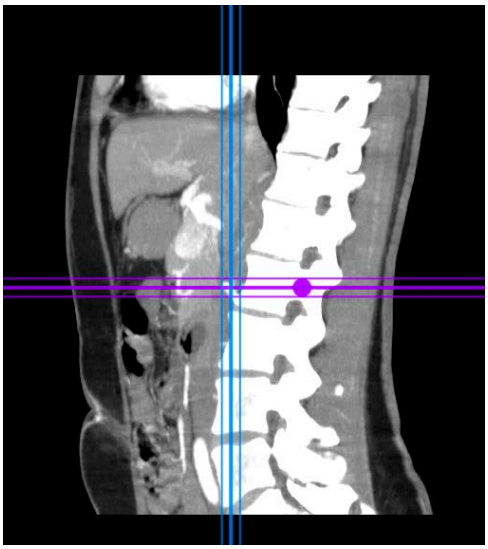

Figure 7.06. A Thick Slab rendering of an abdomen with thickness set to 10mm.

Shading

Shading is available when thick slab is in use and Volume Rendering mode is on. Click on the shading box and then click on the edit button to bring up a popup window. Here you can modify the shading settings for ambient coefficient, diffusion coefficient, specular coefficient, and spectral power.

Views

You can choose from three MPR Views. The default view is to have the screen divided such that there are two views on the left and one on the right. You can also choose to have all three planes displayed one on top of the other on the screen, or all three side by side (horizontally).

Reset

The Reset tool changes the Zoom, Rotation, Pan , and Re-sliced orientation back to the default settings.

Save as DICOM

You can save MPR views as DICOM images and have them added to the database window using this tool. You have the option to name the new series, set the image size (current size, 512x512, or 768x768), and the render quality (current or best). You can also choose to save the resulting images in 8-bit RGB or 16-bit black and white.

You can choose to save only the current image, an animated sequence if a 4th dimension is available, or as a new series (Figure 7.07).

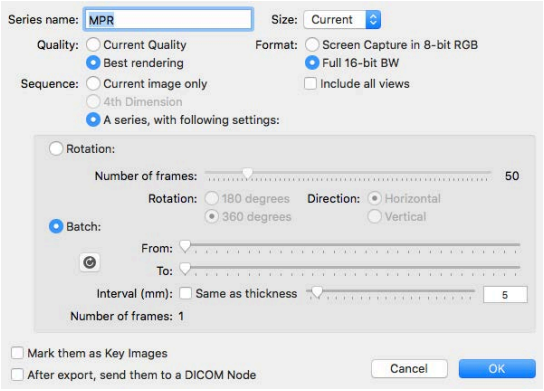

Figure 7.07. The Save as DICOM popup window.

If you select the new series option, you can modify the number of frames, rotation, and direction or choose the Batch mode. In Batch mode, you can re-slice a subset of the series by setting a start and end frame and an interval thickness from 1 to 200mm. Finally, you can mark the resulting images a key images and choose to send them to a DICOM node.

Movie Export

This tool creates a QuickTime movie of the selected series. The options are similar to those for Save as DICOM. You can choose the size of the movie, render quality, and sequence to be saved. The more frames you select, the smoother the movie sequence will appear (but file size will increase). Animated sequences can include 4th dimension data.

Axis

You can toggle on or off the axis lines on the MPR views using this tool.

Mouse Position

You can display or hide the position of the mouse on the two other MPR views when you move the mouse on the third view. The mouse position is denoted by a colored circle along each of the axis lines.

Sync Zoom

Choosing Sync Zoom allows you to have all three MPR views zoom at the same level simultaneously. This works with the Zoom tool from the Mouse tools.

Custom Tools

You can add or remove tools from the toolbar using Format > Custom from the main menu. Tools Custom tools for MPR views include the following:

4D Player

The 4D Player tool works with 4th dimension data series. It allows you to scroll in the 4th dimension (i.e. temporal dimension). The first step is to load a set of dynamic images (i.e. a beating heart) using the 4D Viewer tool in the database window toolbar. Once it is loaded, open the 3D MPR Viewer window and use the 4D Player tool in the toolbar to play the sequence or export the images in DICOM or QuickTime format.

Axis Colors

You can change the colors of the axis lines in each MPR view using this tool. You can choose from any color on the standard Mac OS X color picker.

Best Rendering

You can have the three MPR views rendered in highest quality by clicking on this tool.

Fusion

The 3D MPR Viewer supports image fusion. If you are working with a fused data set (i.e. PET-CT) you will see the fused series in the MPR views. These fused datasets are locked and move together. (You can computer the SUV value for a fused PET–CT study using the Oval ROI tool). When working with fused datasets, you can modify fusion parameters such as fusion mode (linear, log, etc.) and fusion percentage (0 to 100%).

THE 3D CURVED MPR VIEWER

A curved multi-planar reconstruction allows you to re-slice a dataset along a curved plane. This curved plane includes a user specified path (a series of points) and a set of corresponding orientation angles for each point on the path.

The Curved MPR rendering technique is most often used for complexly twisting structures, such as vessels. It essentially allows you to unroll the curved structures (e.g., blood vessels or colon) into a straitened tube. The whole length of the tubular structure is displayed as a single image making abnormalities such as stenoses, aneurysms, and plaques easier to measure and interpret. Curved MPR techniques help physicians make better diagnoses and treatment plans.

Your first step in Curved MPR is to define a curved path using sequential points on the three orthogonal views. For best image quality it is necessary to work with small slice intervals. Horos uses two mode for Curved MPR rendering: Straightened Rendering and Stretched Rendering.

Straightened Rendering

This type of curved MPR fully straightens a complexly folded, tubular structure. The newly straightened tube (i.e. a vessel) varies in diameter along the length of the tube. The advantage is that you can easily see changes in vessel diameter causes by abnormalities. A disadvantage is that you can only measure distances along the tube's length or tube diameters perpendicular to the long axis of the tube.

Stretched Rendering

Stretched rendering MPR preserves isometry (resolution along the X and Y axis are equals, so you can measure distances). If the goal is to preoperatively plan an endovascular stent treatment for an aortic aneurysm, a stretched rendering preserves the lengths of vascular segments allowing more accurate sizing of endovascular protheses.

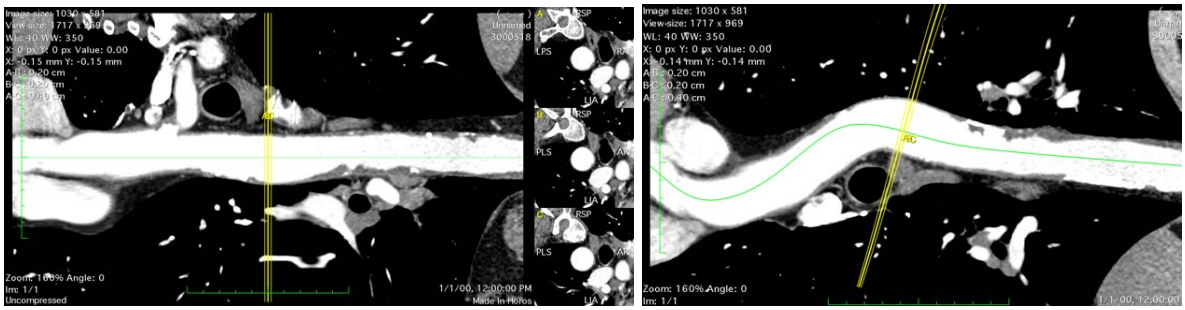

Figure 7.08. The Straightened (left) and Stretched (right) rendering of the aortic arch.

Curved MPR Engine

The 3D Curved MPR Viewer uses a different engine to display a curved plane. The algorithm used in the 3D Curved MPR Viewer is based on the method described by A. Kanitsar et al. 2002 [7]. It is computationally more intensive and so the engine is slower. Performance is linked to CPU processor speed and number of cores, not on GPU performance.

The 3D Curved MPR Viewer is divided into 3 parts: a toolbar, three orthogonal MPR views, and a curved MPR view rendered as straightened or stretched with 3 smaller view windows representing positions A, B, and C.

The toolbar (figure 7.09) contains buttons for the most useful functions. Tools can be added or removed from the toolbar using the Format > Custom Toolbar options from the main menu.

Figure 7.09. The Curved MPR Toolbar

The three orthogonal MPR views (Figure 7.10) are where you will draw your 3D Bezier path. In the lower right is the Curved MPR view where your 3D Bezier path is rendered as a curved plane image. The three smaller views on the right of the Curved MPR view depict three corresponding perpendicular views along the path at positions A, B, and C. Perpendicular views A, B, and C (Figure 7.11) are strictly perpendicular to the Bezier path, but if the path is not a straight line, they will not be parallel to each other.

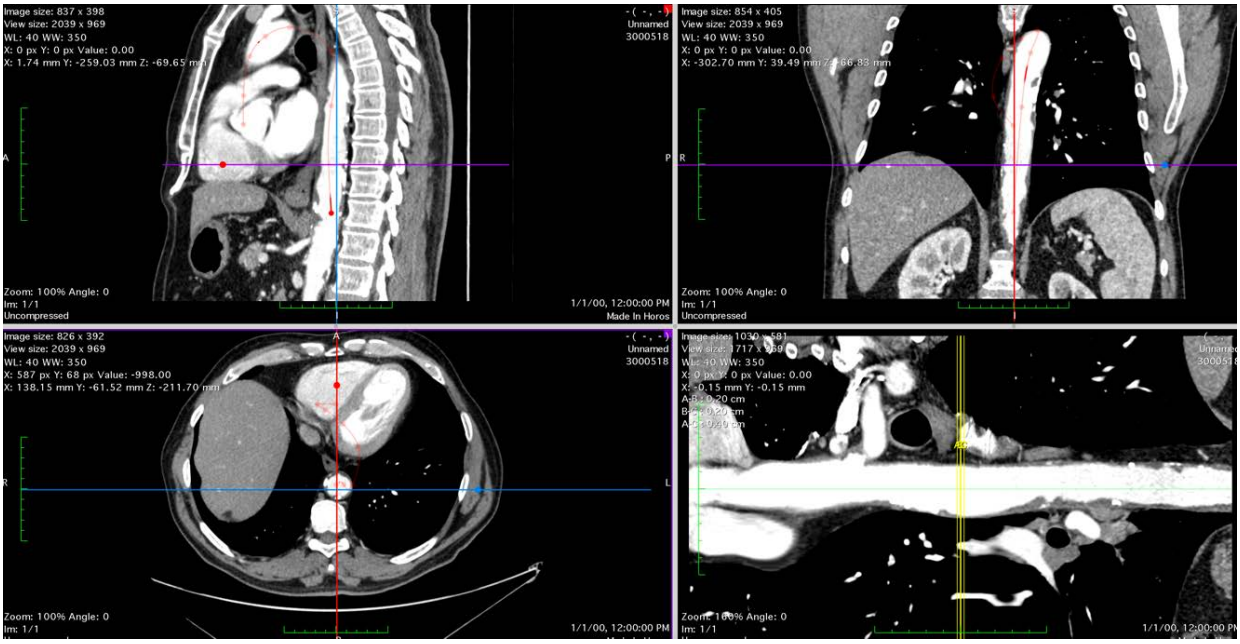

Figure 7.10. The three orthogonal MPR views with the curved MPR view in the lower right.

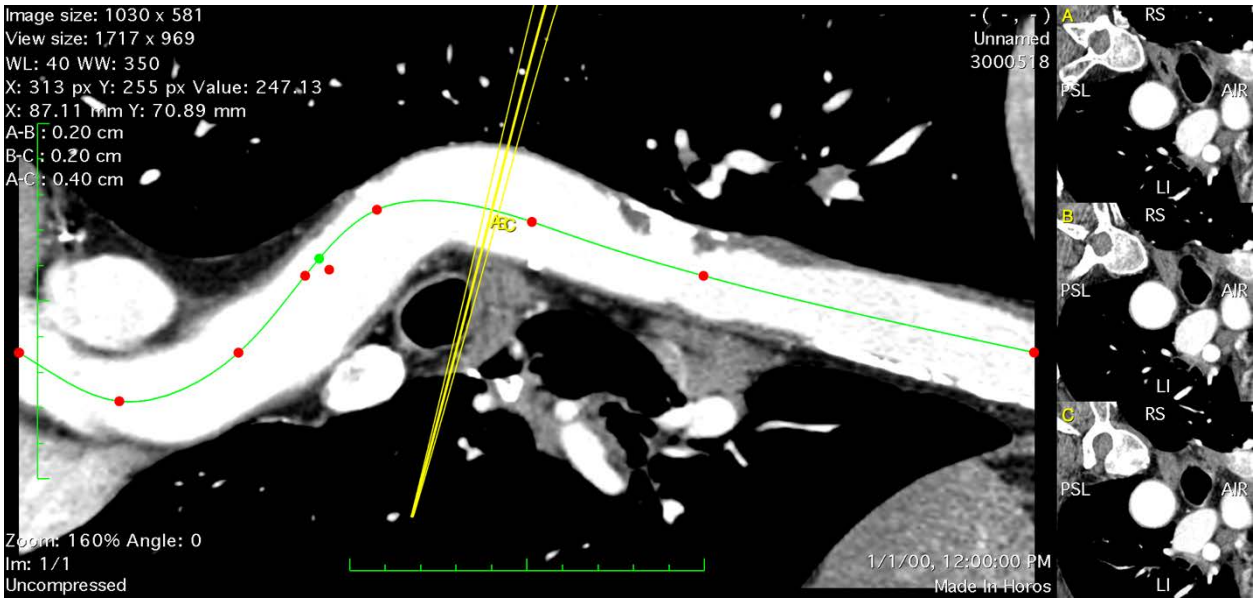

Figure 7.11. The curved MPR view with the three corresponding A, B, and C views. Note that they are not parallel to each other.

You can manipulate these views using the tools in the toolbar or via the mouse or keyboard. You can display a view full-screen by double-clicking on it (double click again to revert to normal size). You can adjust the size of each view using the separators between each view. Lastly, you can change the layout of the views using the View tool in the toolbar.

The Toolbar

This section describes each tool available in the default toolbar from left to right followed by the custom tools in alphabetical order.

Tools

These are mouse button tools accessed by selecting a tool and activating it with a mouse left-click.

- *Curved Path*
- *WL/WW [default tool]*
- *Pan*
- *Zoom*
- *Rotate*
- *Scroll*
- *Plane Rotate*

The left mouse tool can also be one of the following ROI tools:

- *Length*
- *Angle*
- *Rectangle*
- *Oval*

- *Text*
- *Arrow*
- *Opened Polygon*
- *Closed Polygon*
- *Pencil*
- *Point*
- *Brush*

WL & WW

This allows the user to change the settings for WL/WW, CLUT, and opacity using presets.

LOD

You can change the Level of Detail for rendering from fine to coarse suing the slider in this tool.

Curved MPR Angle

You can change the current rendering angle for the Curved MPR plane by moving the slider from 0^{o} to 360^{o}. Alternatively, you can adjust the angle using the mouse scroll wheel if you are in the Curved MPR view.

Reformation Type

As described above, you can switch between a straightened or stretched curved MPR plane (Figure 7.08).

Resolution

You can choose from Standard or High-Res modes.

Path Assistant

The Path Assistant tool automatically finds a path between points. You can choose two to five points for use with the Path Assistant and select a level of path simplification using the slider. Moving the slider to the left reduces the number of interpolated points along the path.

Path Mode

You can select to create a new 3D Bezier path with the Creation Mode or edit an existing path with the Edit Mode buttons.

To create a new path, select the Creation Mode and then the Curved Path tool. Begin by dropping points onto any of the orthogonal MPR views. A new red point will be added to the path as you continue dropping points. The orthogonal views are automatically re-centered on the last point. To finish your path, simply double-click the last point to switch to the Edit Mode. The

points switch to green color in Edit Mode. You can delete the entire path and start over by pressing the escape or delete key on your keyboard. You may find it useful to hide the axis cross reference lines from time to time (use the spacebar) as you drop points. Note that you can restrict points to the same plane by pressing the control key. This prevents angular deformations.

To edit a path, select the Edit Mode, and click on the point you want to change and click and drag the point to move this point to a new position. In Edit Mode, the path and points are displayed in green. You can add new points to the path line, but you cannot extend the path. If you want to remove a point, click and hold the mouse button on a point while also pressing the delete key on the keyboard. To return to Creation Mode, double-click on the last point on the path or select Creation Mode from the toolbar.

It's important to remember that your path is always displayed on the MPR views, but the current MPR plane may not be positioned on the path. This means that your path (displayed in green) could be in front or behind the MPR plane. If the path is crossing the MPR view, the path is displayed in plain and bold green color, but if the path is positioned behind or in front of the MPR plane, it is displayed in darker and transparent green.

Views

You have three options for displaying the MPR views. You can choose three MPR views with a fourth horizontally rendered Curved MPR plane. You can choose a single MPR view with one horizontally rendered Curved MPR plane. Finally, you can choose two MPR views with a vertically rendered Curved MPR plane.

Thick Slab

The Thick Slab tool allows you to render thicker sections than a single slice. You can also select the MIP, MinIP, and Mean rendering algorithms from the Thick Slab dropdown list.

Reset

You can reset the 3MPR views to the default views. If will use default zoom, rotation, and pan setting. If you have a Curved Path visible, this tool will delete the Curved Path.

Save as DICOM

You can create snapshots of your 3D scene, save them to disk as DICOM files, and add them to the database. Clicking on the DICOM tool opens a popup window (Figure 7.12) where you can create a new series name for the exported snapshots. You can also modify the size of the images by choosing between current, 512x512, or 768x768. Depending on the volume rendering you are using, you can also choose between 8-bit RGB or 16-bit BW formats. You can choose to only export the current image, or a series of images. If you choose the animated series, you can change the number of frames to render (up to 360 frames), the direction of rotation for the animation, and the render quality. You can include Curved MPR views and transverse views.

Finally, you have the option to mark the images as key images and the option to send the exported images to a DICOM node.

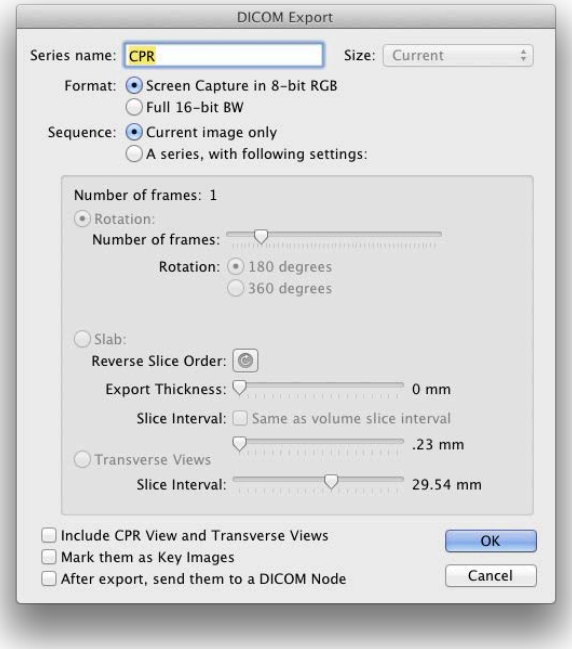

Figure 7.12. The DICOM Export options

Curved Path

If you have created a Curved Path, you can save the Curved Path in a file. This file contains the 3D points of the path, not the dataset itself. However, you can easily re-load the path by adding a Curved Path file to the 3D Curved MPR Viewer window.

Axis Colors

You can change the colors of the axis lines in each MPR view using this tool. You can choose from any color on the standard Mac OS X color picker.

Axis & CPR Axis

You can toggle on or off the axis lines for each of the three MPR views and the Curved MPR view.

Mouse Position

You can display or hide the position of the mouse on the three MPR views. The mouse position is denoted by a colored circle along each of the axis lines.

Sync Zoom

Choosing Sync Zoom allows you to have all three MPR views zoom at the same level simultaneously. This works with the Zoom tool from the Mouse tools.

Axis Colors

You can change the colors of the axis lines in each MPR view using this tool from the Custom Tools options. You can choose from any color on the standard Mac OS X color picker.

Interpolation Mode

You can choose from two interpolation modes, Nearest Neighbor or Cubic. This tool is available in the Custom Tools.

3D CURVED-MPR DETAILS

The three MPR views are reformatted DICOM images in orthogonal views. It is in these views that you will define the 3D Bezier path and the Curved MPR displays a view of the corresponding path.

The Curved-MPR image is calculated in real-time and automatically adjusts as new segments are added to the path. On the right of the Curved MPR view are three, small perpendicular (to the curved plane) views labelled A, B and C. These three views represent cross-sectional views at positions corresponding to locations A, B, and C (yellow perpendicular lines) on the Curved MPR image (Figure 7.13). On the MPR views, the positions of A, B, and C are displayed as yellow dots along the Bezier path.

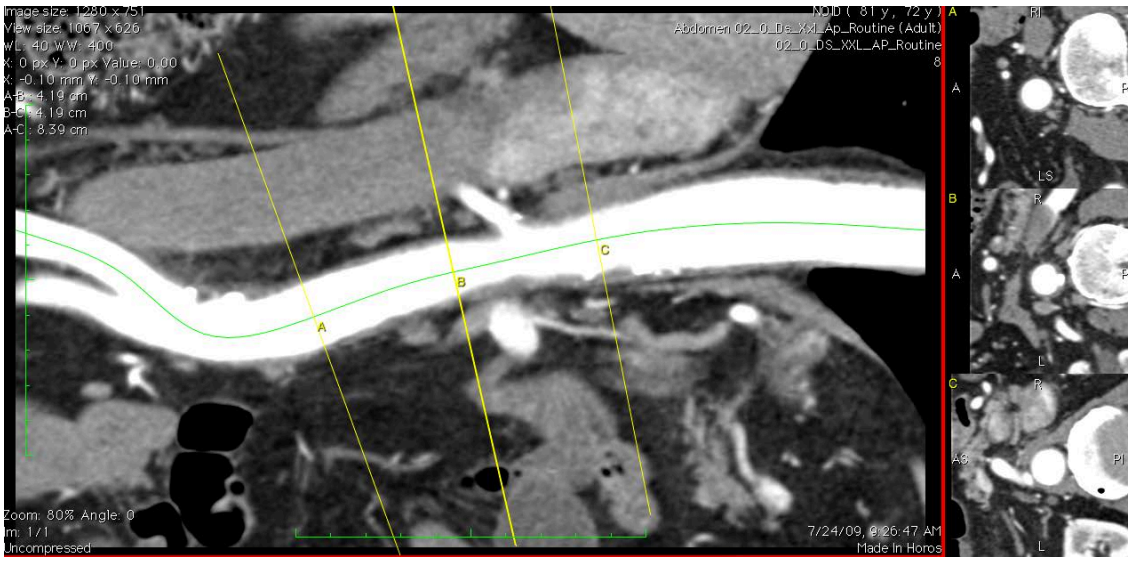

Figure 7.13. The Curved MPR view and the three small orthogonal views at positions A, B, and C.