Fiducials

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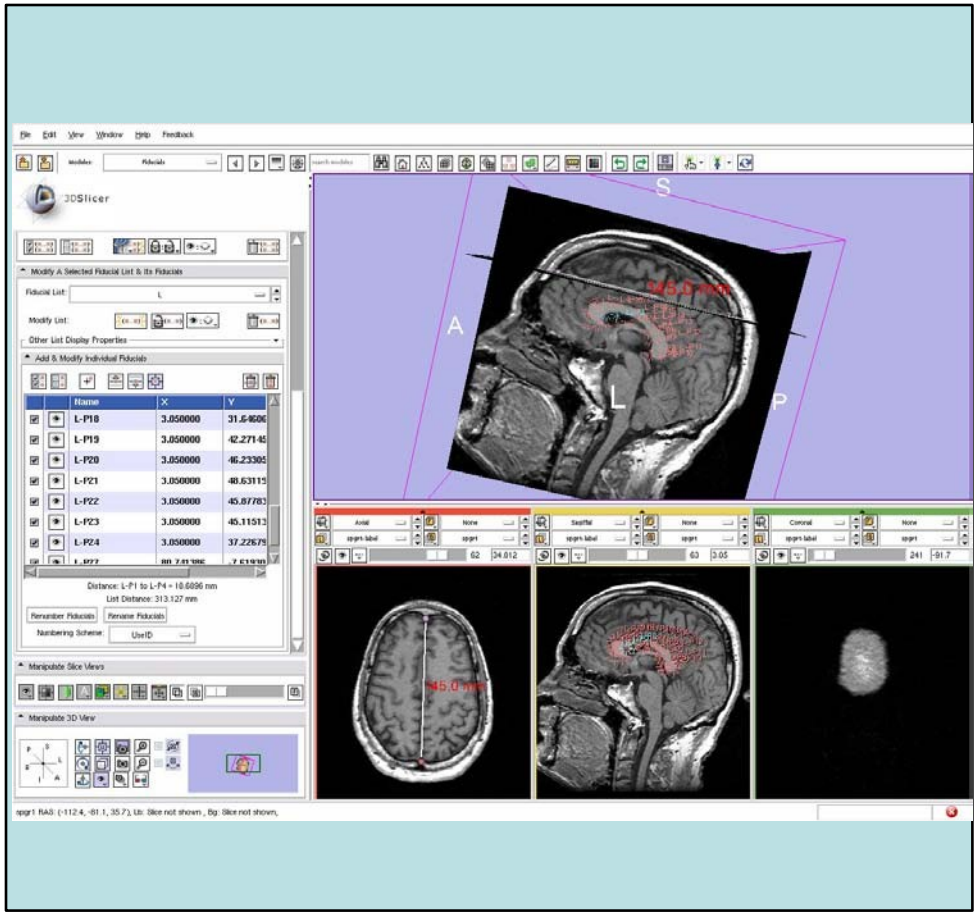
Brigham and Women's Hospital

NA-MIC Tutorial Contest: Summer 2010

Learning Objective

The goal of the tutorial is to familiarize users and developers with the capabilities of the fiducials in Slicer.



Pre-requisite

- This tutorial presumes that the student is familiar with the following :
  - –Slicer3Visualization Tutorial by Sonia Pujol, Ph.D.

http://www.slicer.org/slicerWiki/index.php/Slicer3.6:Training

Material

- This tutorial requires the installation of the **Slicer3.6 release**and the tutorial dataset. They are available at the following locations:
- **Slicer3.6** download page

http://www.slicer.org/pages/Downloads/

- **Tutorial dataset**:

http://wiki.namic.org/Wiki/index.php/File:Fiducials_TutorialContestSummer2010.zip

Disclaimer: *It is the responsibility of the user of Slicer to comply with both the terms of the license and with the applicable laws, regulations, and rules.*

Platform

- This tutorial was developed and tested on a 64 bit linux machine, and tested on a 32 bit windows machine.

Overview

- Adding and Deleting Fiducials
- Editing Fiducials
- Display properties
- Using Fiducials
  - –Linking and jumping slices
  - –Measurements
- Passing Fiducials to Command Line modules
- Fiducial Seeding
- Saving and Loading Fiducials

Overview

- **Adding and Deleting Fiducials**
- Editing Fiducials
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- Saving and Loading Fiducials

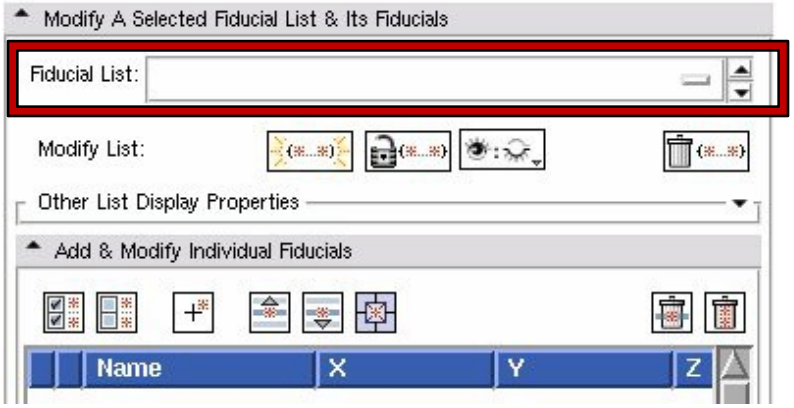
Adding and Deleting Fiducials

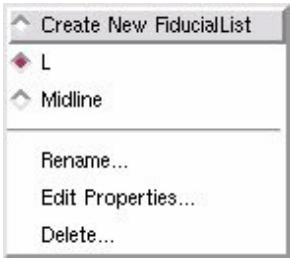
Fiducials can be added through the Fiducials module GUI.

In the toolbar, click on the Fiducials icon to go to the fiducials module.

Adding and Deleting Fiducials

Fiducials can be added through the Fiducials module GUI.
Click on the Fiducial List selector and click on Create New FiducialList.

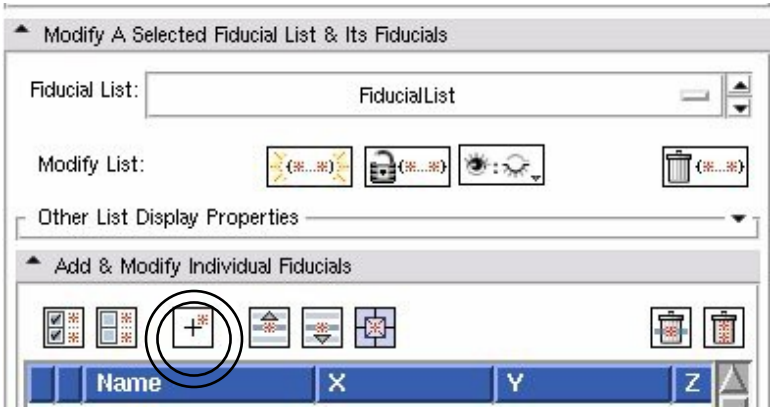




Control-l (lowercase letter L) will also create a new list.

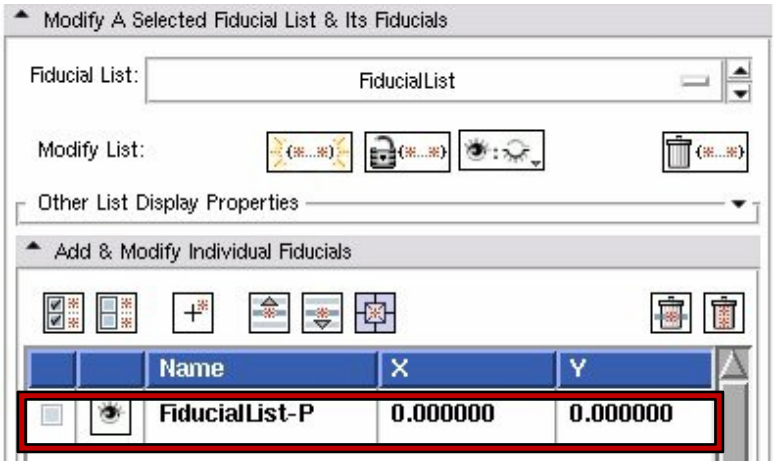
Adding and Deleting Fiducials

Click on the add a Fiducial button. A new fiducial will be added to the list, with a default position of (0,0,0)



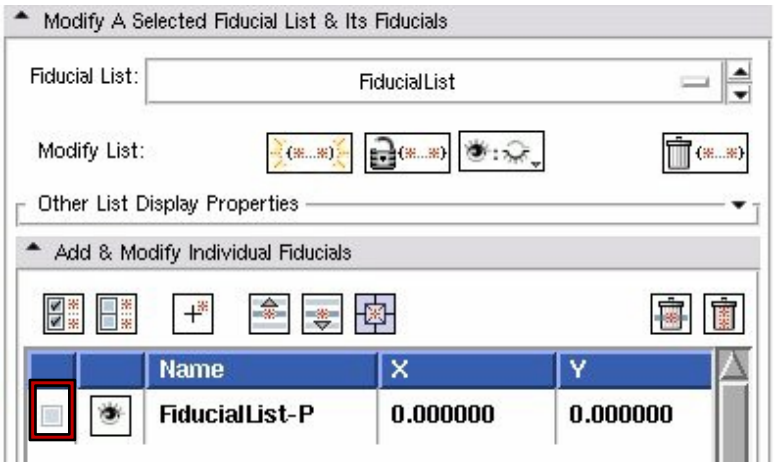
Adding and Deleting Fiducials

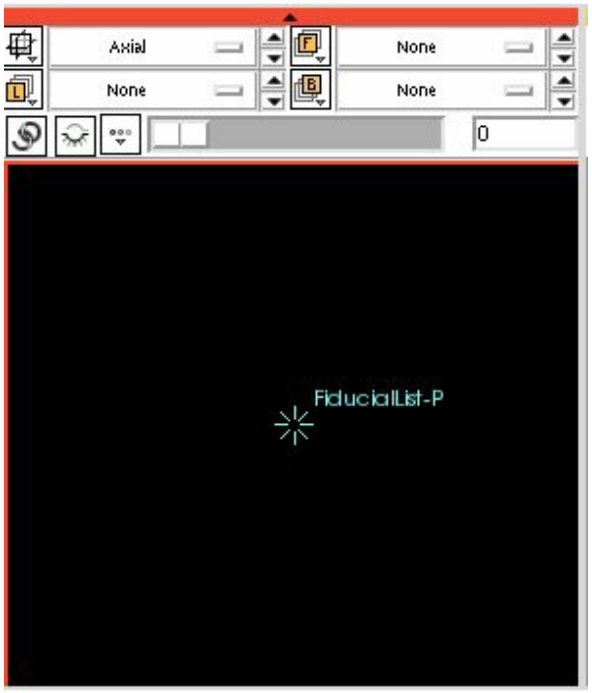
Click on the add a Fiducial button. A new fiducial will be added to the list, with a default position of (0,0,0)



Adding and Deleting Fiducials

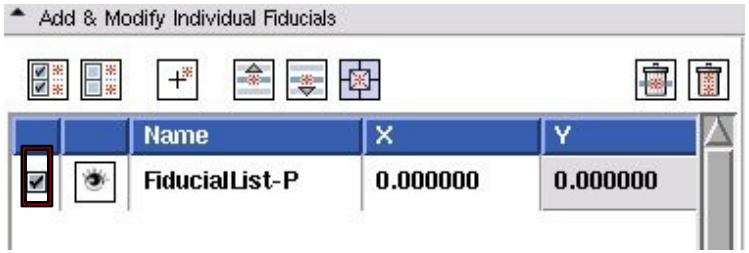
The new fiducial is set up by default to not be selected, click on the checkbox in the first column to select it.

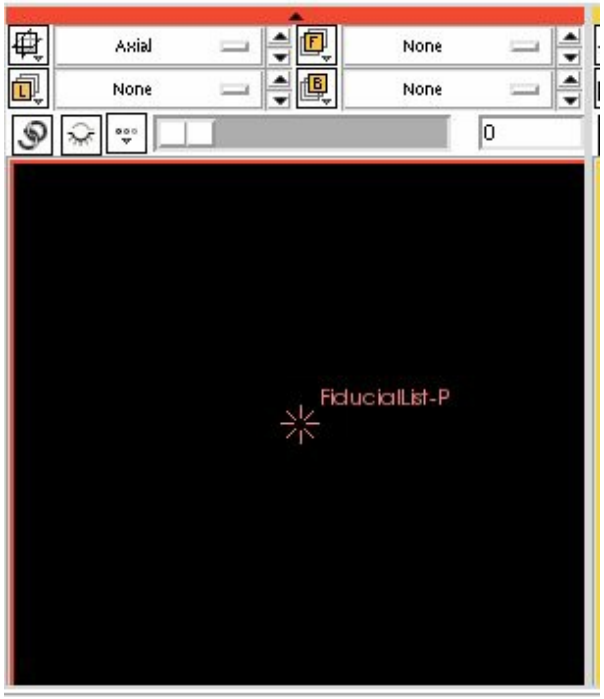




Adding and Deleting Fiducials

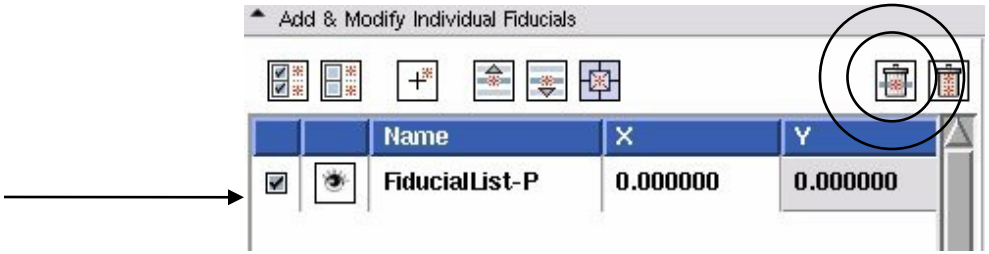
The new fiducial is now selected, and the color changes to reflect the new state.

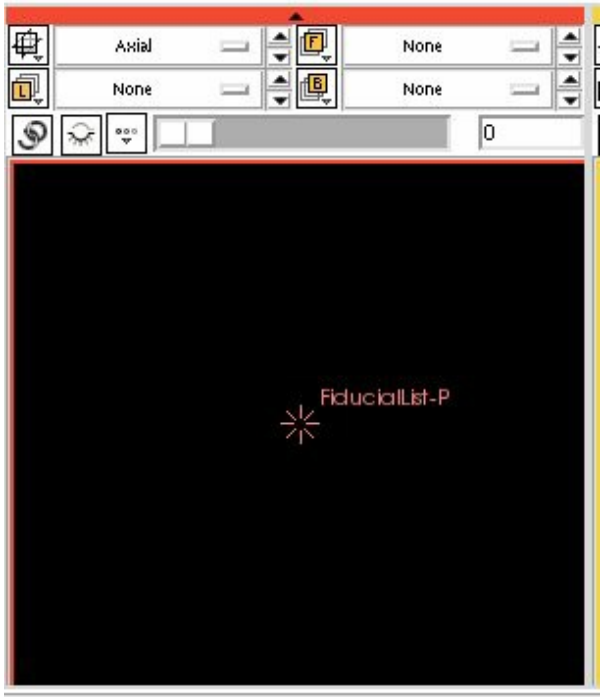




Adding and Deleting Fiducials

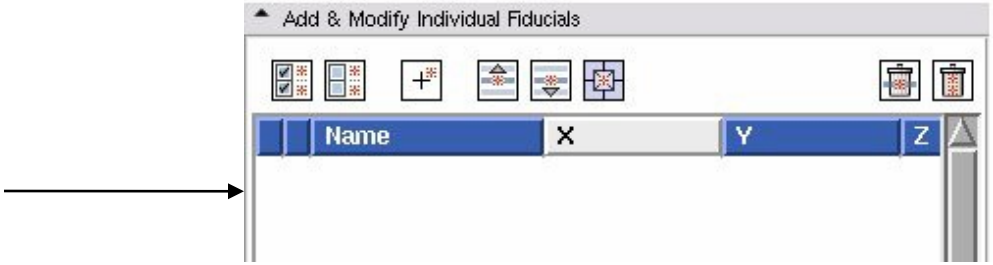
To delete the fiducial, click on the line in the table containing the fiducial you wish to delete, then click on the remove one fiducial button.

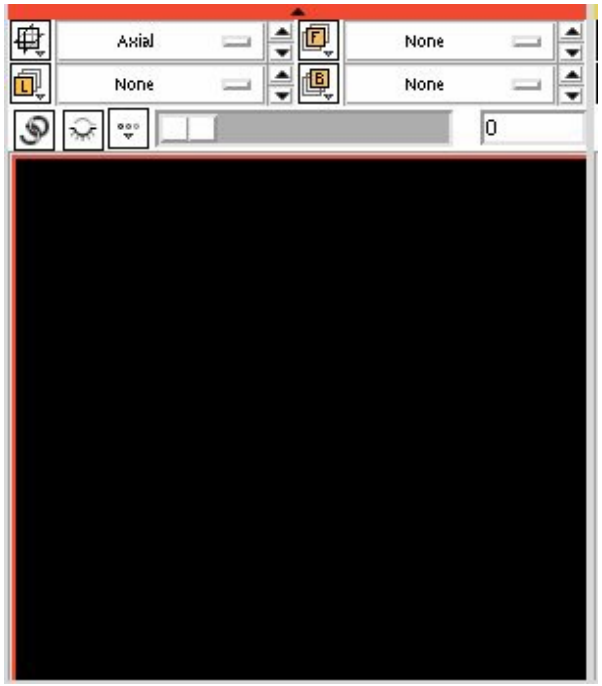




Adding and Deleting Fiducials

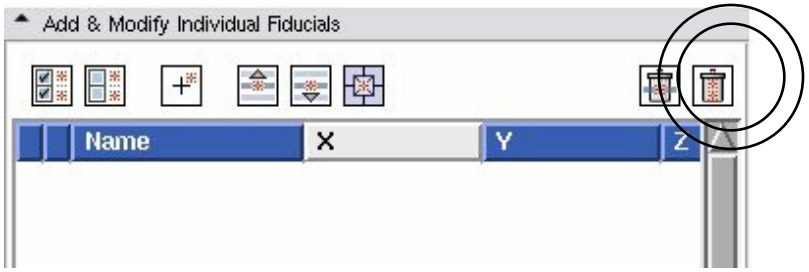
The fiducial is gone:





Adding and Deleting Fiducials

All the fiducials in a list can be removed by clicking on the remove all fiducial points from the selected list button.

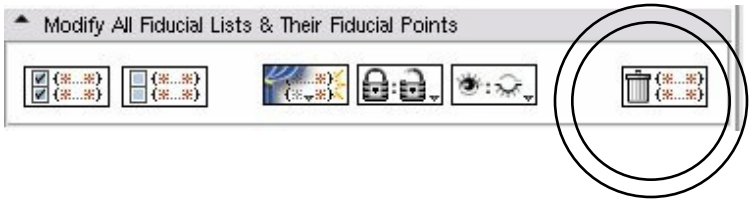


Adding and Deleting Fiducials

All the fiducials in a list and the list can be removed by clicking on delete all fiducial points in the selected list and then delete the list button:

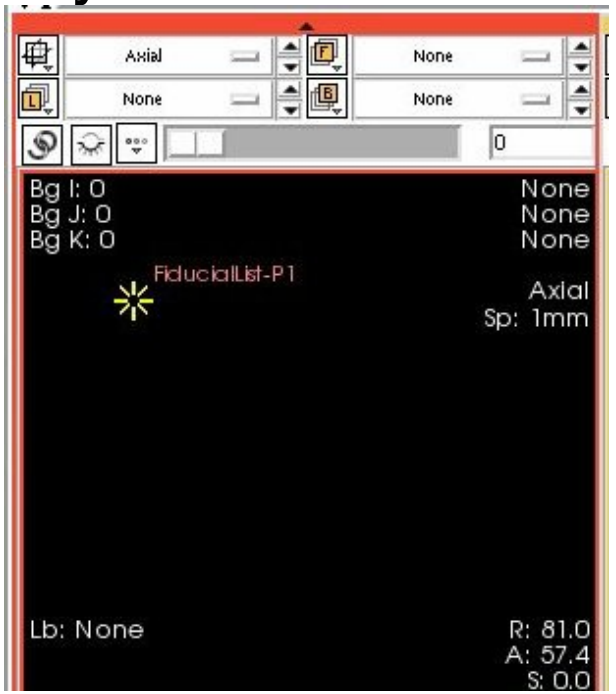
Adding and Deleting Fiducials

All the fiducials and all the lists can be removed by clicking on delete all fiducial points in all fiducial lists and all fiducial lists button:



Adding and Deleting Fiducials

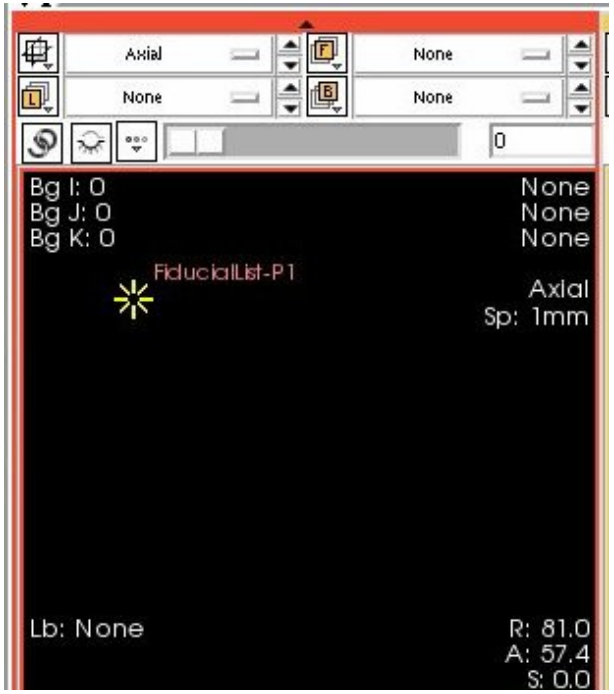
You can add a fiducial using the p key. Position the Mouse in a 2D slice window (you may have to click to take focus), then press the p key.



This allows you to place fiducials anywhere in the slice windows.

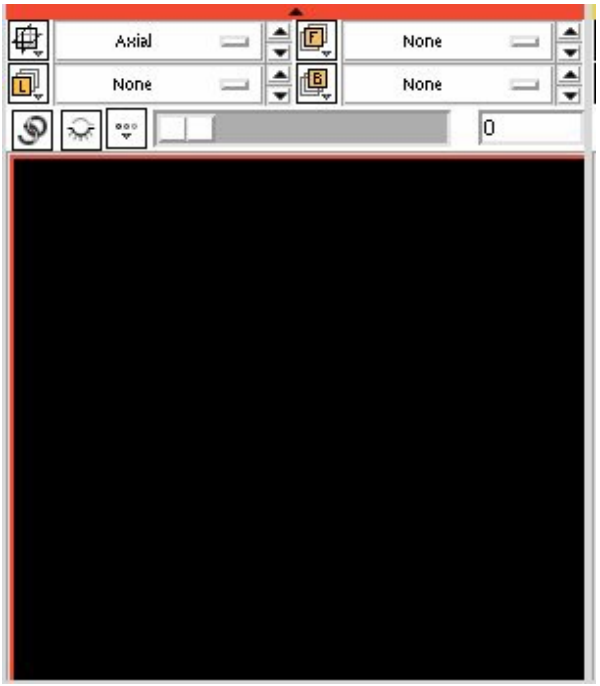
Adding and Deleting Fiducials

You can delete a fiducial using the delete or backspace keys. Position the mouse in a 2D slice window (you may have to click to take focus), over the fiducial you wish to delete. When it highlights, press the delete or backspace key.



Adding and Deleting Fiducials

The fiducial has been deleted.



Adding and Deleting Fiducials

Fiducials can be added using the mouse.
On the toolbar, click on the Create and Place drop down menu and select the second option:
Use mouse to Create-and-Place persistently.

To place just one fiducial and then go back to rotating the view automatically, select the first option:
Use mouse to Create-and-Place one time

Adding and Deleting Fiducials

You can now use the mouse to left click anywhere in the 2D slice windows to place new fiducials.

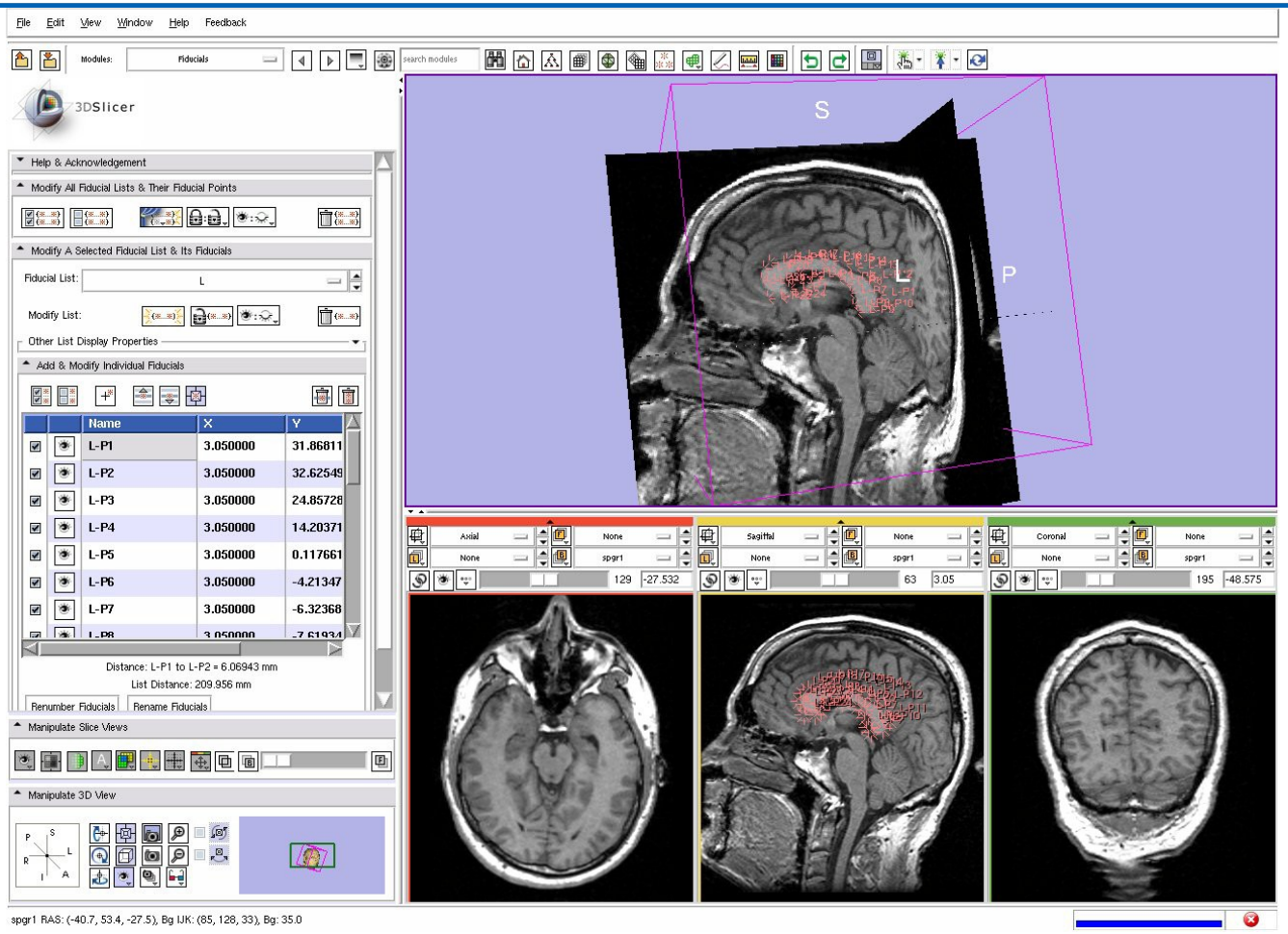
You can also click on models or slices or volume renderings in the 3D view to place fiducials in 3D.

In order to stop placing fiducials, click on the rotate view icon in the toolbar.

Adding and Deleting Fiducials

Load the file spgr.nhdr that is included in the tutorial data set. Make the slices visible and practice using the mouse to place fiducials in 2D and 3D.
Try outlining an anatomical feature with a list of fiducials.

Adding and Deleting Fiducials



Overview

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- **Editing Fiducials**
- Display properties
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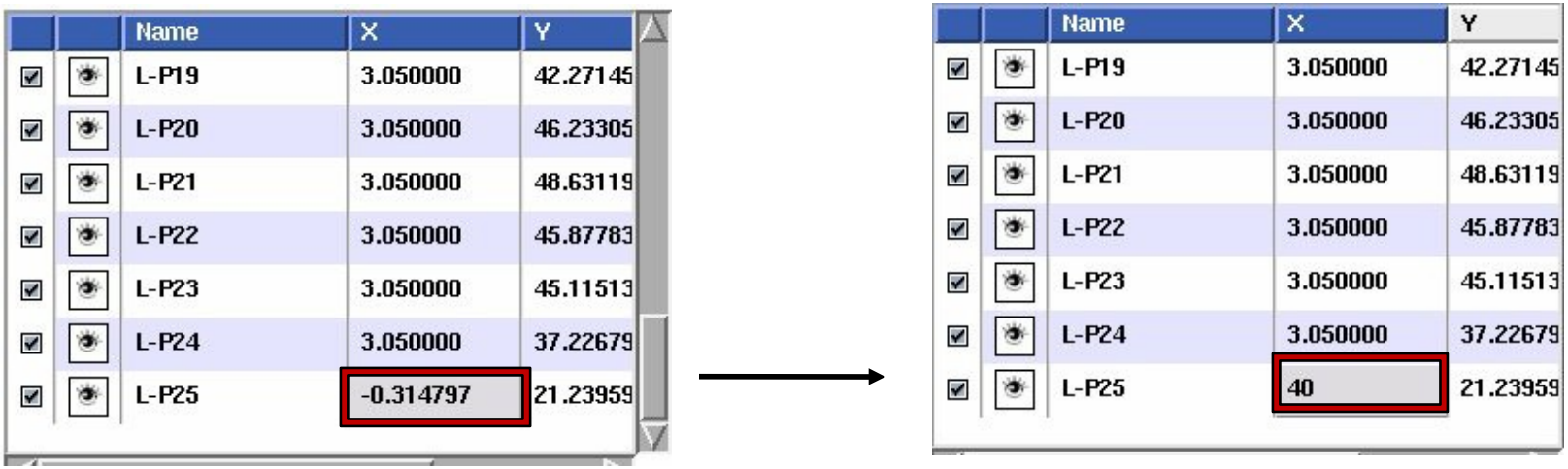
Editing Fiducials

Fiducial locations can be edited in the Fiducials module GUI. Double click in an X, Y, or Z column in the row of the fiducial you wish to change, press enter, type in a new value, then press enter. The fiduicial will move to the new location.

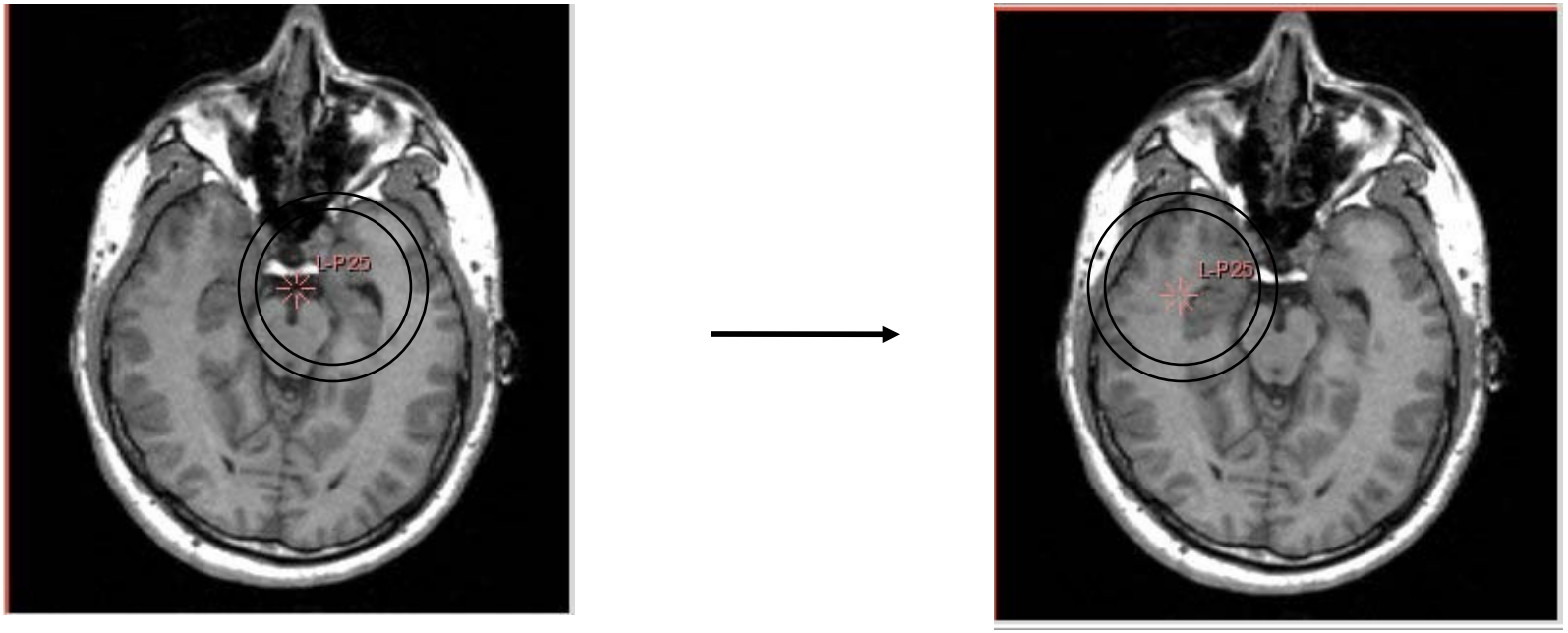
Editing Fiducials



	Name	X	Y
☑	L-P19	3.050000	42.27145
☑	L-P20	3.050000	46.23305
☑	L-P21	3.050000	48.63119
☑	L-P22	3.050000	45.87783
☑	L-P23	3.050000	45.11513
☑	L-P24	3.050000	37.22679
☑	L-P25	-0.314797	21.23959

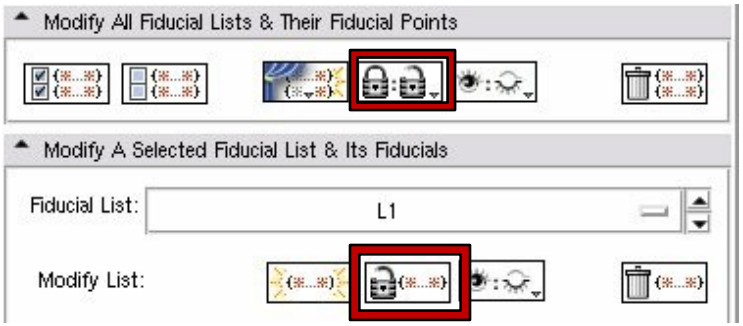
	Name	X	Y
☑	L-P19	3.050000	42.27145
☑	L-P20	3.050000	46.23305
☑	L-P21	3.050000	48.63119
☑	L-P22	3.050000	45.87783
☑	L-P23	3.050000	45.11513
☑	L-P24	3.050000	37.22679
☑	L-P25	40	21.23959

Editing Fiducials



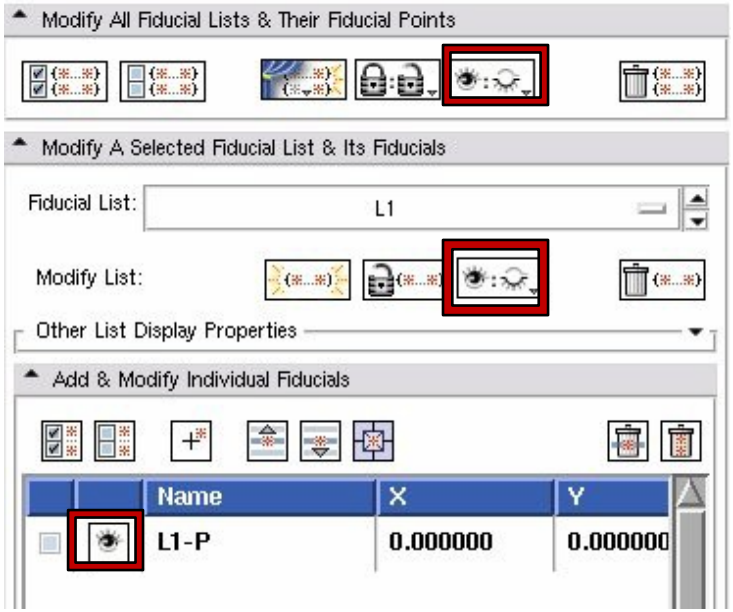
Editing Fiducials

Fiducials can be locked so that they cannot be moved by the mouse, either on the single list level or for all lists.



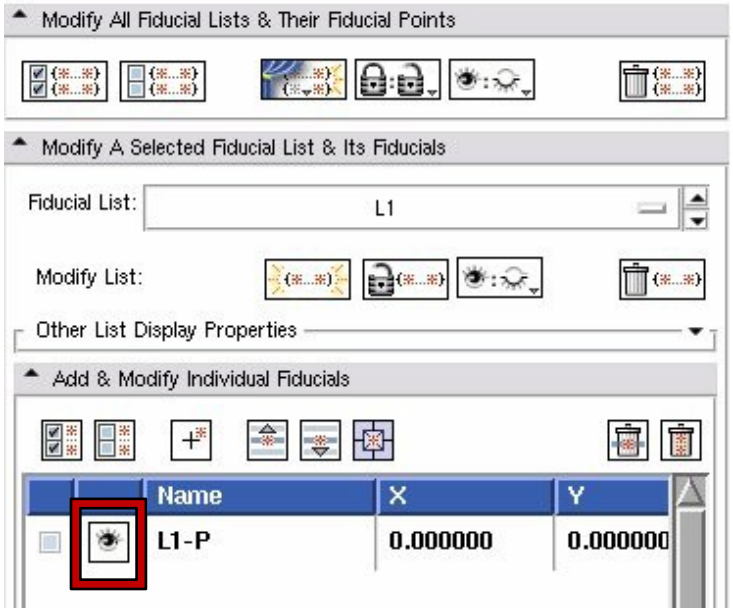
Editing Fiducials

Fiducials can be visible or invisible, set either on a single fiducial, on a single list or for all lists. Look for the eye buttons.

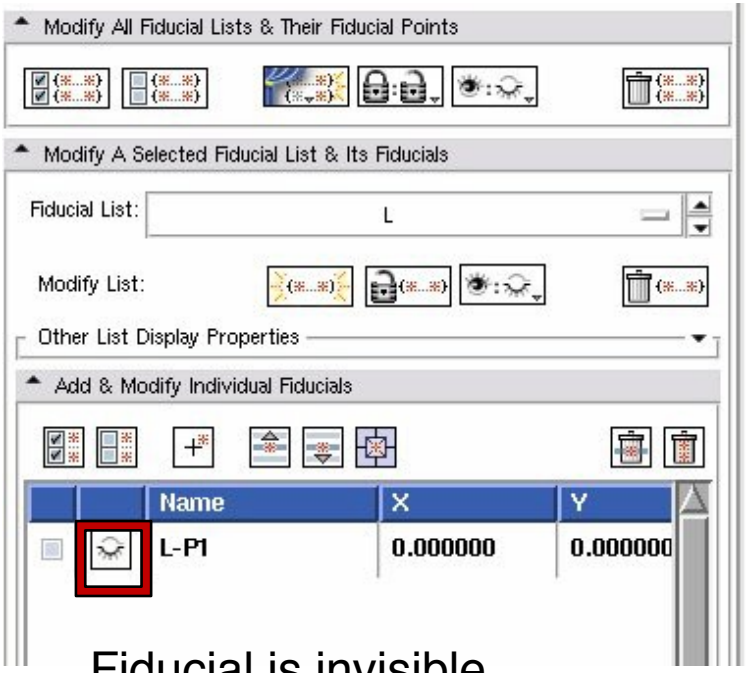


Editing Fiducials

Toggle visibility on a single fiducial by clicking on the eye icon next to the fiducial label in the list.



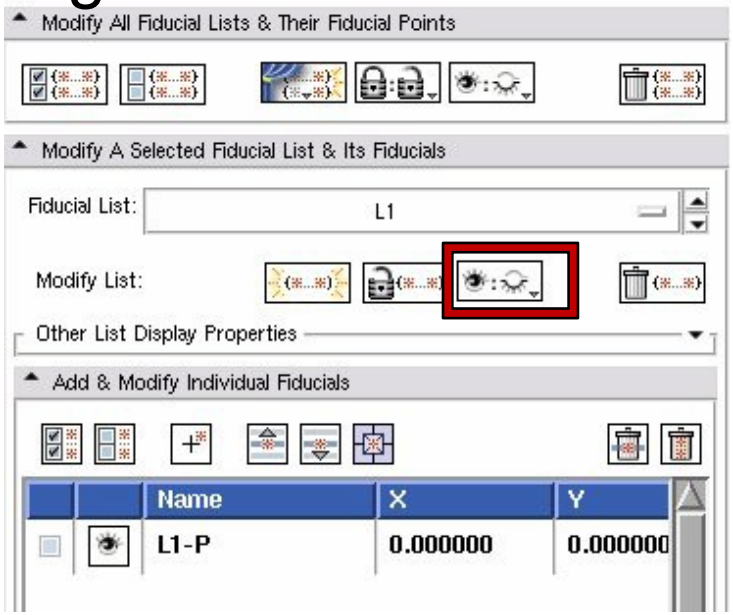
Fiducial is visible.



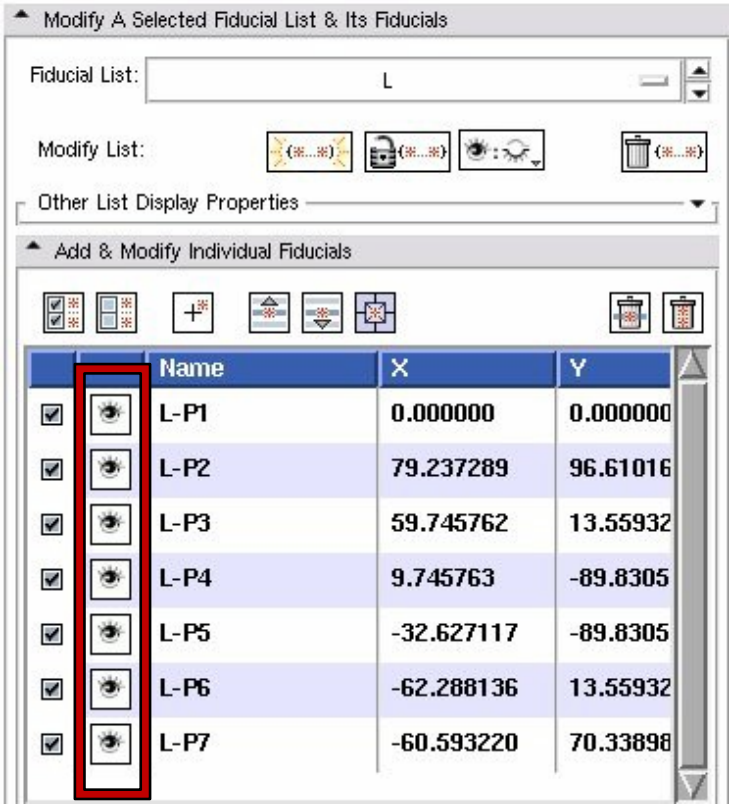
Fiducial is invisible.

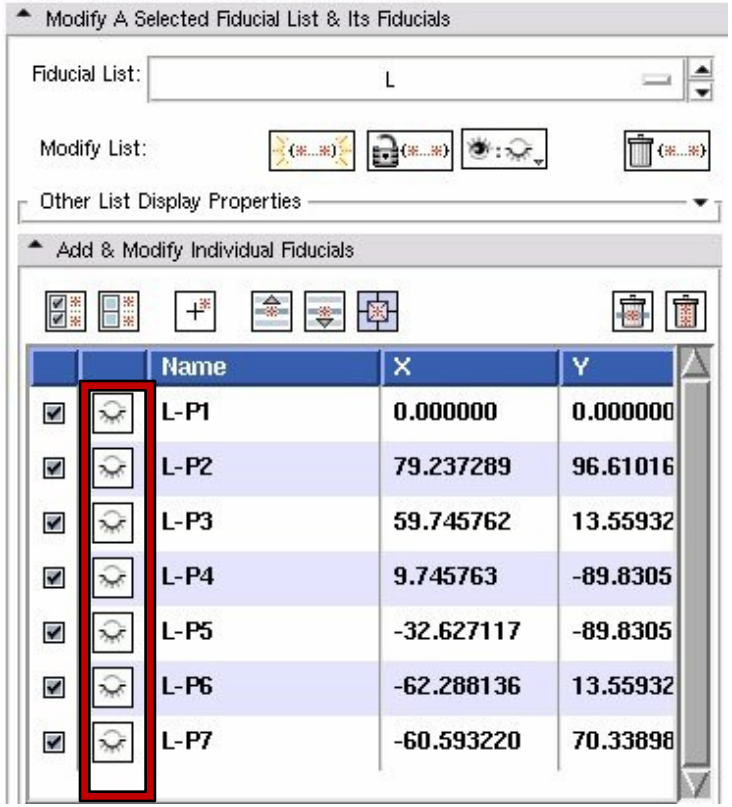
Editing Fiducials

Toggle visibility on a whole list by selecting either Lists Fiducials Visible, or Lists Fiducials Invisible from the drop down menu. This will change the visibility settings for each fiducial in the list.



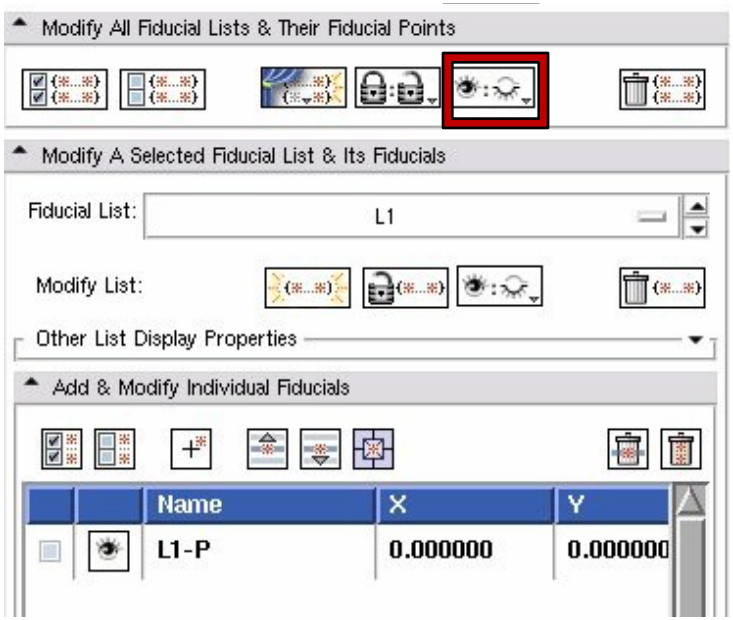
Editing Fiducials





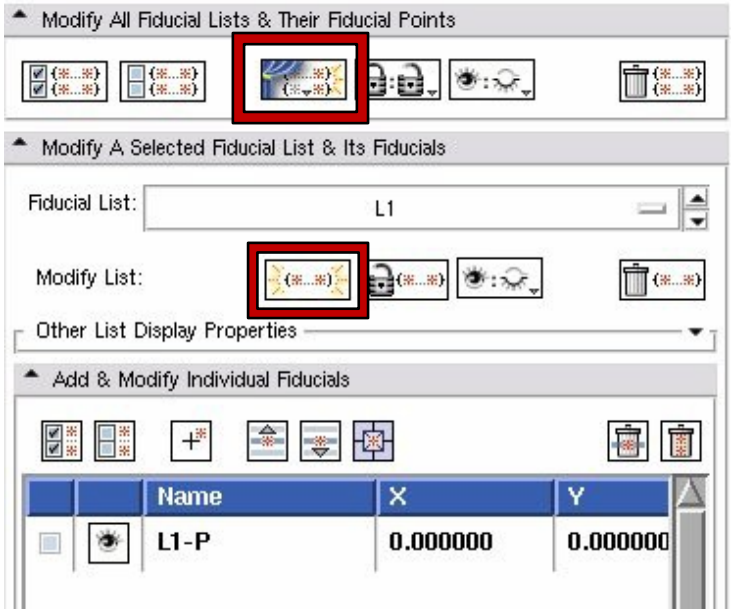
Editing Fiducials

Toggle visibility on all the lists list by selecting either All Fiducials Visible, or All Fiducials Invisible from the drop down menu. This will change the visibility settings for each fiducial in all the lists.



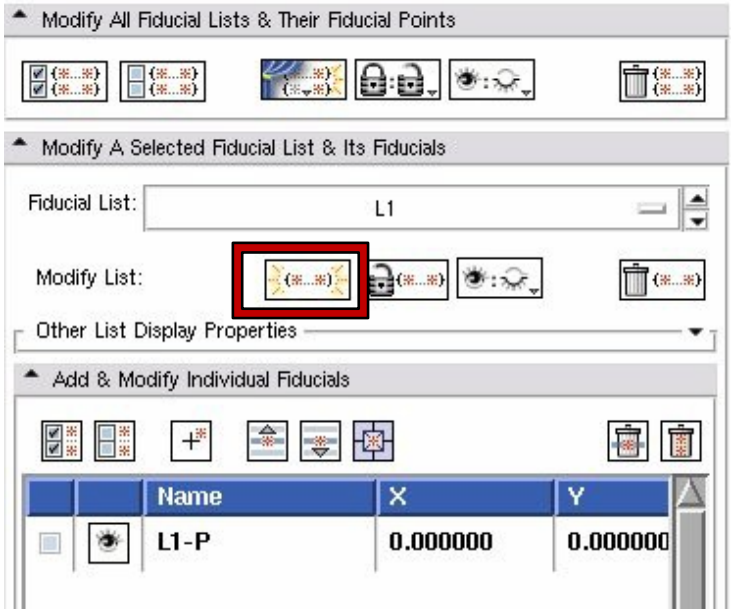
Editing Fiducials

Fiducials can be exposed or hidden (which does not over-ride the visible or invisible settings) for either all lists or individual lists.



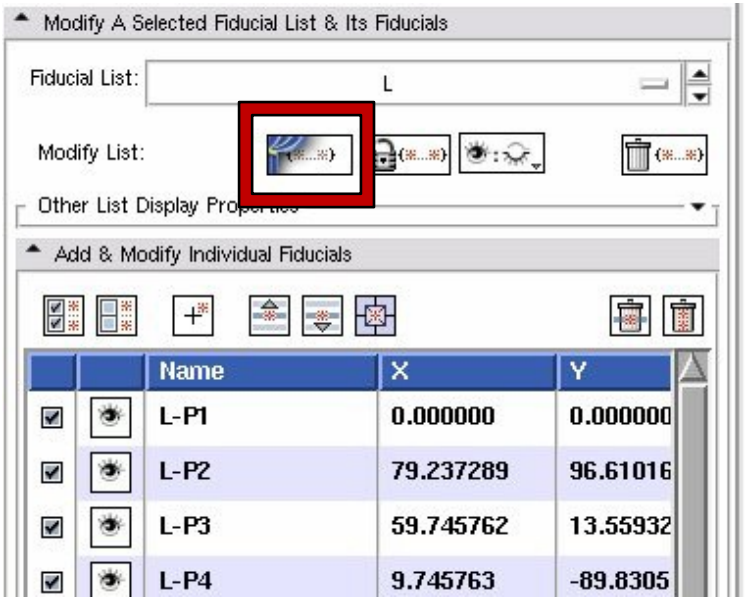
Editing Fiducials

When a list is exposed, the button shows this graphic, and pressing it will hide all fiducials in the list while preserving individual fiducial point visibility settings.



Editing Fiducials

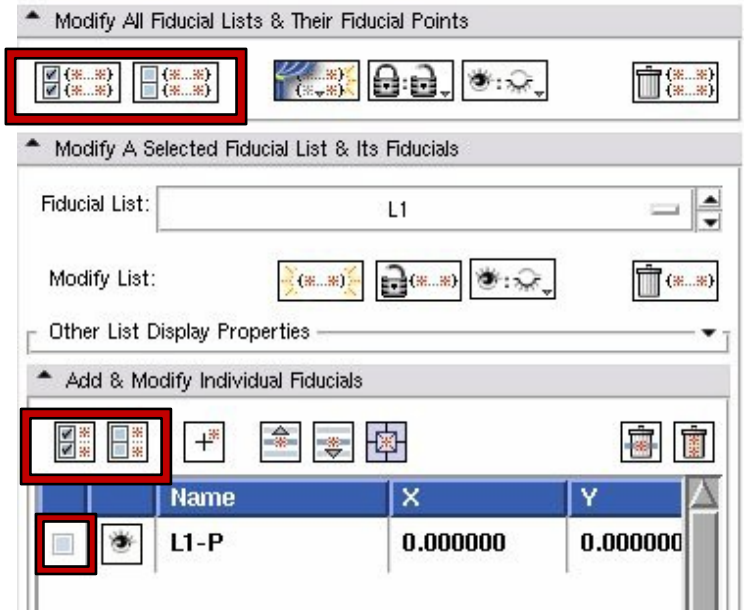
When a list is hidden, the button shows this graphic, and pressing it will expose all fiducials in the list that are set to be visible.



In this state, no fiducials will be shown in 2d or 3d for this list.

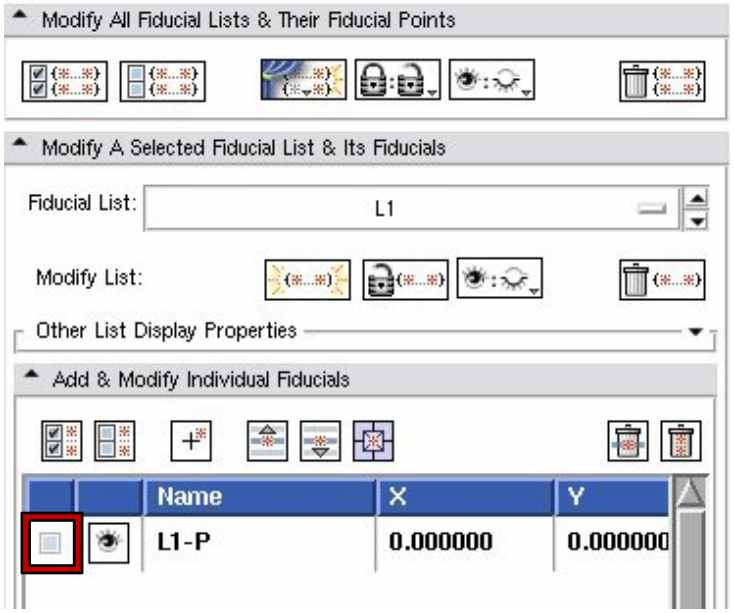
Editing Fiducials

Fiducials can be selected or unselected, set on either a single fiducial, on a single list or for all lists.

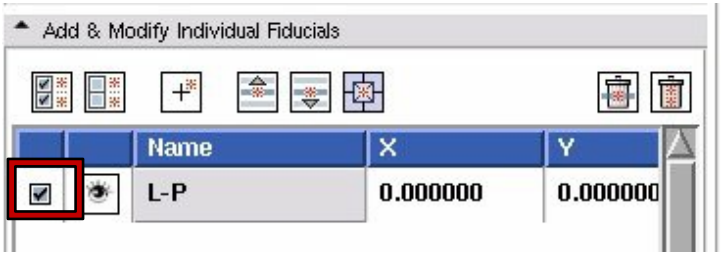


Editing Fiducials

Select or deselect an individual fiducial by clicking on the checkbox in the first column of the table. When a fiducial is selected, it can be passed to a command line module.

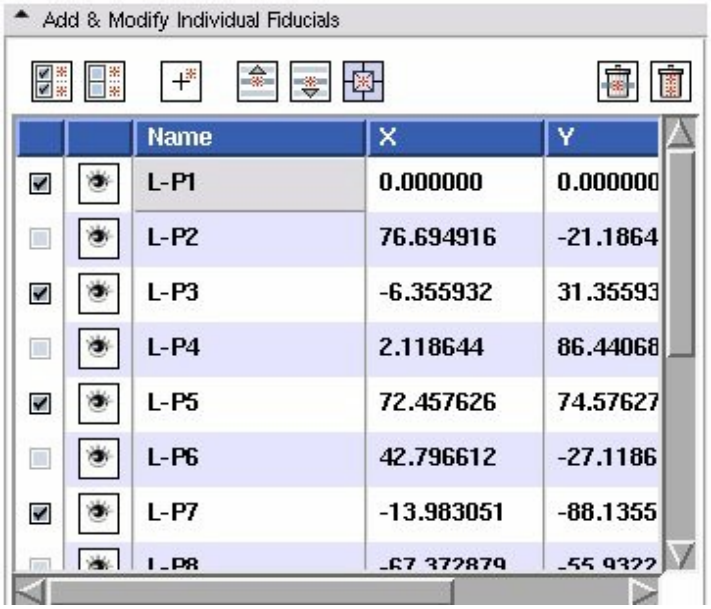


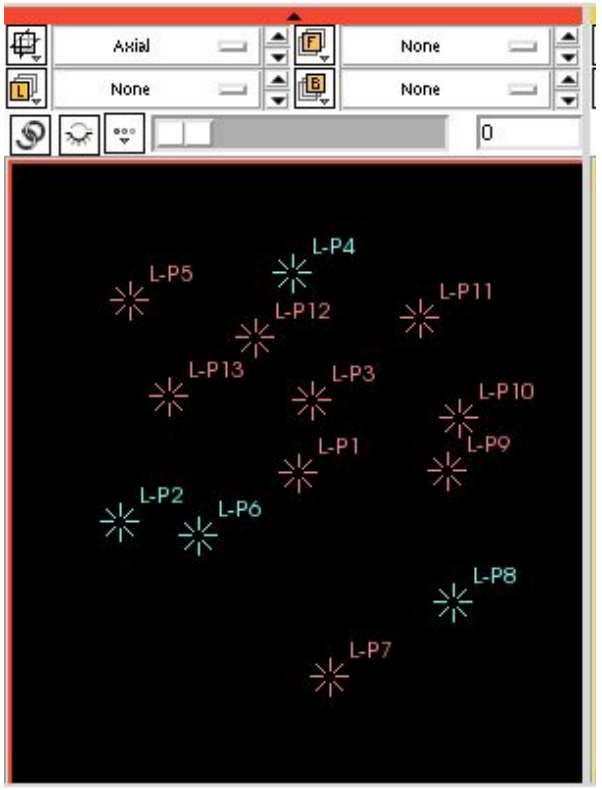
The color of the fiducial changes when it has been selected, according to the Display settings for the list.



Editing Fiducials

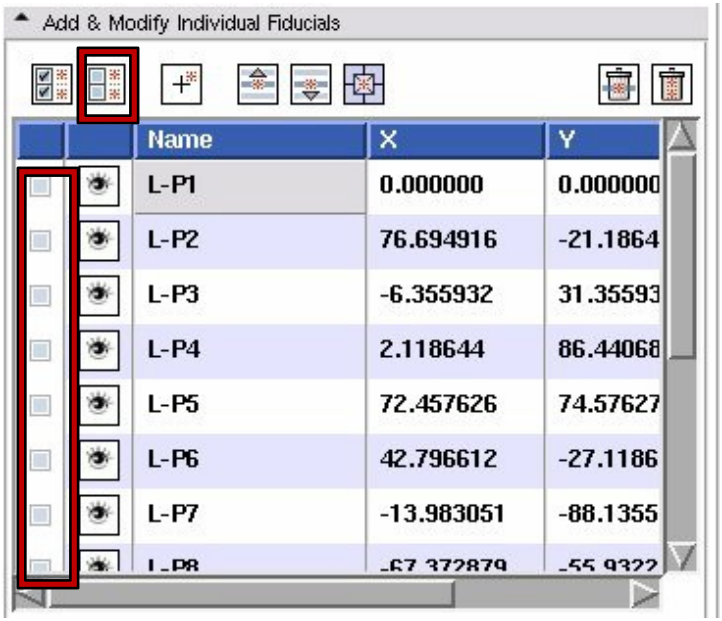
Here's an example list with every other fiducial selected.





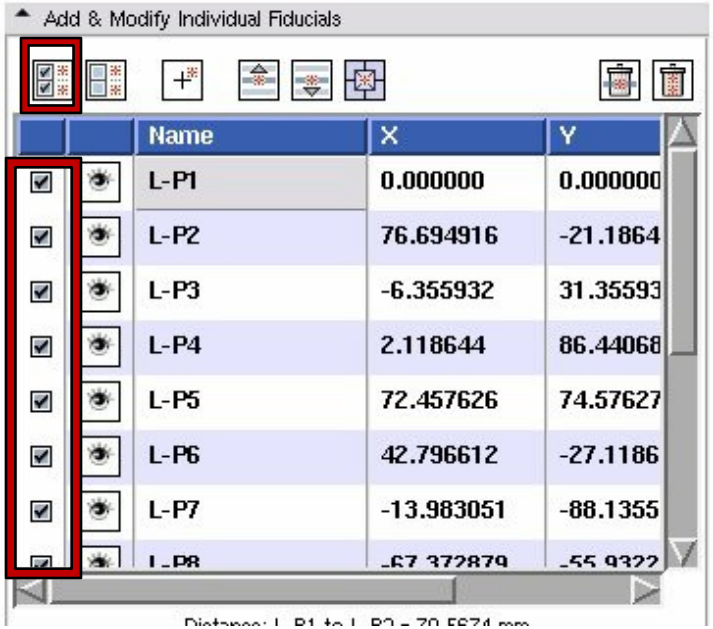
Editing Fiducials

All fiducials in the list can be deselected by clicking on the Deselect all fiducial points from this fiducial list button.



Editing Fiducials

All fiducials in the list can be selected by clicking on the Select all fiducial points from this fiducial list button.



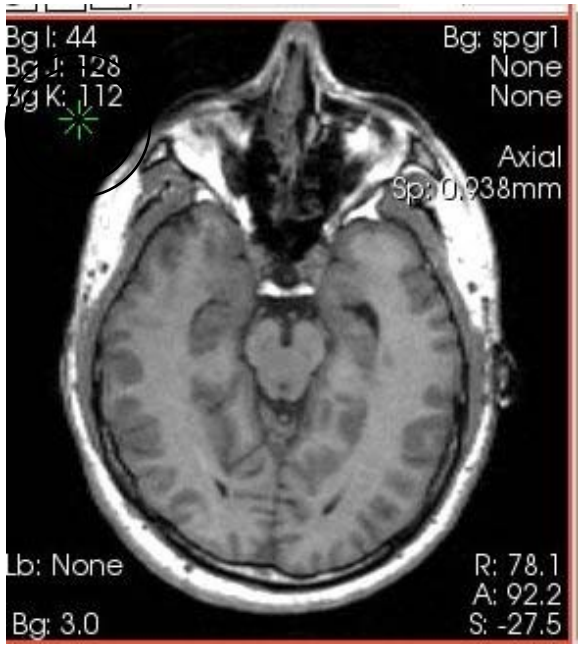
Editing Fiducials

Fiducials can be “picked up” and dragged by the mouse in the 2D slice windows, or in 3D.

In the toolbar, click on the Pick and Manipulate icon and select the second option from the drop down menu:
Use mouse to Pick-and-Manipulate persistently.

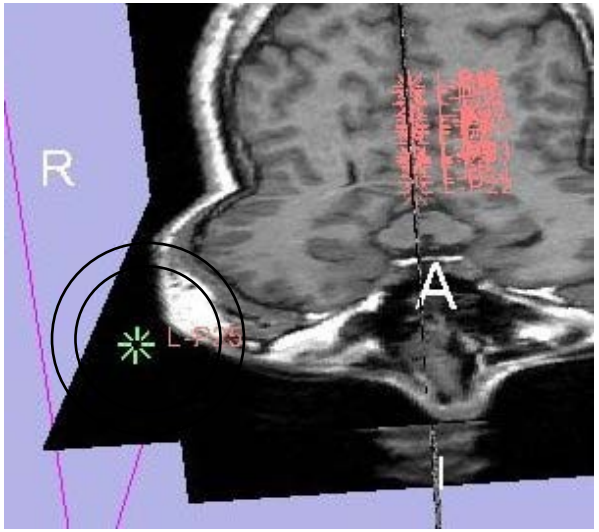
Editing Fiducials

Move the mouse over a fiducial in 2D, when it highlights, left click to pick it up and release to put it down. The fiducial will turn green as it's being moved and the entry in the table in the Fiducials GUI will update.



Editing Fiducials

Move the mouse over a fiducial in 3D, when the cursor changes to a hand, left click to pick it up and release to put it down. The fiducial will turn green as it's being moved. The table entry will also update in the Fiducials GUI as the fiducial is being dragged.



Editing Fiducials

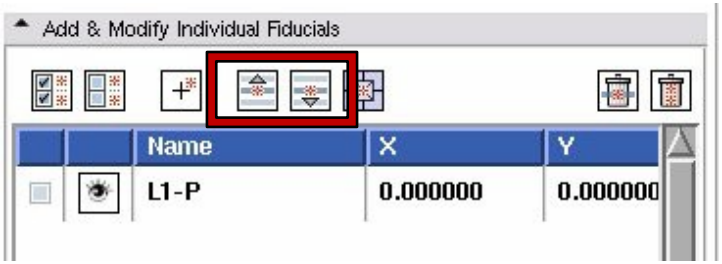
In order to stop manipulating fiducials, click on the rotate view icon in the toolbar.

Editing Fiducials

In the toolbar, click on the Pick and Manipulate icon and select the first option from the drop down menu:
Use mouse to Pick-and-Manipulate one time.
This mode is currently only present for completeness, the fiducials can be manipulated when in Rotate View mode as well, but that may be disabled in future.

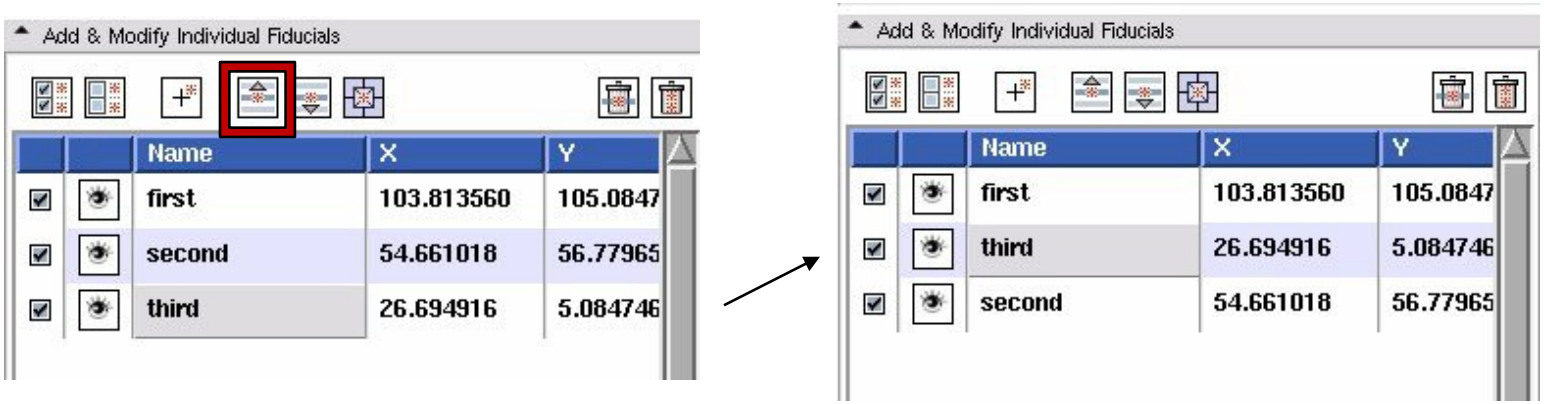
Editing Fiducials

To move fiducials up and down in the list, use the move up and down buttons.



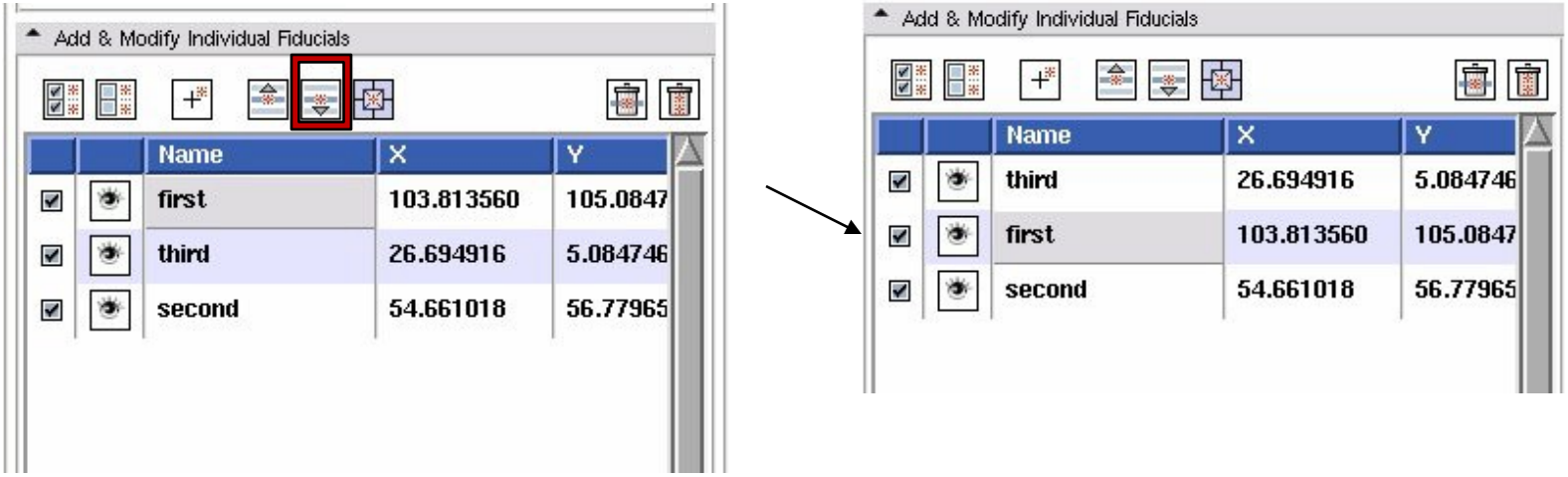
Editing Fiducials

Left click on a fiducial label in the fiducial list, and then click on the move up button, which has the pop up text: Move the last fiducial whose name was "clicked on" in the table one row up in the table.



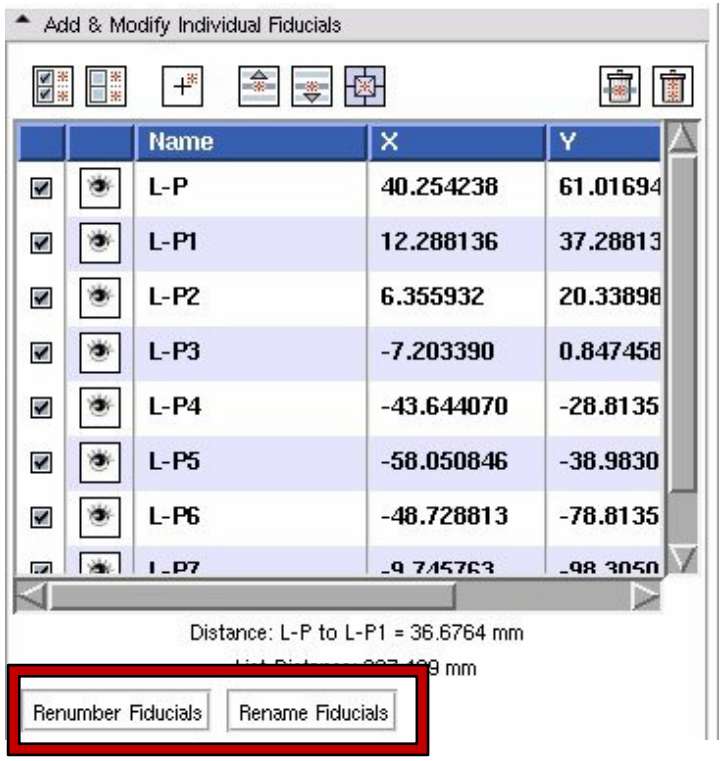
Editing Fiducials

Left click on a fiducial label in the fiducial list, and then click on the move down button, which has the pop up text: Move the last fiducial whose name was "clicked on" in the table one row down in the table.



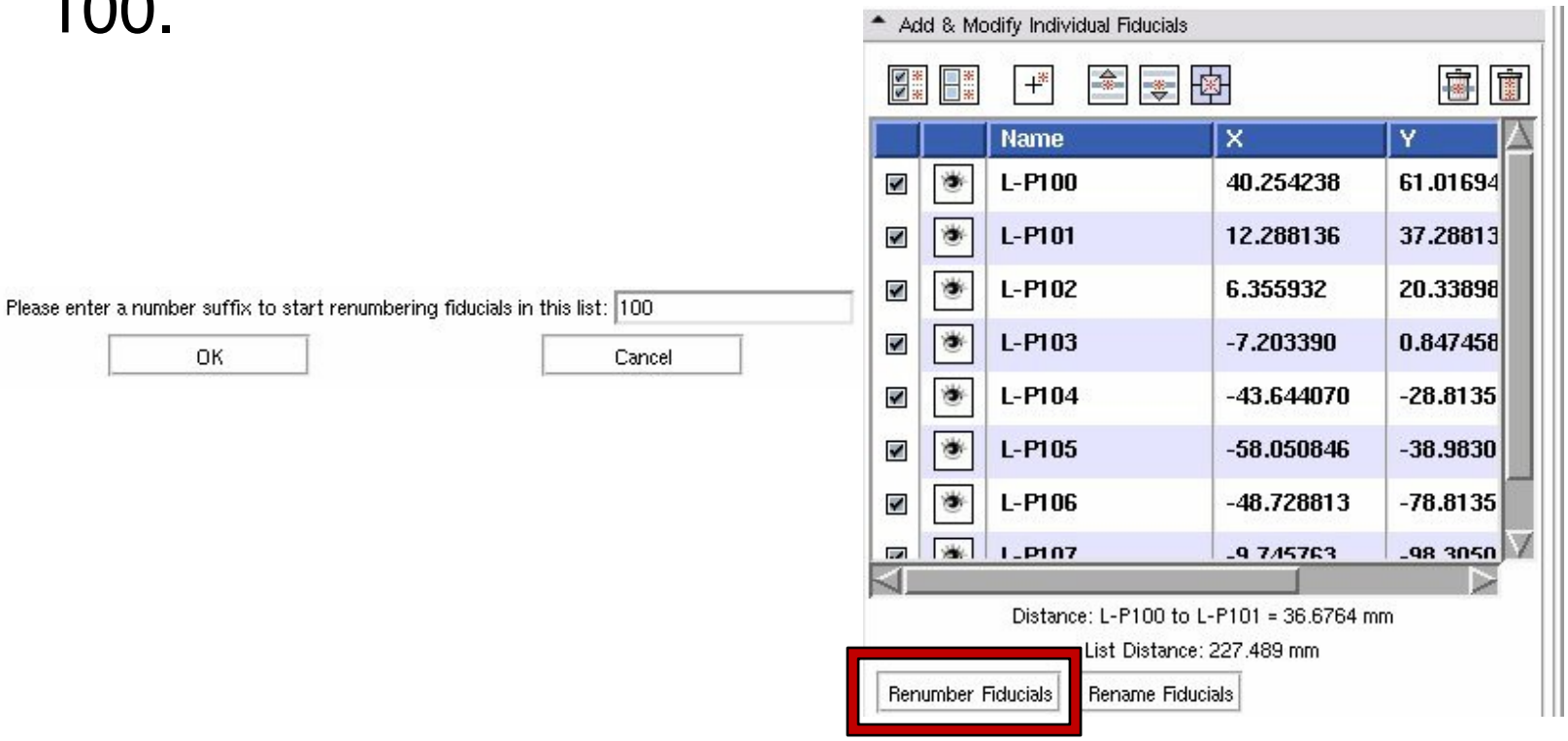
Editing Fiducials

You can renumber and rename all the fiducials in the list by using the Renumber Fiducials and Rename Fiducials buttons.



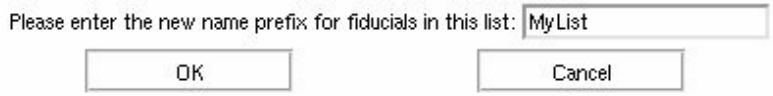
Editing Fiducials

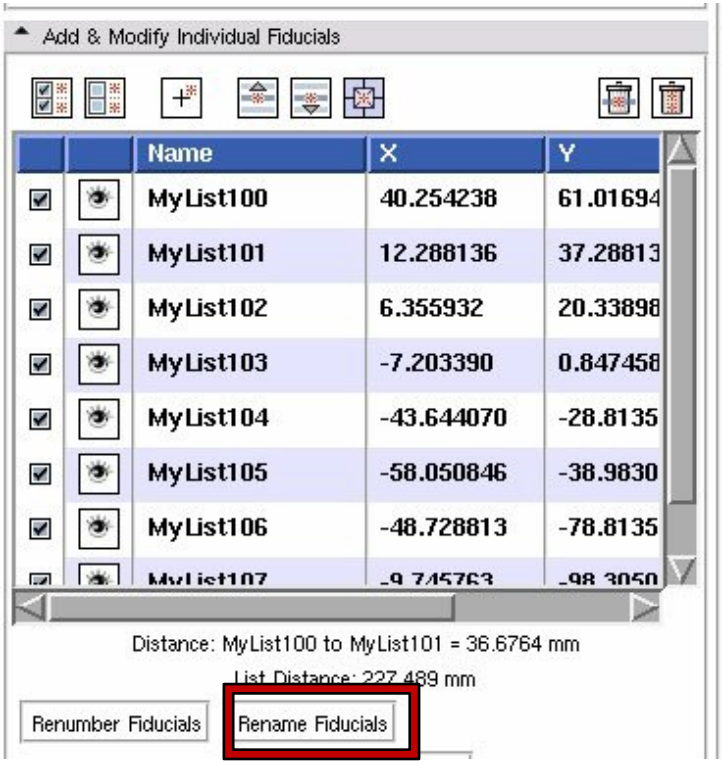
Renumber all the fiducials in the list starting from 100.



Editing Fiducials

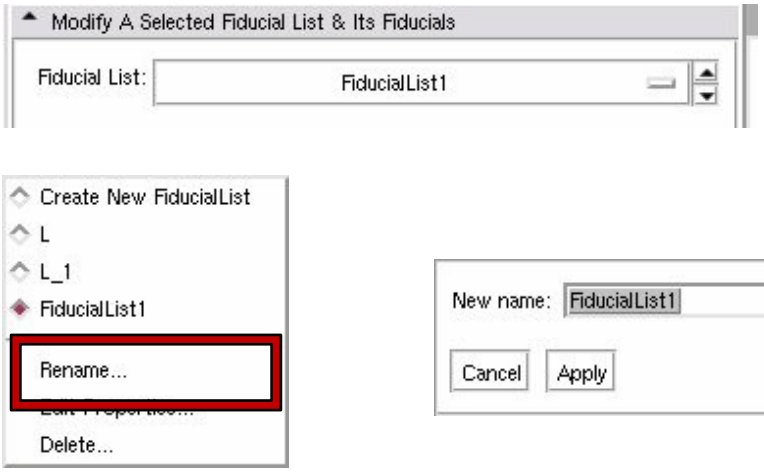
Rename all the fiducials in the list using the string MyList. The dash is part of the text string, this time we're leaving it out.





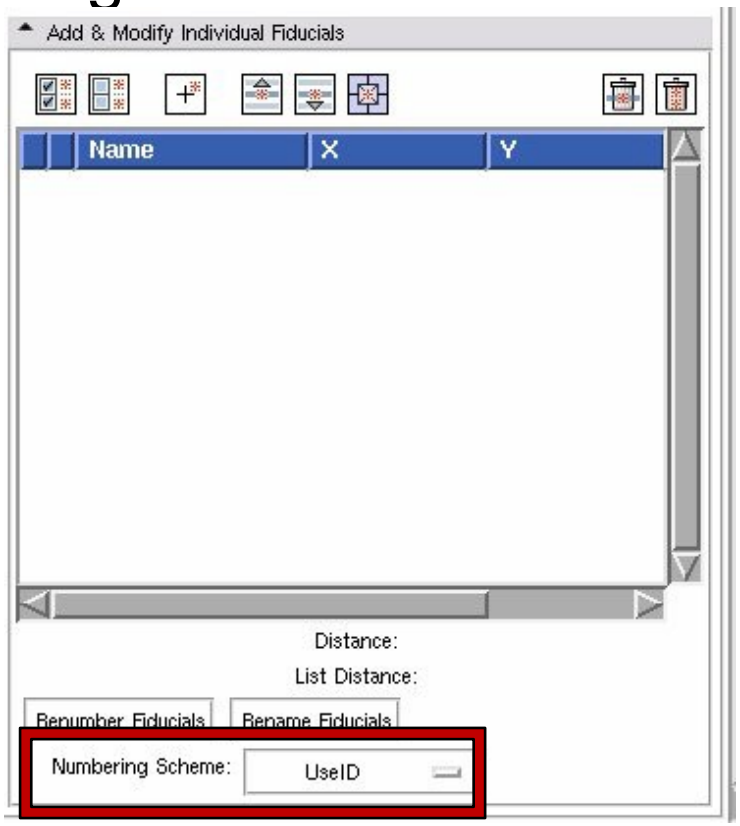
Editing Fiducials

To change the default name for all new fiducials added to a list, rename the fiducial list from the Fiducial List drop down menu.



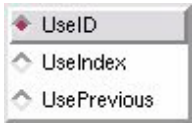
Editing Fiducials

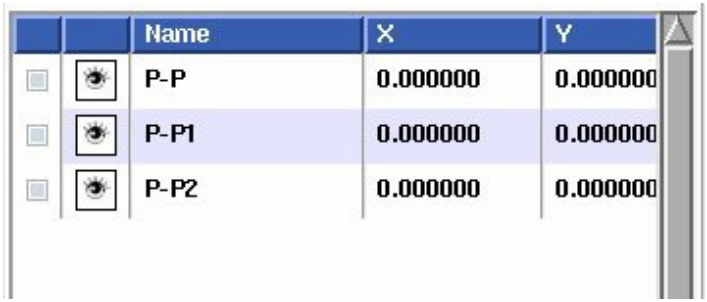
To change the default numbering for all new fiducials added to a list, select an option from the Numbering Scheme drop down menu



Editing Fiducials

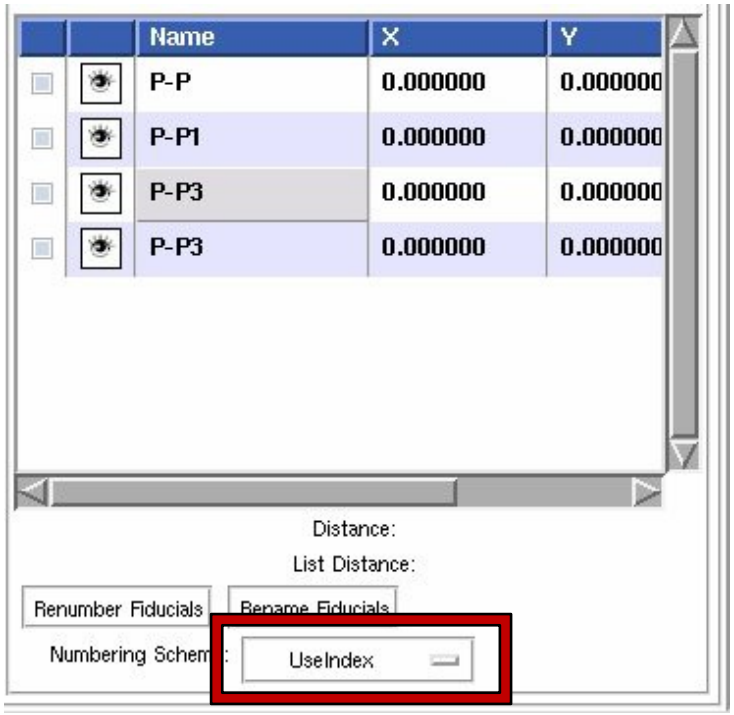
Using the UseID option will number fiducials by an internally kept identifier that increments with each fiducial added. This is the default and can cause gaps in the numbering if you delete fiducials.





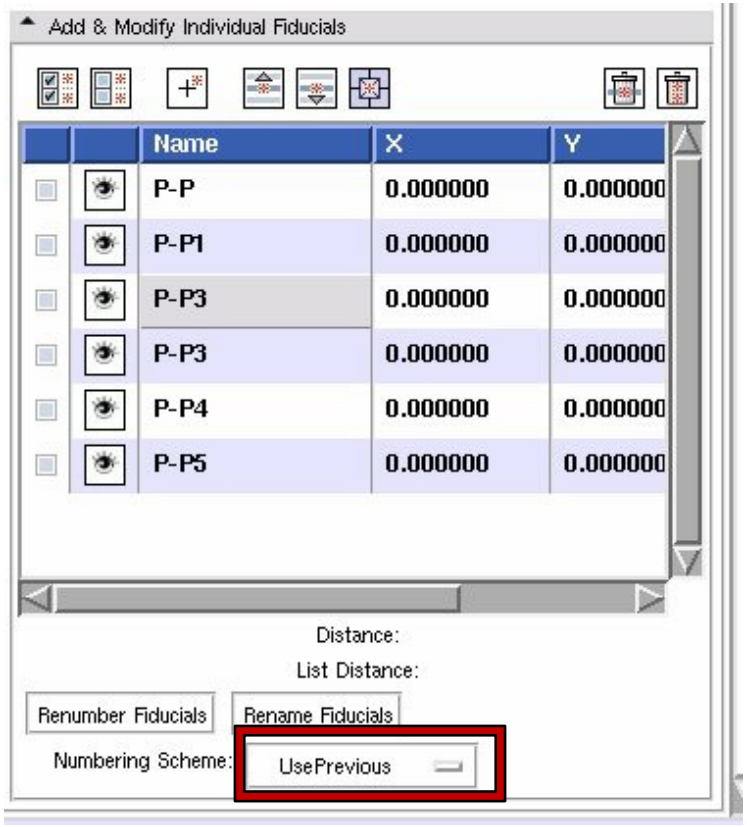
Editing Fiducials

Using the UseIndex option will number fiducials by the index of the point in the list, starting from 0. If you delete a fiducial in the middle of the list, the next one added may have the same number as it now occupies the index location of the last fiducial in the list that moved up.



Editing Fiducials

Using the UsePrevious option will number new fiducials by incrementing the number in the label of the last fiducial in the list.



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- Saving and Loading Fiducials

Display Properties

In the Fiducials GUI, expand the Other List Display Properties panel.

Display Properties

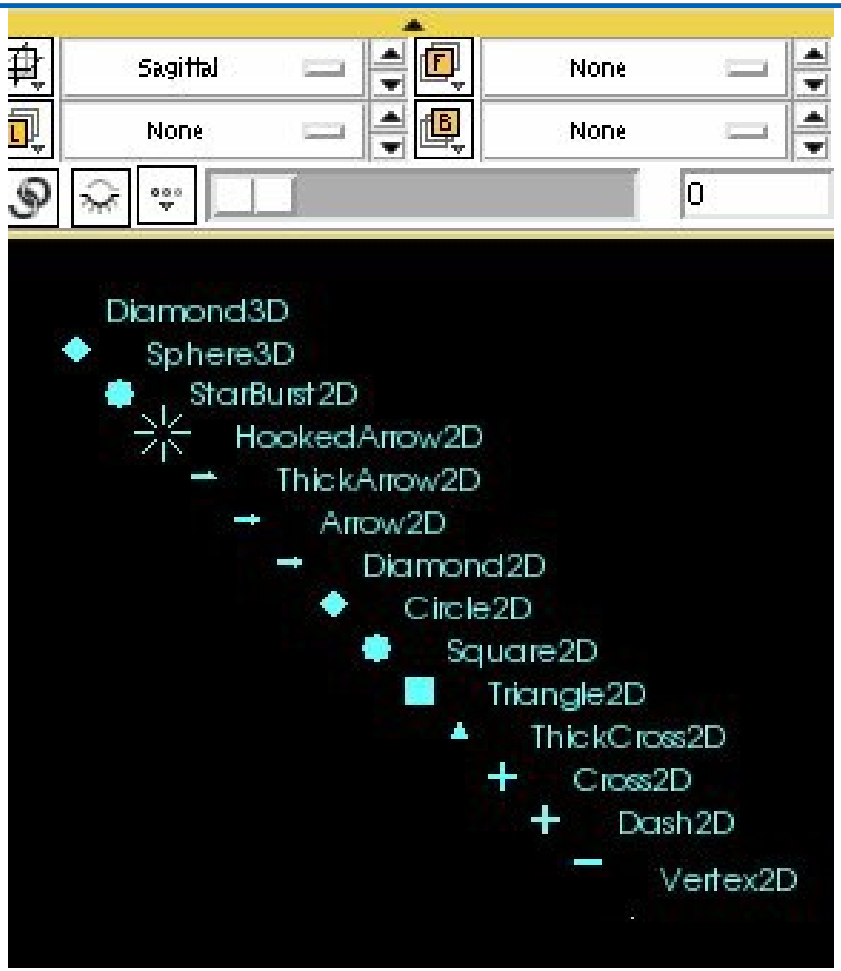
Glyph Type: Select the glyph used to represent this point in 2D and 3D. There is a list of glyph types available, each list can have a different glyph type but all fiducials in a list have the same glyph type. The default is the 2D starburst.

Display Properties

Glyphs in 3D.

Display Properties

Glyphs in 2D. The Diamond3D is represented by a 2D diamond, and the Sphere3D by a 2D circle.



Display Properties

Selected Color: Select the color used to represent the fiducials when they are selected.

Unselected Color: Select the color used to represent the fiducials when they are not selected.

Glyph Scale: Select the scale of the glyph. For the 3d glyphs (Sphere and Diamond3D), 1 corresponds to 1mm in diameter.

Text Scale: Select the scale of the fiducial label text.

Display Properties

Opacity: Select the opacity of the fiducial glyph and text. 0 = invisible.

Ambient: Set the ambient material property for the fiducial glyph.

Diffuse: Set the diffuse material property for the fiducial glyph.

Specular: Set the specular material property for the fiducial glyph.

Power: Set the power material property for the fiducial glyph.

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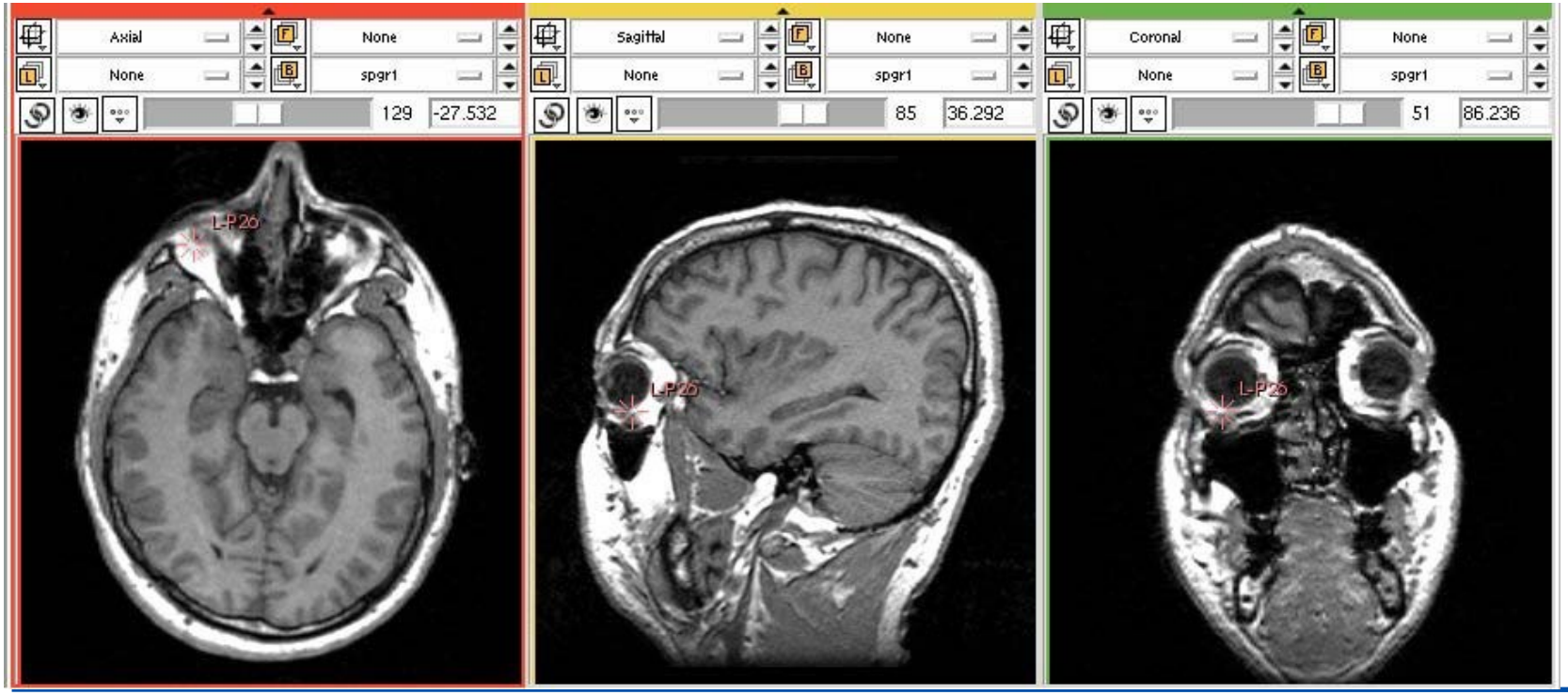
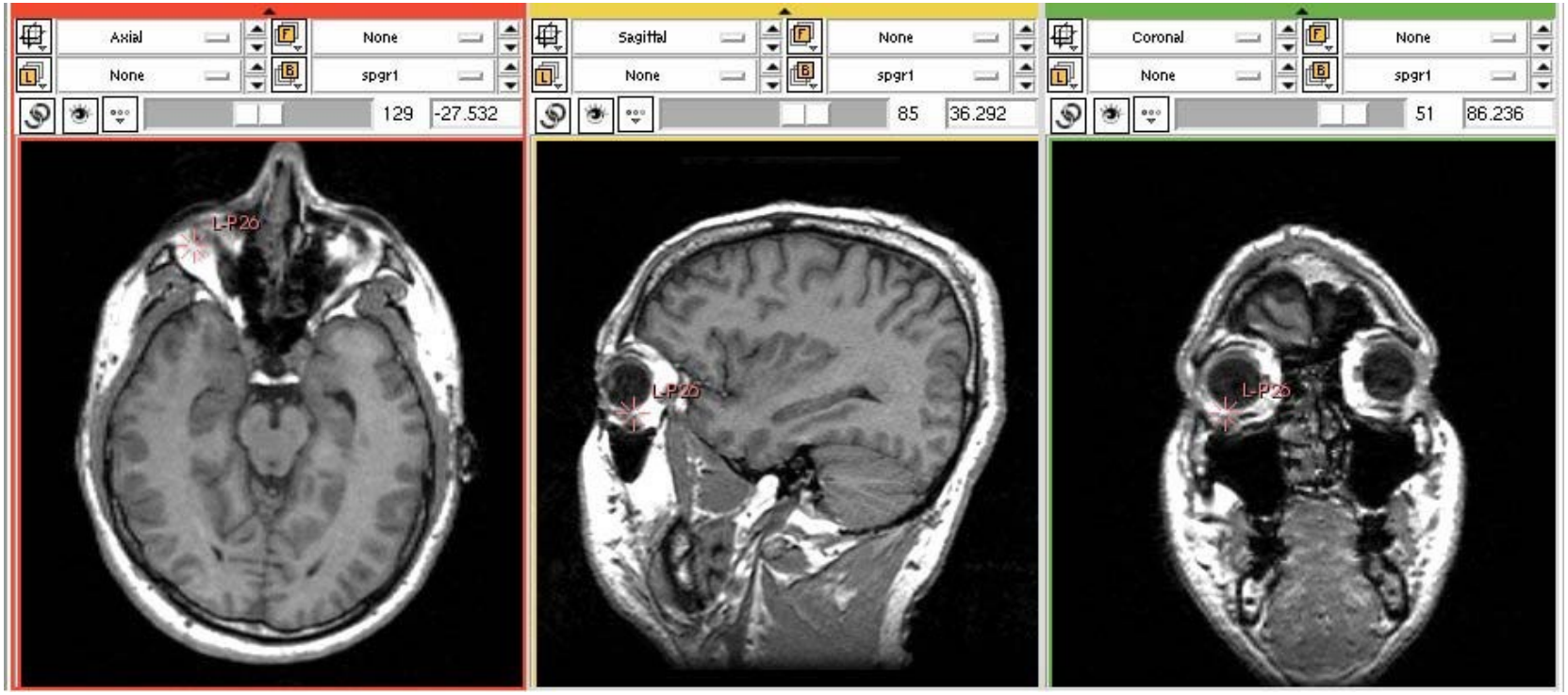
Linking, Jumping Slices

Load the file spgr.nhdr that is in the tutorial data set. Place a few fiducials on various slices while scrolling through the volume.



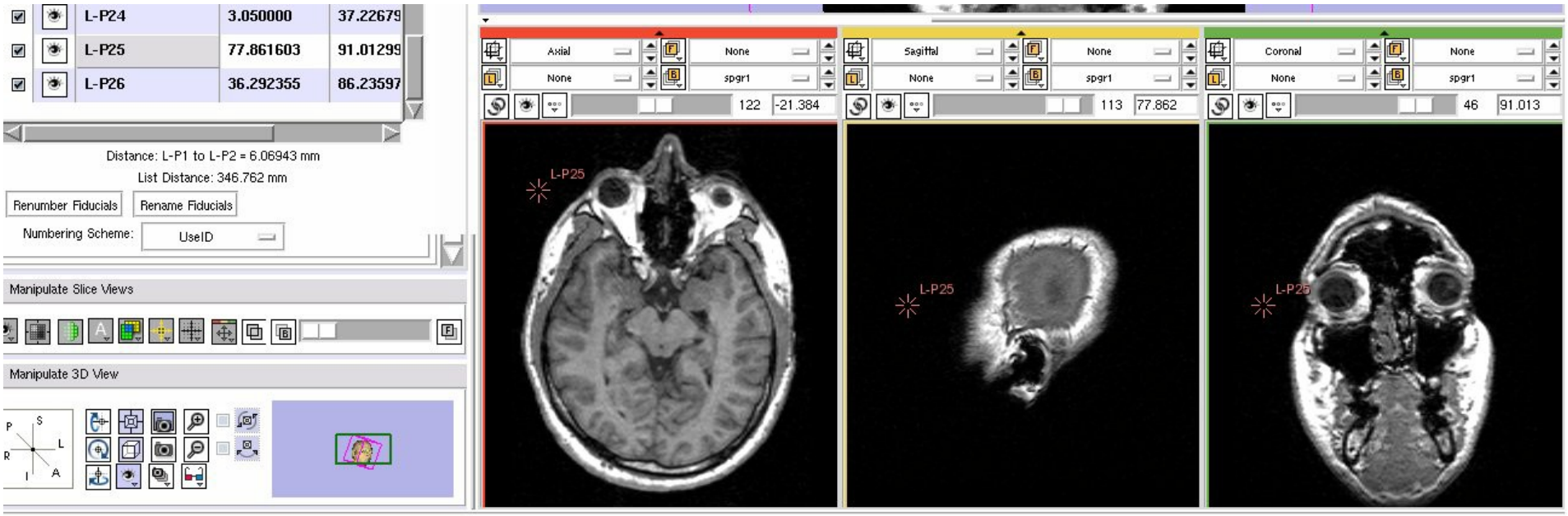
Linking, Jumping Slices

To see the fiducial location on all the slices, hold down the Control key while manipulating the fiducial.



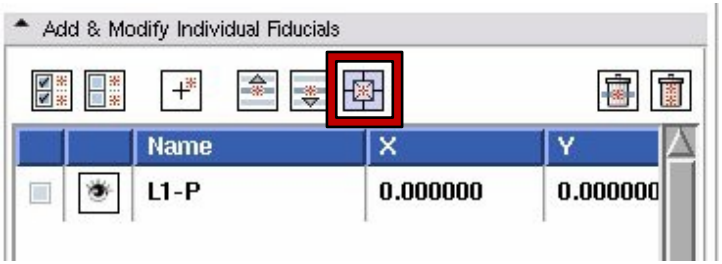
Linking, Jumping Slices

To jump all the slices to a fiducial selected from the Fiducials GUI table, right click in that row.

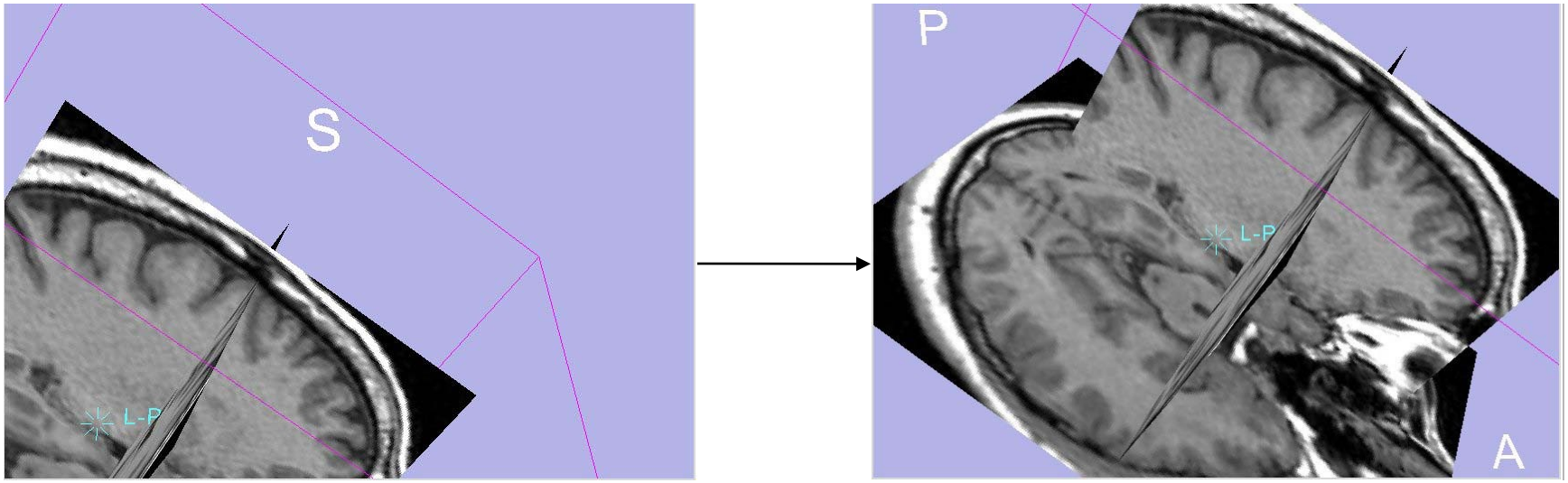


Linking, Jumping Slices

To center the 3D view on the last fiducial clicked on in the Fiducials GUI table, click on the center 3D view button.

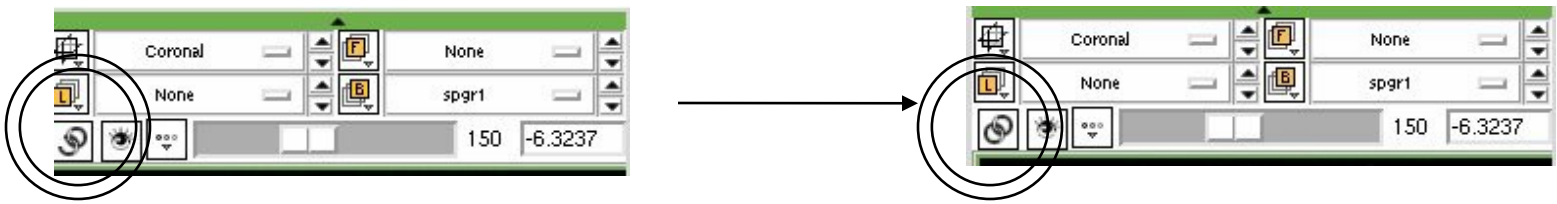


Linking, Jumping Slices



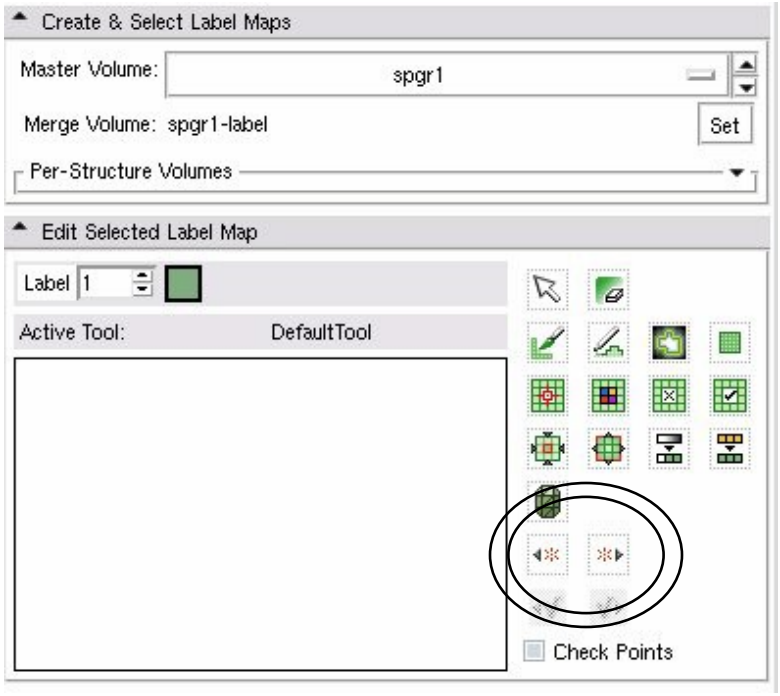
Linking, Jumping Slices

To jump a slice to the next fiducial in the list, you can press the back-tick key ` in 2D.  Press Control-` to jump to the previous fiducial in the list.
To jump all slices to the next or previous fiducial in the list, link the slices by pressing the link button.



Linking, Jumping Slices

To jump a slice to the previous or next fiducial, you can also use these buttons in the Editor module:



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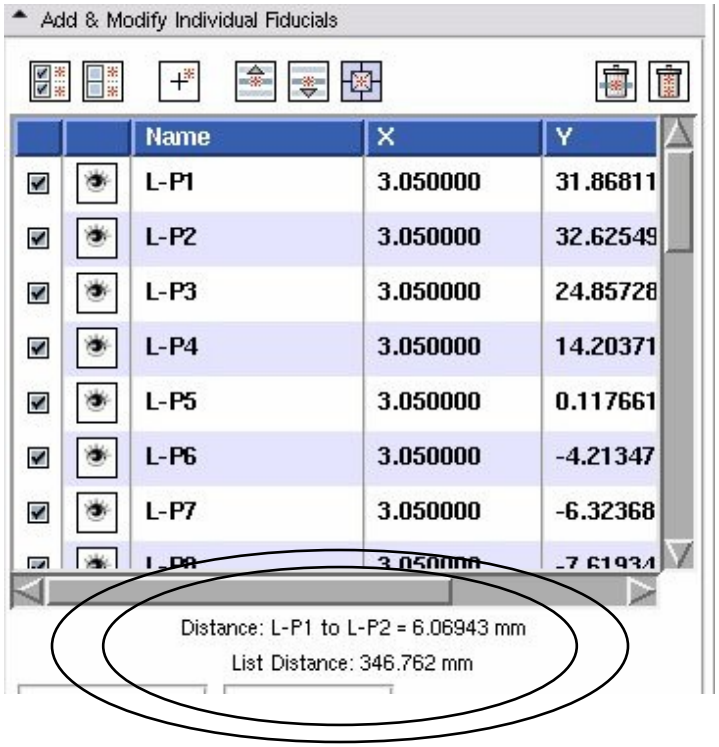
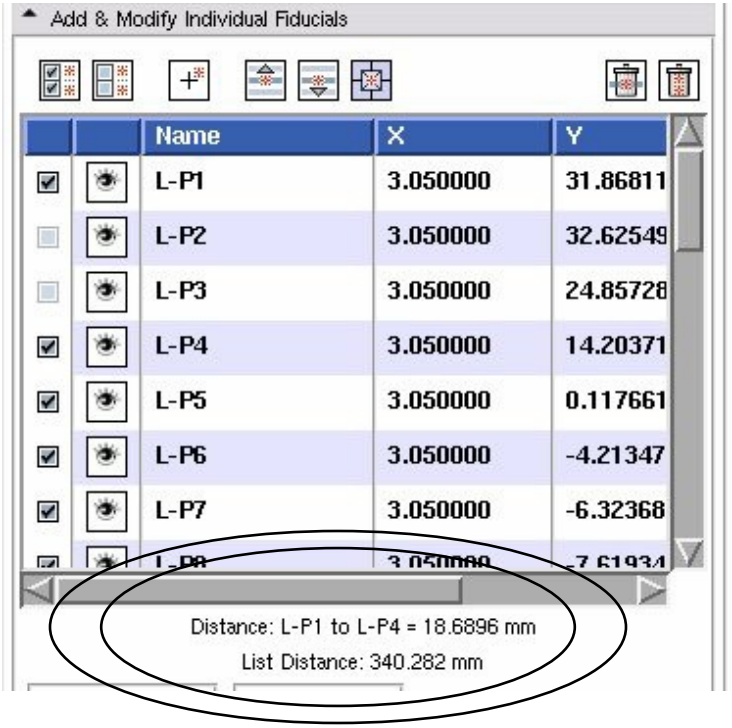
Taking Measurements

The linear distance between the first two selected fiducials in the currently selected list in the Fiducials GUI will be displayed below the table of fiducial points. The summed linear distance between all selected fiducials in the list also appears below the table.



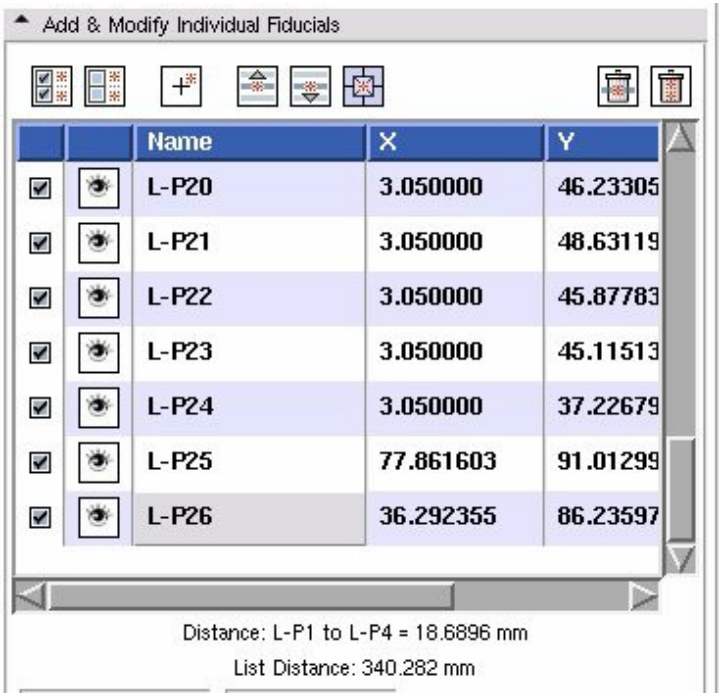
Taking Measurements

Change the selections, and the distances will update. Unselect the second and third fiducials in the list.



Taking Measurements

You can also create a ruler between the last two selected fiducials in the active list.
WARNING: *this will delete the fiducials.*
Press Control-m to create a new ruler.

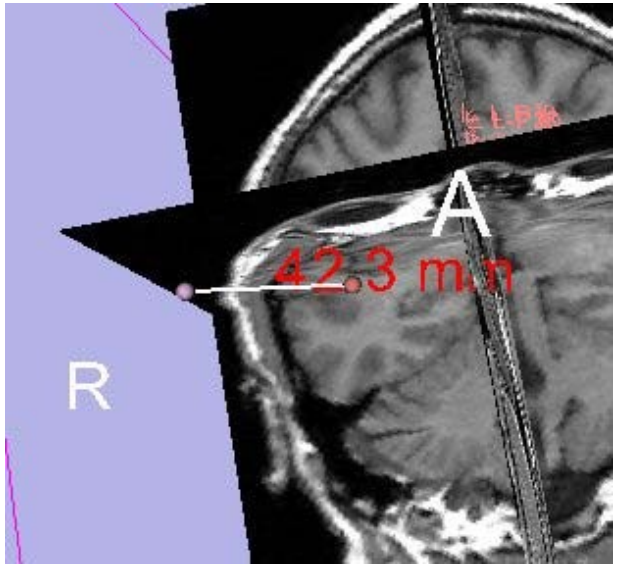


Taking Measurements

You can name the new ruler, or just press OK to have it only show the distance in the ruler annotation.

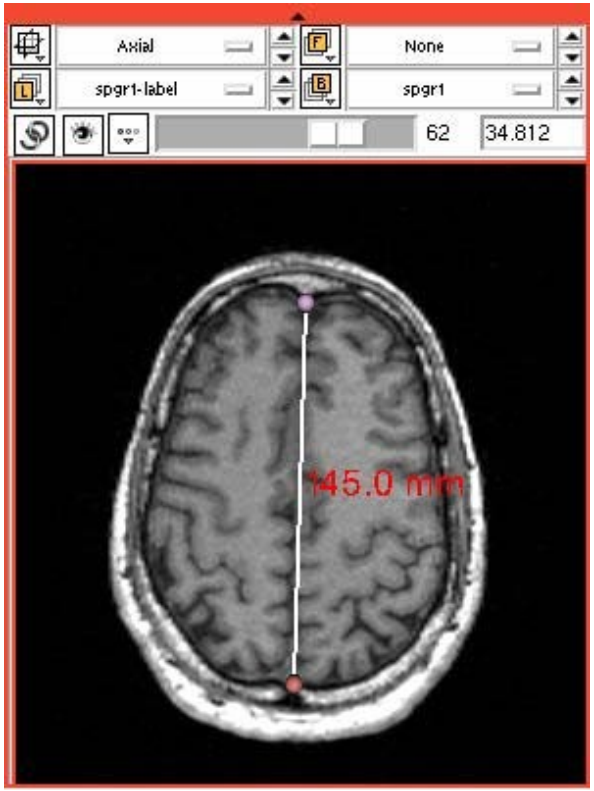
Taking Measurements

Here's the ruler in the 3D window:



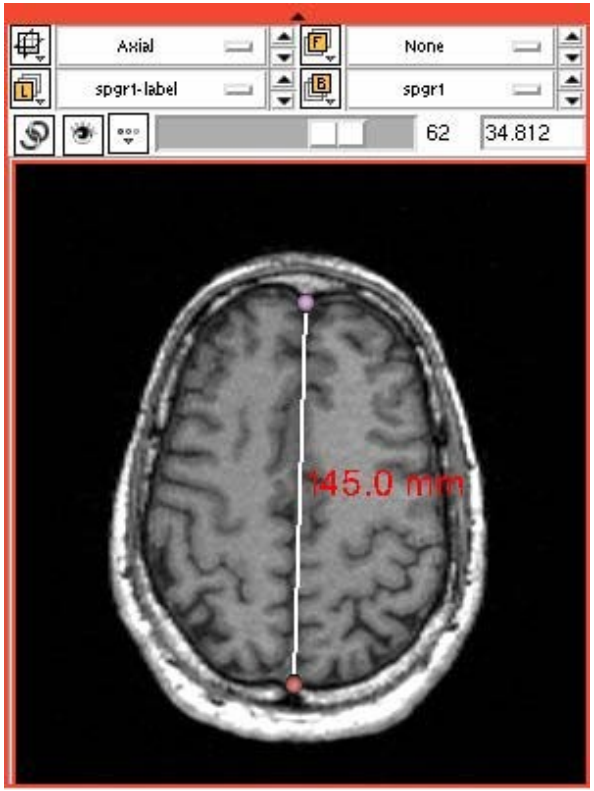
Taking Measurements

If you make the ruler between two fiducials that you've placed on a single slice, it will also show up in 2D.



Taking Measurements

The ruler end points can be manipulated in the same way that the fiducials can be. As you change the ruler end points, the distance annotation will update.



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Command Line Modules

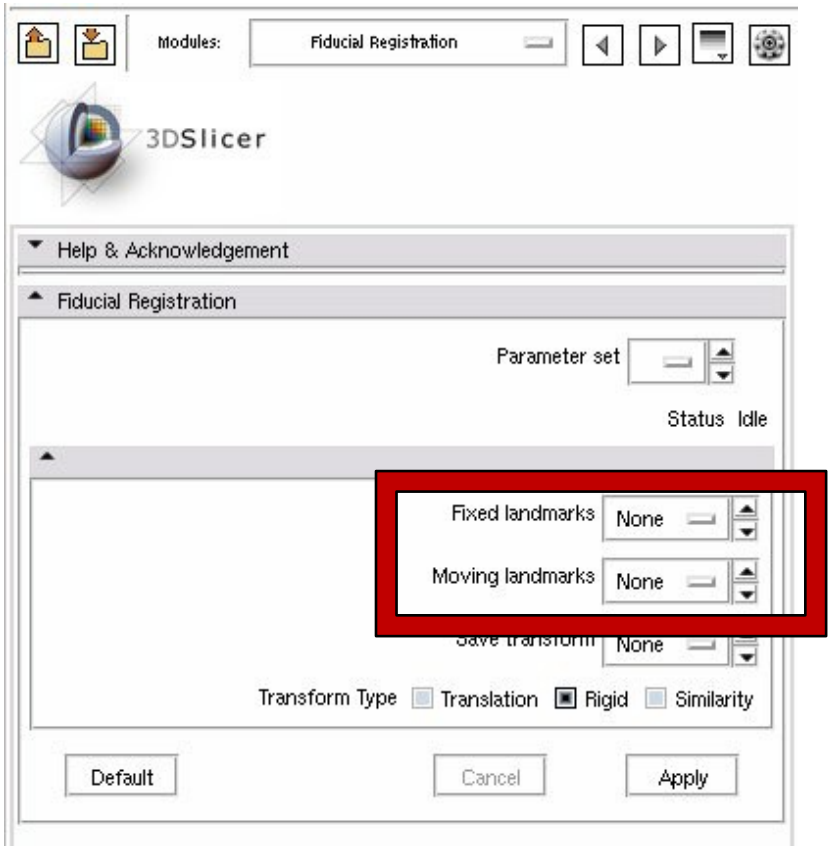
Fiducial points can be passed to command line modules, as point lists.

Only the fiducials that are marked as selected will be passed to the command line module, unselected fiducials will be skipped.

Some of the Registration modules, such as Fiducial Registration and ACPC Transform, require you to choose fiducial lists from the scene to pass to the module for processing.

Command Line Modules

The Registration module Fiducial Registration allows you to compute a transform between two fiducial lists. Create two fiducial lists, and place the fiducials at the same anatomical locations in both volumes.



Command Line Modules

The Registration module ACPC Transform is a more specific use of fiducial lists. Two lists are created of points on a single brain image, one list marking the midline, the other the ACPC line. This module will calculate the transform that will align the volume along the AP axis and AS plane.

Command Line Modules

When writing a new command line module, you can include a fiducial list as an input by using the following parameter definition in the .xml file:

```
<point coordinateSystem="ras" multiple="true">
    <name>PointList</name>
    <label>Point List</label>
    <longflag>--points</longflag>
    <description>A list of fiducial points</description>
    <default>0,0,0</default>
  </point>
```

Command Line Modules

The selected fiducials in the list will be passed via the command line with the longflag preceding the coordinates:

--points x1,y1,z1 –points x2,y2,z2 –points x3,y3,z3

Command Line Modules

When writing a new command line module, you can access a fiducial list in the cxx file in the following manner:

```
for (i= 0; i < PointList.size(); i++ )
        {
        std::cout << i << ": " << PointList[i][0] << ", " << PointList[i][1] << ", " <<
PointList[i][2] << std::endl;
        }
```

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Fiducial Seeding

The Fiducial Seeding module, in the Diffusion, Tractography category, uses fiducials to trigger the calculation of tracts. As the fiducial is dragged with the mouse, the tractography will update.
See the Diffusion MRI tutorial for more information.

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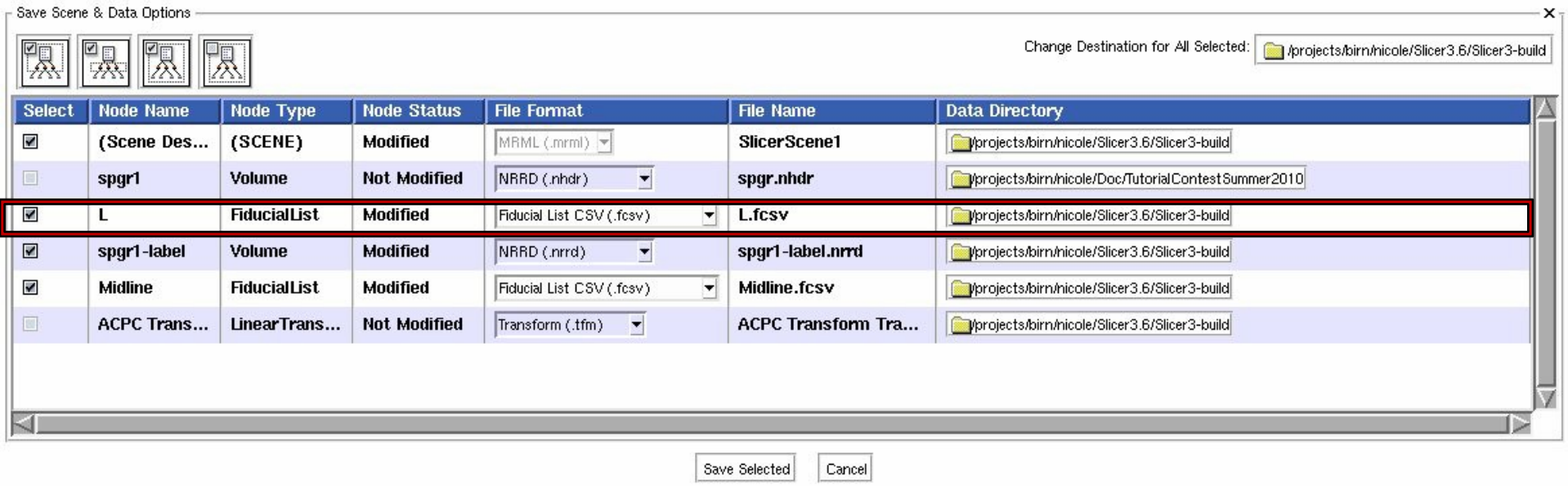
Saving and Loading

Fiducial lists can be saved to disk through the File, Save panel.



Saving and Loading

L.fcsv is saved to disk as a comma separated value file, each fiducial on one line in the format:
Label,x,y,z,selected,visible
Label is a text string.
x,y,z are floating point values.
Selected and visible are either 0 or 1.

```
L-P1,3.05,31.8681,4.07374,1,1
L-P2,3.05,32.6255,10.0957,0,1
L-P3,3.05,24.8573,12.6245,0,1
L-P4,3.05,14.2037,10.1786,1,1
L-P5,3.05,0.117661,7.4924,1,1
L-P6,3.05,-4.21347,4.15586,1,1
L-P7,3.05,-6.32368,-2.12508,1,1
L-P8,3.05,-7.61935,-10.207,1,1
L-P9,3.05,-9.89737,-14.6855,1,1
```

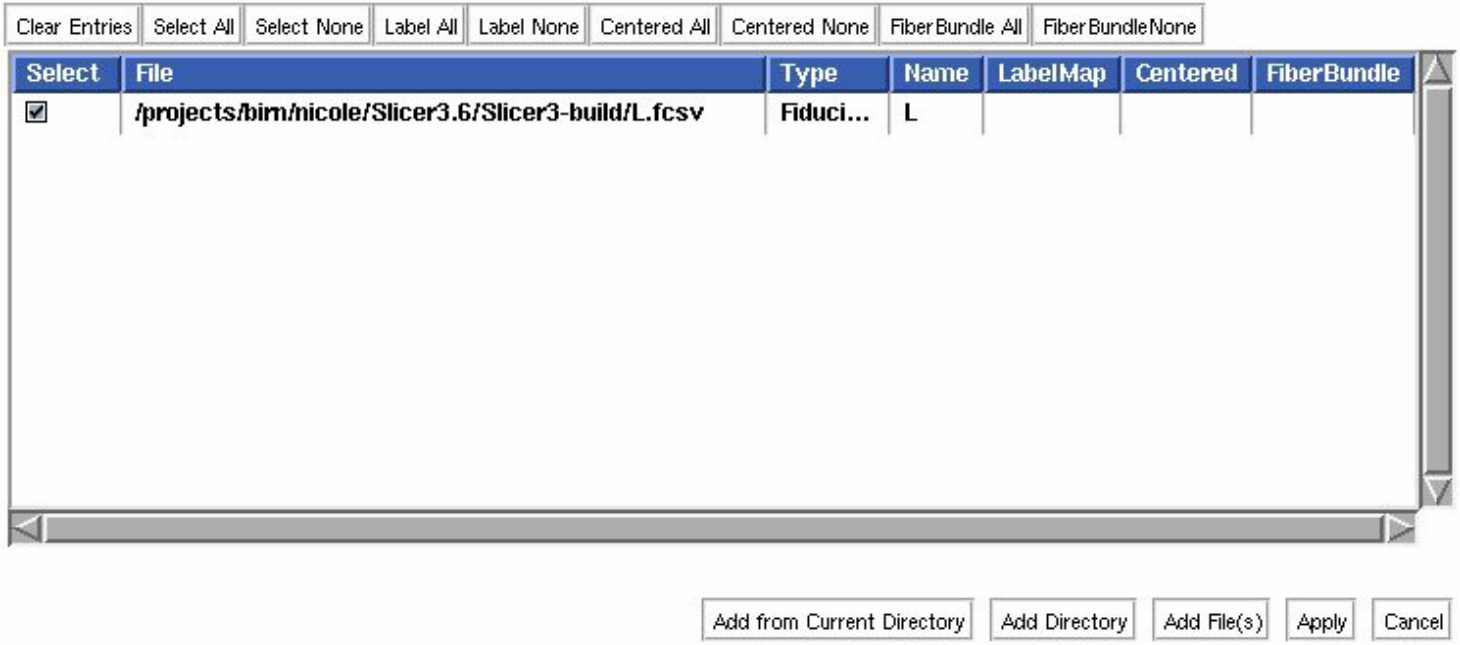
Saving and Loading

There are a few lines of header information at the top, commented with hash marks, that are parsed for the list display parameters.

```
# Fiducial List file /path/to/L.fcsv
# version = 2
# name = L
# numPoints = 25
# symbolScale = 5
# symbolType = 12
# visibility = 1
# textScale = 4.5
# color = 0.4,1,1
# selectedColor = 1,0.5,0.5
# opacity = 1
# ambient = 0
# diffuse = 1
# specular = 0
# power = 1
# locked = 0
# numberingScheme = 0
# columns = label,x,y,z,sel,vis
```

Saving and Loading

Fiducial lists can be read from disk through the File, Add Data panel.



Conclusion

This tutorial covered topics related to using fiducials in Slicer3.6.
After completing this tutorial students will be able to add, delete, edit, manipulate, modify display properties, save and load fiducials as well as using them to inspect data.

Acknowledgments

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