

Semi-Automatic Alignment of 3D Volumes Using 3D Slicer v4

Download the open source software D3Slicer v4 from <http://download.slicer.org>

Also download the open source software Fiji <http://fiji.sc/wiki/index.php/Fiji> It's essentially the same as ImageJ, but comes with many pre-installed plugins and can update itself automatically.

Introduction

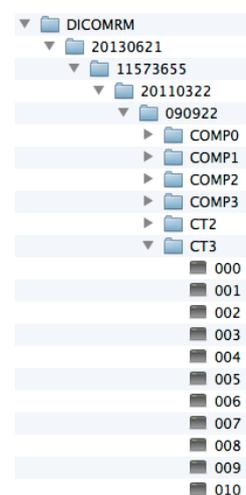
This document focuses on Slicer and assumes a working knowledge of Fiji / ImageJ which can be used for quantifying image characteristics after aligning the volumes.

Preparing Volume Stacks in Fiji

Importing DICOM Series and Converting to NRRD Format

If the raw data is in DICOM format, it can be imported into Fiji and turned into a tif or nrrd file, both of which can be opened in Slicer and are easily moved between programs.

The easiest method of finding the folder containing the series of images is to open all the folders until you find the one containing the (hundreds) of image files in the series. Sorting the folders on size may help.



Once the correct folder is located, drag the folder's icon to the main menu of Fiji (above) and confirm you want to open it as a stack (ie. a series).

Check the format of the data in the image window and convert to an 8-bit image using Image / Type / 8-bit if it is not already.



Once imported into Fiji, go to File / Save as ... / nrrd and save the series in this format. Tif format will also work, but Slicer defaults to nrrd format, so this keeps things tidier, but is not essential.

Repeat with the other series you wish to align the first one to. Save both files in a new folder and keep all associated files in this folder too. The file will appear as a single icon, but does contain all the images in the series, unlike the DICOM series which shows all the files as individual files.

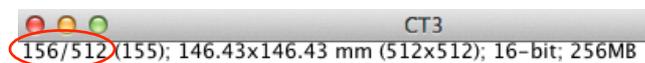
Basic Stack Alignment

Although the two stacks represent the same subject, variations in tilt may mean the series begin at quite different regions. If these are too far out of register it may make the automatic alignment shifts too difficult for the program to achieve. It helps considerably if the stacks are edited in Fiji to make

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their first few slices begin in roughly the same feature. This may mean losing a number of slices from one of the stacks.

Open both stacks in Fiji and see how closely they align in the first few slices of the series. Take note of the slice numbers in each of the series at the point where the features are roughly synchronised. For example, it may be that the mandible is the first feature which comes into view at slice 15 in series 1 but in slice 25 in series 2. To even up the series, remove slices 1-14 in series 1 and slices 1-24 in series 2.



Removing Slices from Image Series

Option 1: Slice Removal

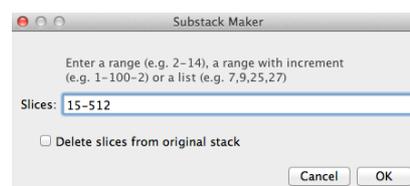
Go to Image / Stacks / Tools / Slice Remover and the following window appears. Choose the number of the series to begin at and the one to end at, always have the increment option set to 1, the default value is 2 which will cause every second slice to be lost. In this example, the first 14 slices have been removed.



This option removes the slices from the original series, so it is wise to save it with a new name in case you need to return to the original series.

Option 2: Make Sub-Stack

Go to Image / Stacks / Tools / Make Sub-Stack, the following window appears. Enter the range of images you want to use in the new series, in this example it is slices 15-512. Do not tick the 'Delete slices from original stack' option to keep the original series untouched.



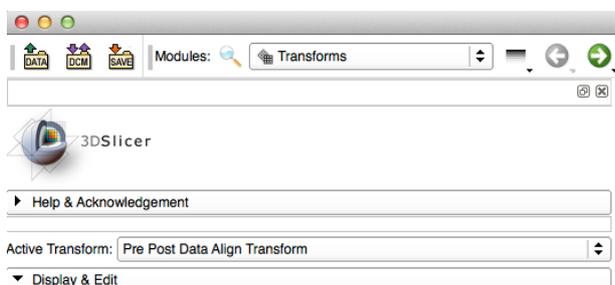
This option makes a new series containing only the images in the range specified above.

With the series in rough alignment, switch to Slicer and complete the registration process. Some experimentation may be necessary, particularly with regard to the method of alignment chosen, ie. 'Registration Phases', page 6.

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Manual Pre-Alignment

If your image volumes are by chance closely aligned, you may be able to move to the next page and not have to do this step. It is likely however that you will have to do some manual alignment to get the volumes close enough to then be finally aligned automatically.

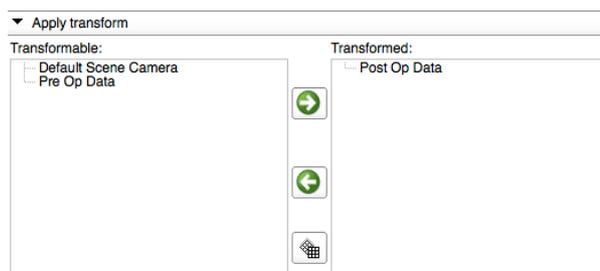


First, a transform must be named, this will then have all the manual movements associated with it when you move one data set to reasonably closely match the other.

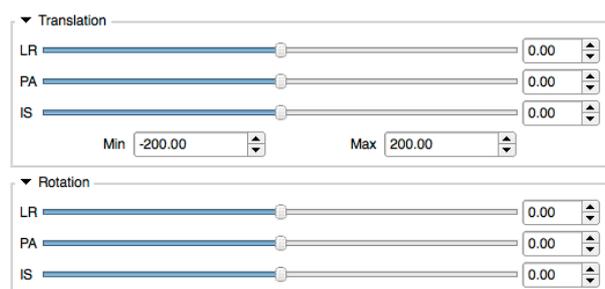
Click on the arrowed menu beside Active Transform and choose 'Create and Rename New Linear Transform'.

Set the transparencies of the two data sets as described on page 5. This allows the two data sets to be viewed simultaneously when manually aligning them.

Highlight the moveable volume in the left hand panel, in this case the Post Op Data, and click the green arrow to move it to the right hand panel 'Transformed'. This associates the movements of the transform file above with this volume.



Under the Data module you will now see the Post Op Data volume nested within the Pre Post Data Align Transform.



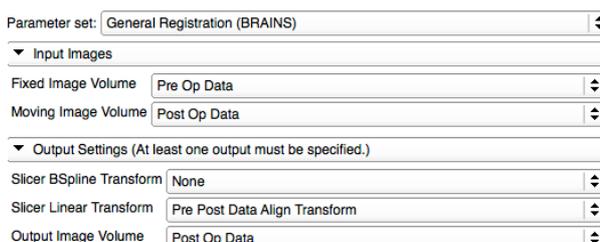
Adjust the Translation and Rotation sliders to align the Pre and Post Op data sets.

When finished, highlight the file name in the

Transformed panel and click the  symbol to 'harden' the transform. This associates all the transforms to the moveable file and is used to generate a new volume in the next section.

Choose the Registration / General Registration (BRAINS) module and set up the panel as shown here. Select the two volumes to align and the linear transform created in the previous section.

Under Output Image Volume create a new name for the aligned (Post Op in this case) volume which will be created and used in later analysis.



Continue from the top of page 6 to complete the process of generating a new aligned image volume.

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Aligning Prepared Series in 3D Slicer

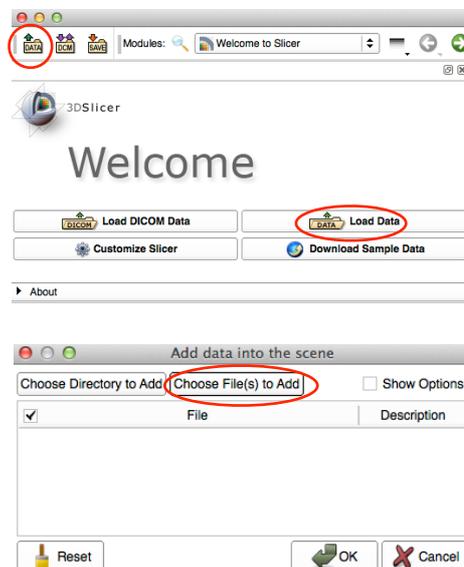
Opening Series

When Slicer opens, the default screen is the one to use for importing image series. Use either of the two options shown here to navigate to the two image series and open them.

DICOM files can also be loaded directly using the other options on this window. You will still have to navigate through the file folders and trimming the series is more difficult - mainly because I haven't worked this out yet.

When the window opens, click on the 'Choose File(s) to Add' option and then navigate to the appropriate folder.

Hold down 'command' key on a Macintosh to open non-sequential files. A similar keystroke allows this in Windows if you have the misfortune to be using it as an operating system.

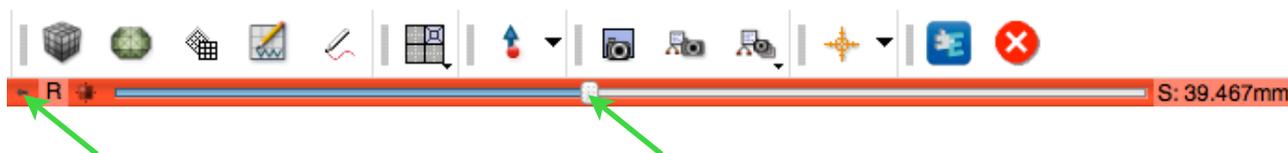
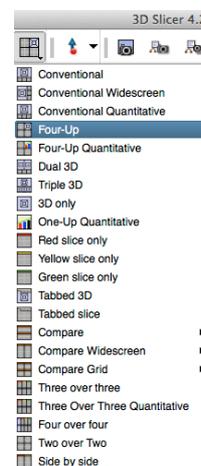


Slicer View Setup

To make life easier and see how your images align in axial, coronal and sagittal planes select the 'Four-Up' view option from the main menu, as shown in this image.

There are many choices of view, but Four-Up is a good starting point. The fourth view is of any 3D volumes of the series data, if they are used.

Some of the Slicer controls are very cryptic and well hidden. Some of the more useful ones are described below. They allow the two image series to be superimposed, plus the re-aligned series and the degree of their alignment judged.

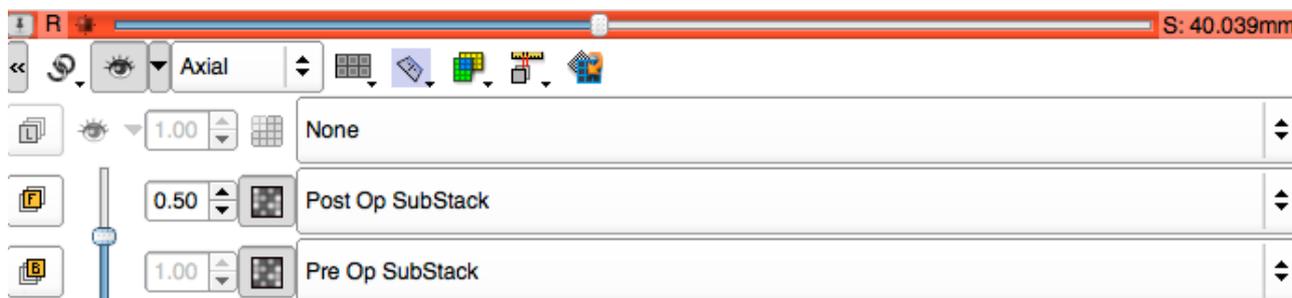


Hover over this icon to show image overlay options and other useful things. Clicking it keeps the menu visible until clicked again.

Move this arrow left and right to scroll through the image series.

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After clicking the corner icon the window below will be visible, from this select the two data series to compare. For consistency, for all alignments pre-op series will be the fixed volume and post-op will be the series which is repositioned to align with the pre-op series.



Choose the pre-op as the background image and the post-op as the foreground image. As shown by the yellow B and F symbols above. Use the vertical blue slider to adjust the transparency of the background image, making their alignment apparent in the view window.

Choosing Automatic Alignment Module

If the pre-alignment in Fiji was done correctly, the images will be roughly in alignment. To align them completely another module of Slicer is required.

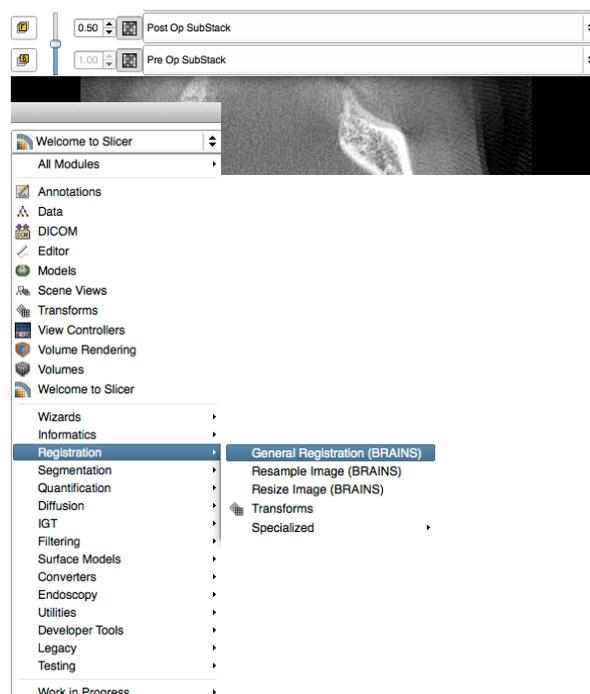
Choose the Registration / General Registration (BRAINS) option from the main drop down menu.

This will perform the final registration process and generate a new aligned series.

Again, use the pre-op series as the fixed reference image and the post-op series as the moving series which is aligned to the fixed series.

The new series generated will therefore be a copy of the post-op series, but oriented in a way to match up with the pre-op series.

The pre-op series is left unchanged and is used to match up regions of interest in Fiji for the final analysis stage.



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Performing Automatic Alignment

From the drop down menus, choose the appropriate series files to align. These must have already been loaded into Slicer.

It is critical to choose an output image volume, otherwise nothing will be generated. Click on the menu and choose the 'Create and Rename New Volume'. Enter an appropriate name and the window will look something like the one on the right.

For registration phases, the choice comes down to how difficult the alignment is and how long it will take to calculate it. Some experimentation is required, but Rigid+Scale+Skew or Affine are good starting points to try.

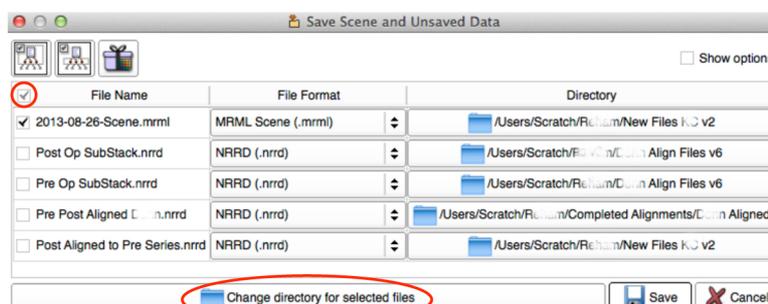
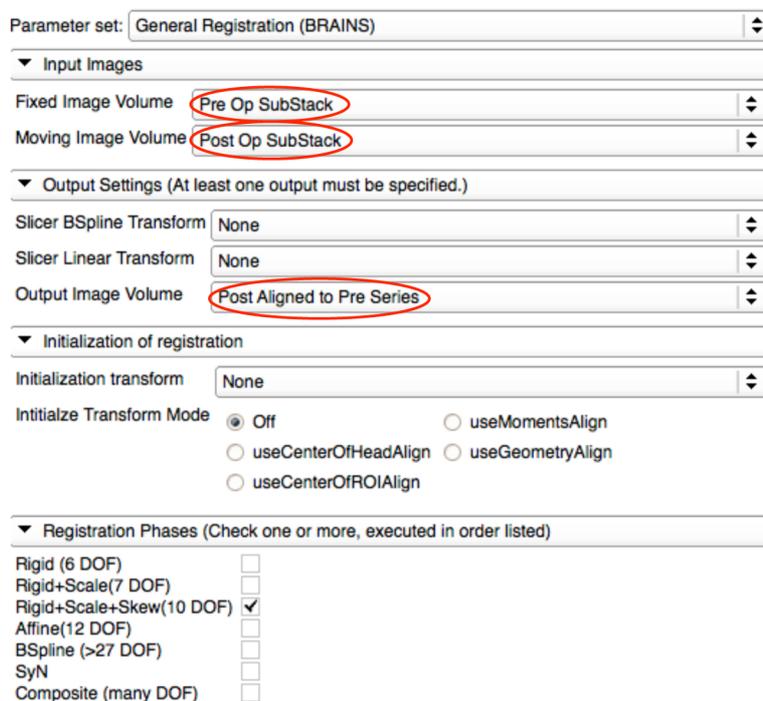
More than one alignment open can be performed if more than one option is ticked. (But don't go crazy, more is not always better.)

After a few seconds, or minutes, a new slice series is generated and can be viewed like any other from the viewer menu described above.

Before going too much further, click the 'Save' button at the top left of the main window. If the program crashes at this stage you will lose all your alignments - you've been warned!

In the save window either tick the files you want to save, or tick the upper most tick to select all the files.

To save all files to the same folder, select all the files as described above and then click the lower icon 'Change directory for selected files'. Navigate to the appropriate folder and select 'Choose'. All files will be saved to that folder.



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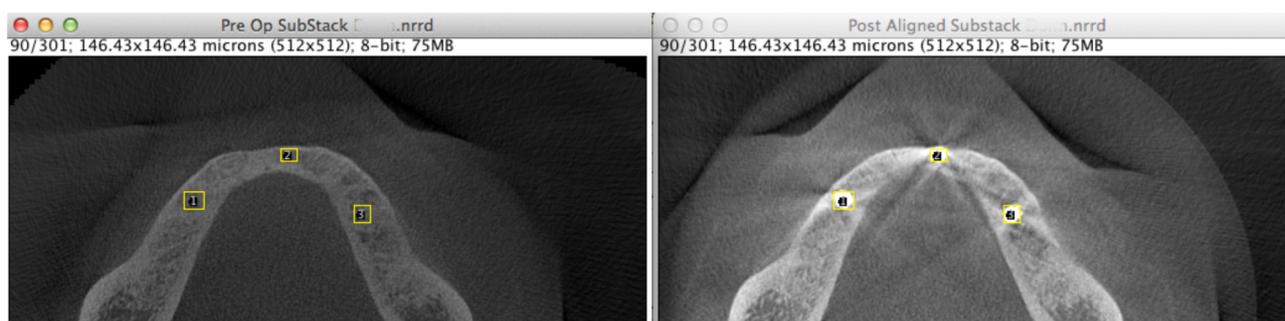
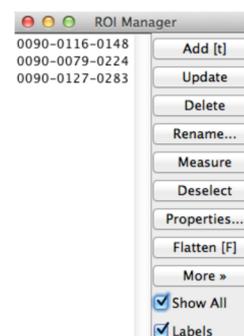
Matching Post and Pre-Op Regions in Series Using Fiji

Open the pre-op and aligned post-op series in Fiji. Check they are both 8-bit images, if not, change them using the Image / Type / 8-bit menu.

Find a region of interest (ROI) in the post-op series and open the ROI Manager using Analyse / Tools / ROI Manager menu. Add the ROI to the list by clicking in the manager window, or just press the 't' button.

Note the slice number, as the ROIs are slice specific, and scroll to the same slice number on the pre-op series. Click the 'Show All' box to force the ROIs to appear in the pre-op series. If all goes well the images should look like the ones shown below.

If the ROIs do not appear, check you are in the matching slice number in the second series and you may have to switch the 'Show All' option off and on a second time.



Density analysis can now be performed on the pre-op series in the areas since replaced by implants in the post-op series.

Potential Problems

Occasionally an aligned file may open in Fiji with its intensity scale reversed. It is sometimes fixed by inverting the image and then inverting it again to the usual intensity order. Edit / Invert menu.

If this doesn't work, you may have to export the image again from Slicer.