust it to capture the full airway. Note: If the ROI box is green and not editable,

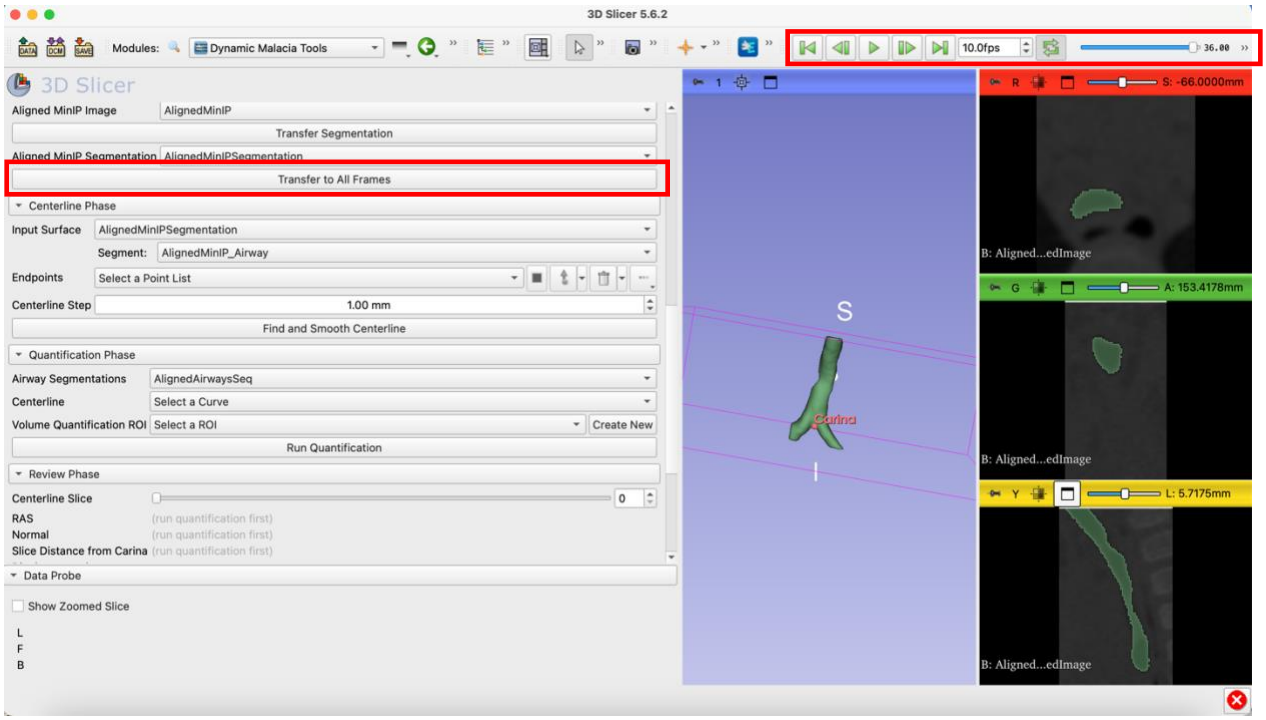
right click it and select the check box for “interactions” to make it adjustable. Once completed, select “Recrop Images and Create Aligned MinIP”.



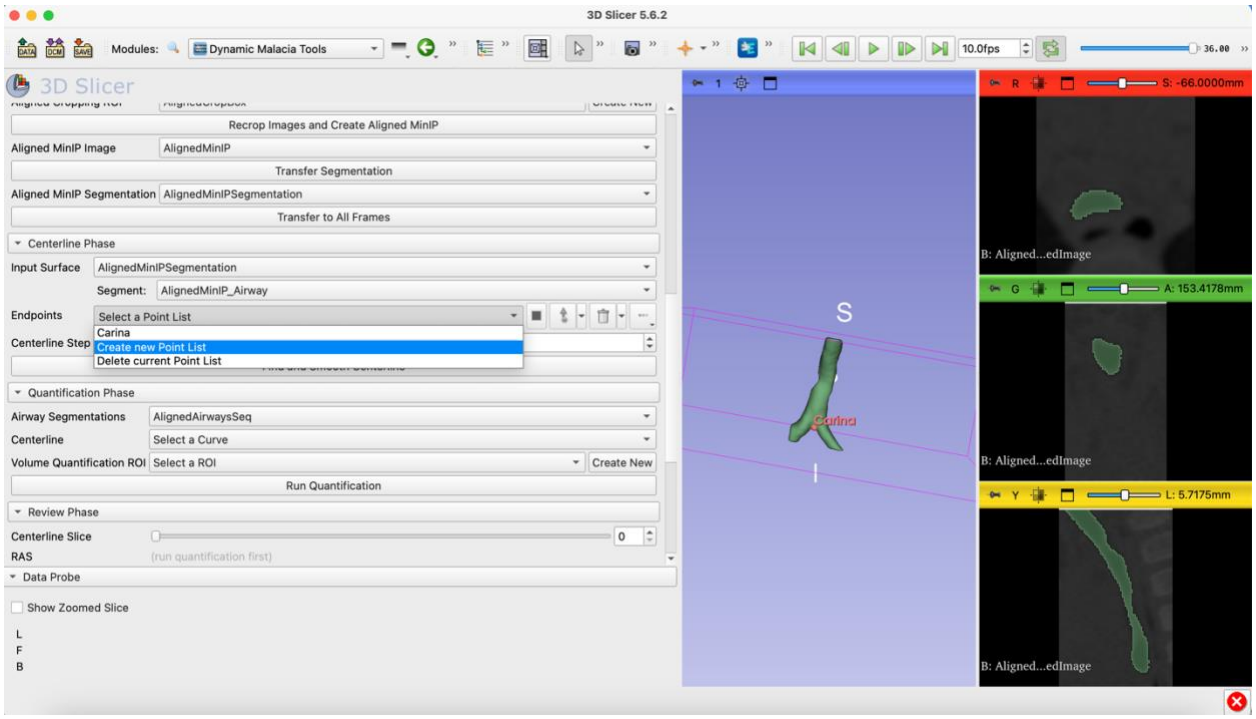
20. Select “Transfer Segmentation” to generate the Aligned MinIP. Note: This step may require additional manual editing/ cleaning of the segmentation in Segment Editor as previously described.

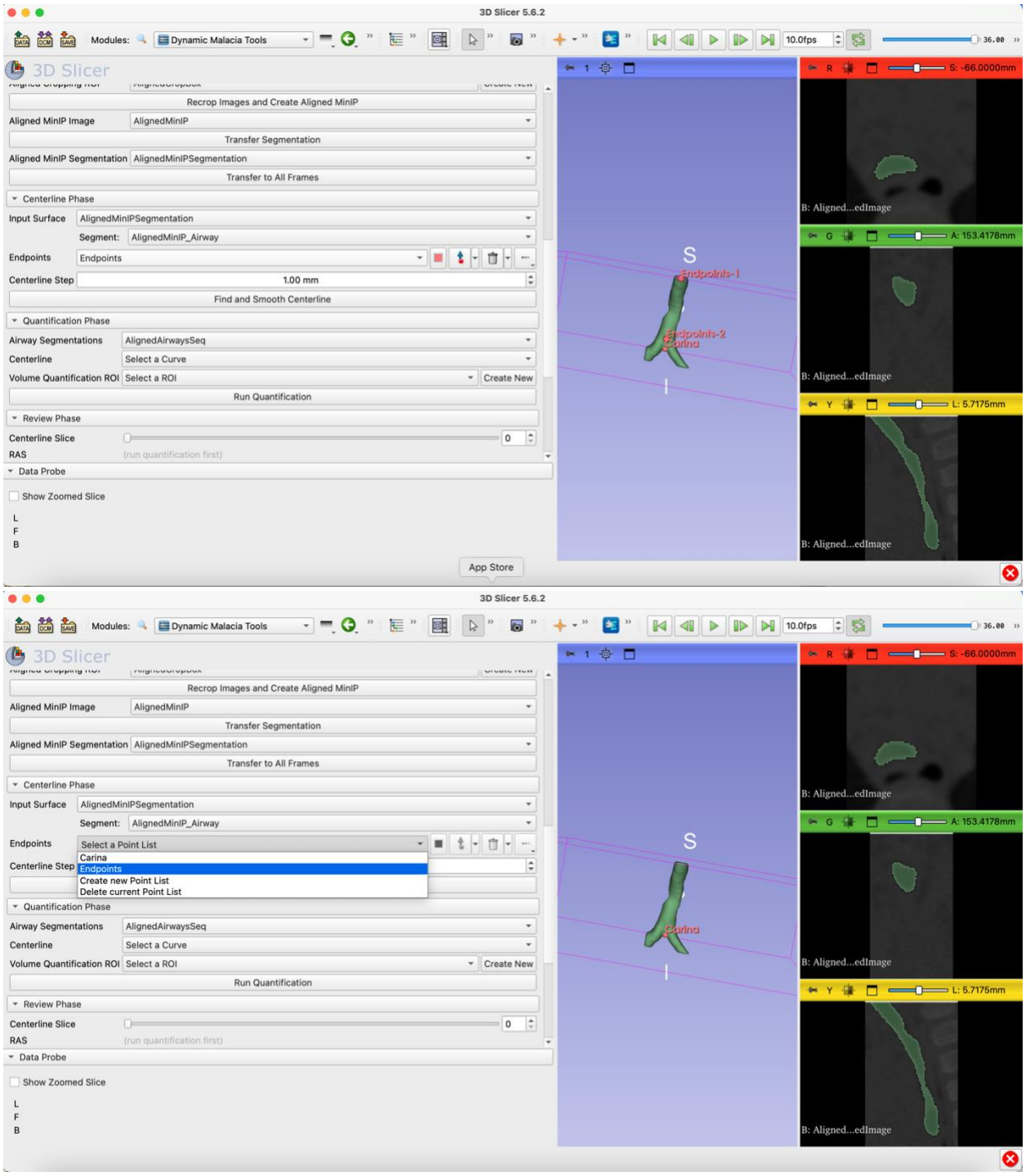


21. Select “Transfer to All Frames”. This generates the dynamic segmentation. It is a good idea at this time to scroll through each frame using the green arrows on the top right to ensure each frame’s segment is clean, without overlap of other structures. Note: You may need to edit frames in Segment Editor as previously described.



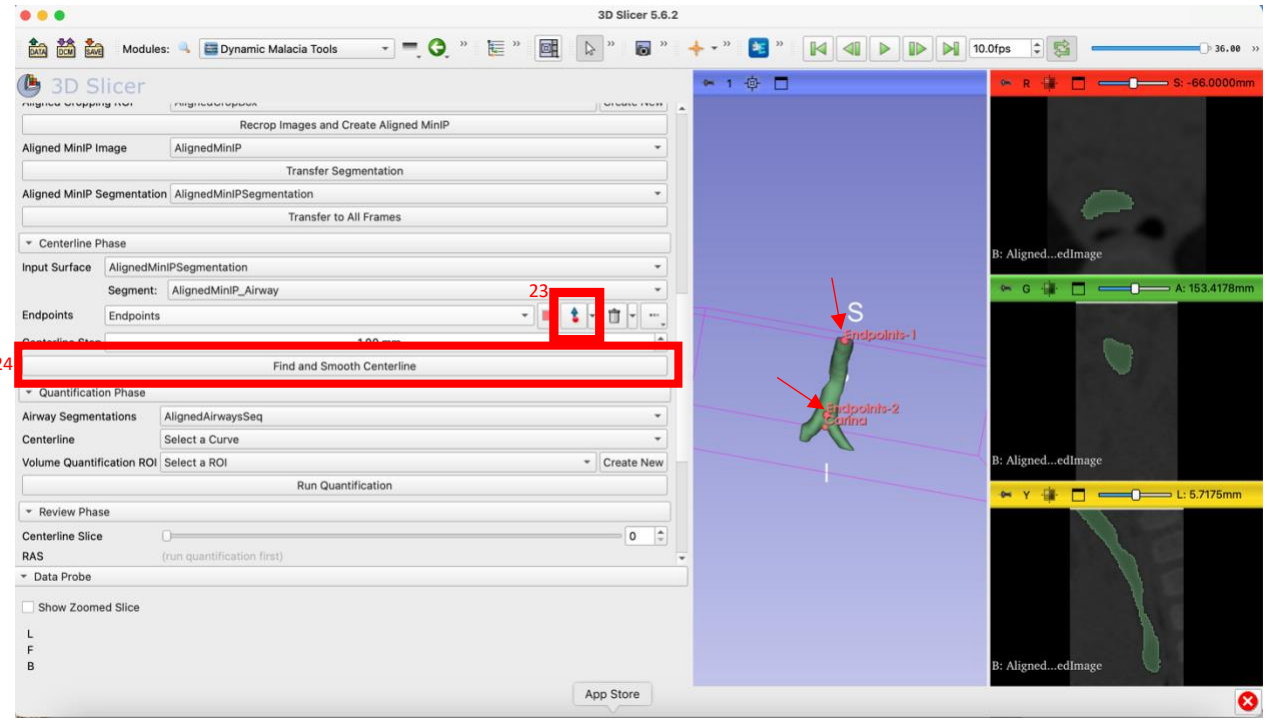
22. To analyze the segmented airway, first generate a smoothed centerline. To do this, select “Select a Point List”, “Create a New Point List”, then “Endpoints”.





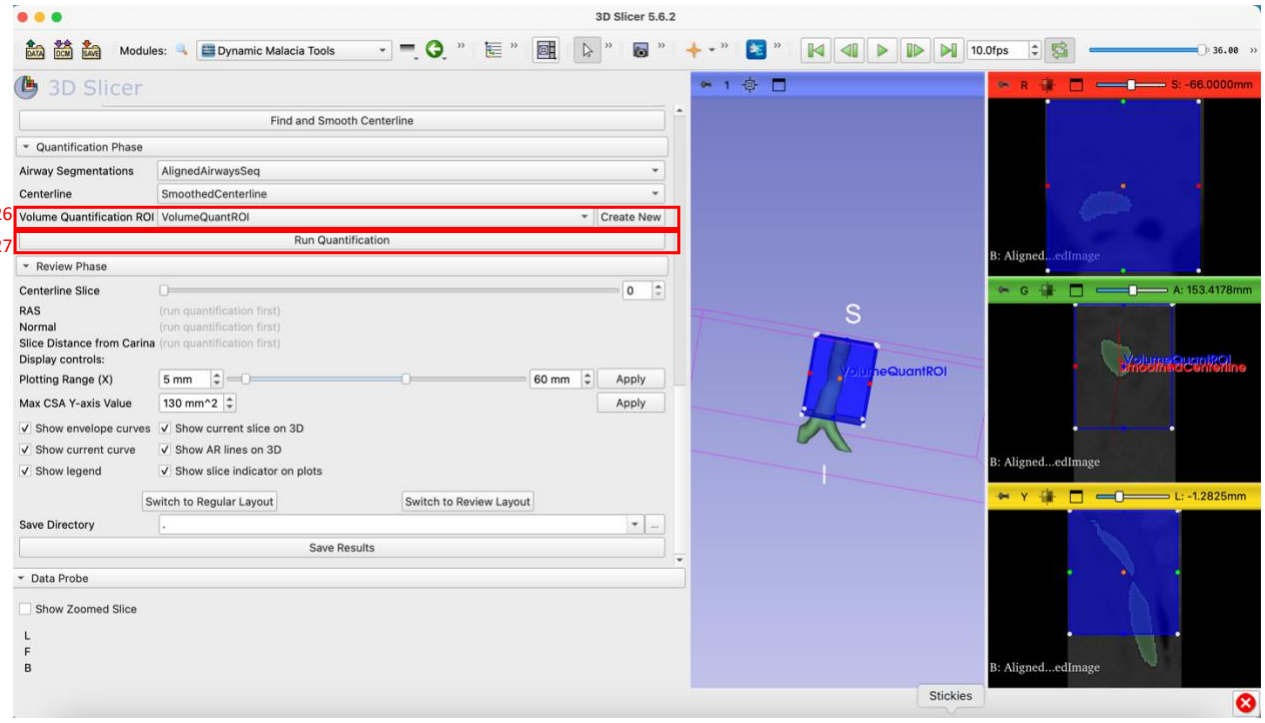
23. To define endpoints, click the icon of the pink dot with the blue arrow and on either the 3D segmentation or sagittal CT window, select two endpoints: (1) at the superior aspect of the segmented airway and (2) above carina, before the bronchi branching occurs.

24. Once the endpoints are defined, select “Find and Smooth Centerline”.

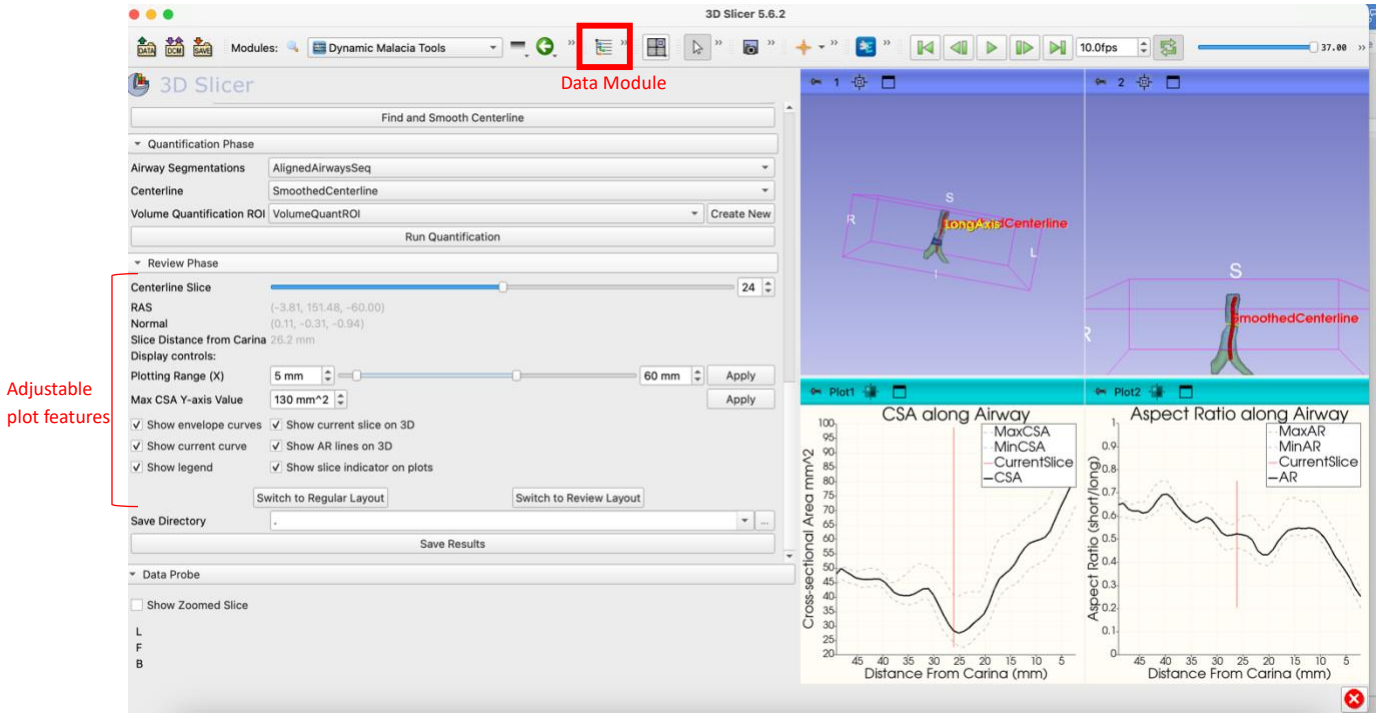


25. Once the centerline is defined, scroll through the sagittal CT view to ensure the centerline does not extend beyond the limits of the airway in any frame. If it does, the analysis will not work and you must repeat steps 23 & 24.
26. Select “Create New” to define a Volume Quantification ROI. This will determine the airway volume at each frame to see how it changes throughout respiration and the collapse event. This ROI should terminate above carina and NOT include the mainstem bronchi.

27. Once the ROI is defined, click “Run Quantification”.



28. The quantification will generate plots of maximum and minimum cross-sectional area (CSA) and aspect ratio (AR) along the airway with the ability to scroll through each frame and see how that frame/ slice corresponds to the displayed values. It also generates tables for CSA, AR, and volume values that can be further investigated under the data module.



29. To save results, select the file location you'd like to save results to in "Save Directory" step. Then click "Save Results". It is a good idea to double check the files have saved in the appropriate location prior to closing out the Slicer session. Note: If you desire to save the full Slicer scene, we recommend saving it as an mrb file using the save icon in the top left.