

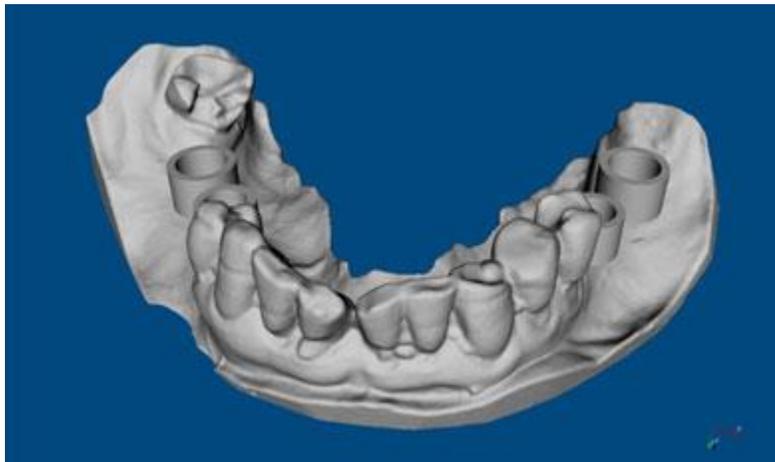
Dental Implant Drill Guide Design

Objective:

Learn how to use mesh repair and editing tools in VRMesh to create a drill guide for dental implant surgery. The following instructions will take you step-by-step through the general procedure of dental drill guide design.

Import File:

Click the **Import** command  to import a STL file. The imported file name is shown in the Object Tree Window on the right side of the screen. Clicking on an object name in the tree window will have the object selected.

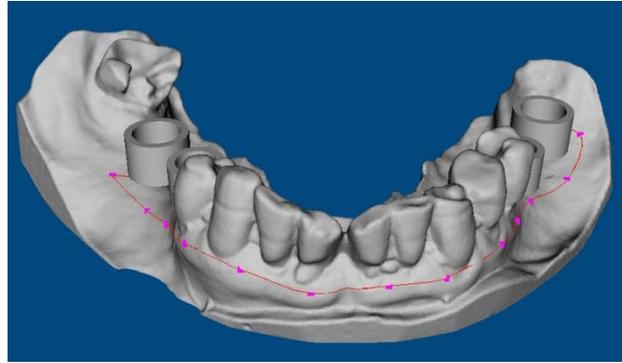


Note: The STL file used in this example is courtesy of Blue Sky Bio. Cylinders and tubes have been properly positioned using their treatment planning software, Blue Sky Plan.

Step 1: Define a drilling region

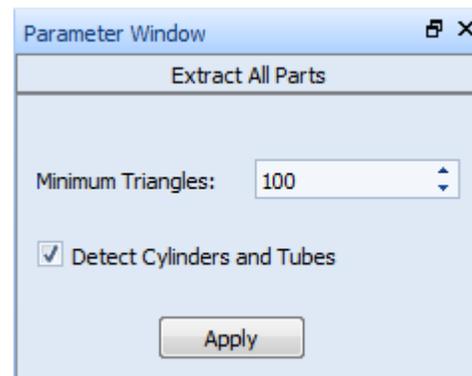
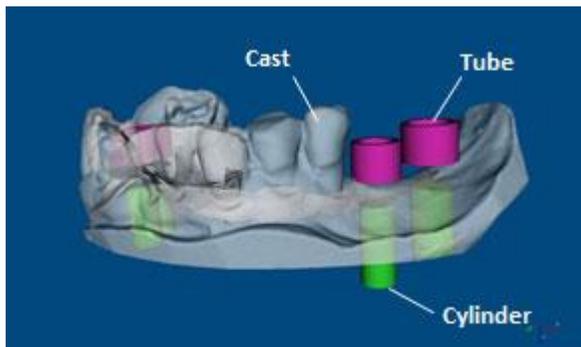
Click the **Sketch** command  in the Surface Curve menu. Draw a curve to surround a desired region and select [Apply] in the right-click menu to define a closed curve. You may use the **Adjust Surface**

Curve command  to move the control points of the curve.

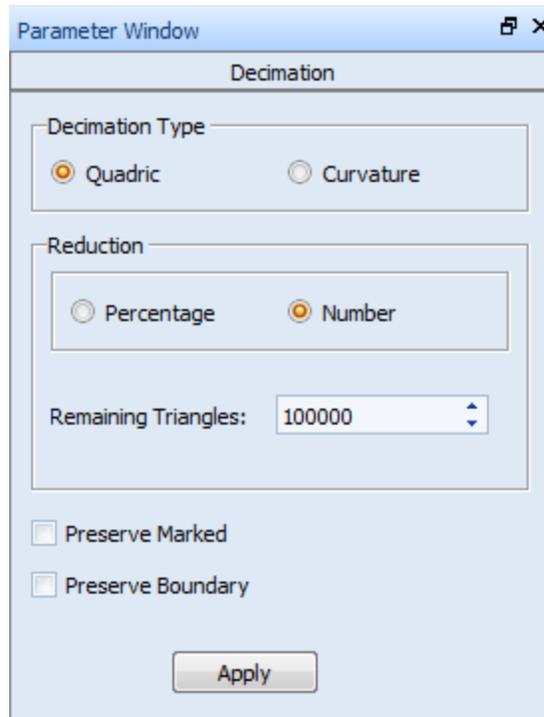


Step 2: Create a drilling template

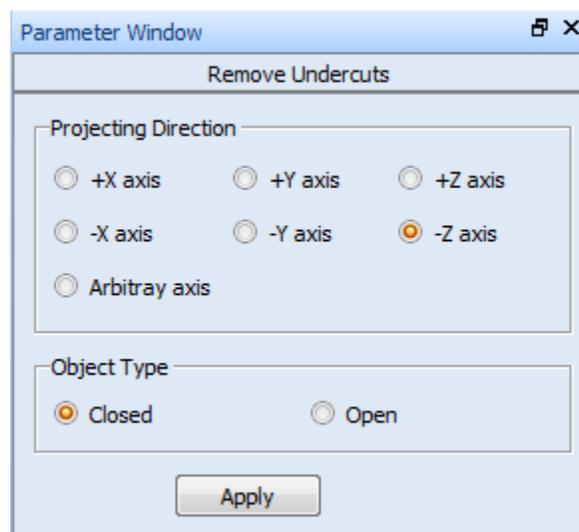
1. **Extract Cylinder, Tube, and Cast:** This step uses the **Extract All Parts** command  in the Mesh Editing menu to extract cylinders and tubes from the dental cast and groups them into a separate object listed in the Object Tree window. The *Detect cylinders and tubes* option must be selected in the Parameter window.



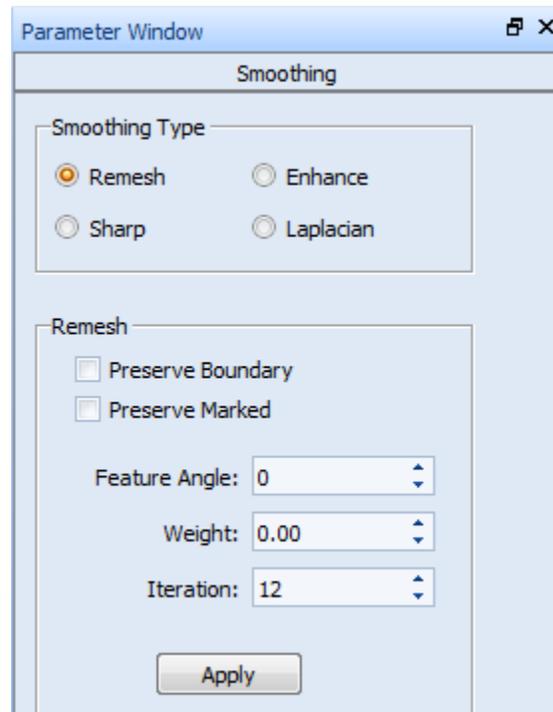
2. **Decimate Cast:** You may use the **Decimation** command  in the Mesh Editing menu to reduce the number of triangles on dental cast to around 100,000 in order to speed up the remaining processes.



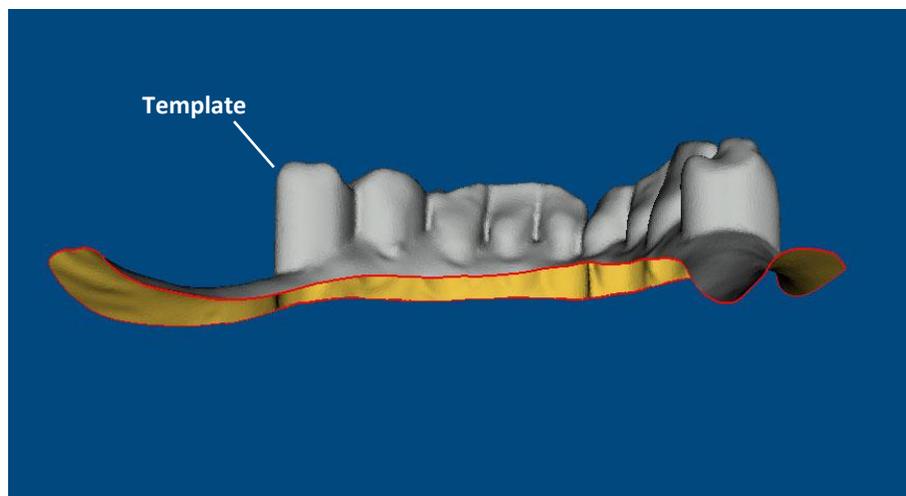
3. **Remove Undercuts from Cast:** This step uses the **Remove Undercuts** command  in the Mesh Repair menu to find the vertices inside the undercut region along a given direction and fixes them. Please be sure that the direction of projection must match your data. The *Arbitrary axis* option allows you to define an arbitrary axis by placing two dots on the surface. In this example, we specify the direction of projection as “-Z axis” and the object type as a “Closed” surface.



4. **Remesh Smoothing on Cast:** You may use the **Smoothing** command  in the Mesh Editing menu to remove noises from the dental cast. The default value of *Smoothing Iteration* is set to 12. This step is optional, just in case the mesh has poor quality.



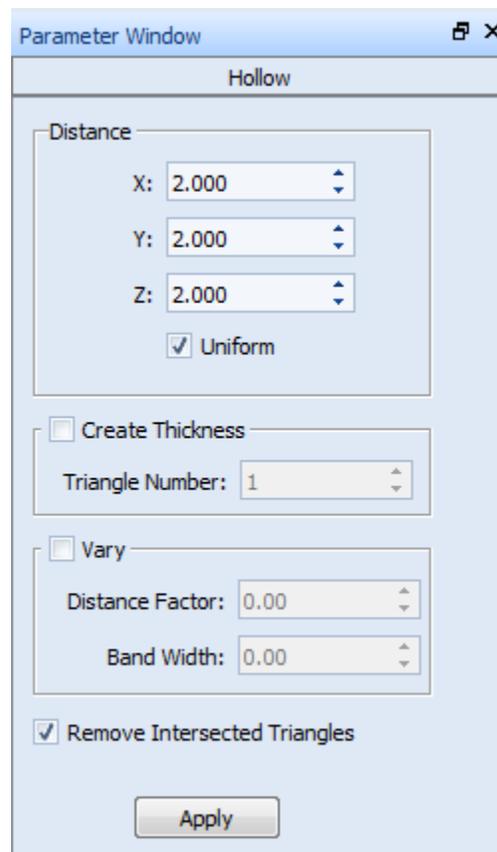
5. **Extract Contour Region from Cast:** This step uses the **Extract Contour Region** command  in the Mesh Editing menu to extract the region within the surface curve (drawn on the first step) from the dental cast. The extracted object is named as **Template**.



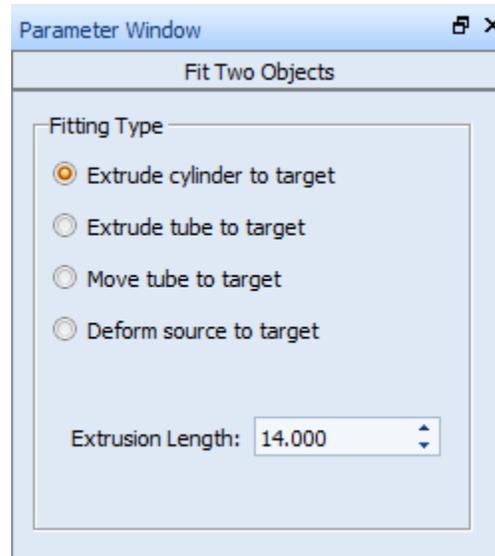
6. **Fill Boundary by Skin on Template:** This step uses the **Fill Boundary by Skin** command  in the Mesh Repair menu to cover the open area on bottom of the template to make it a closed surface.



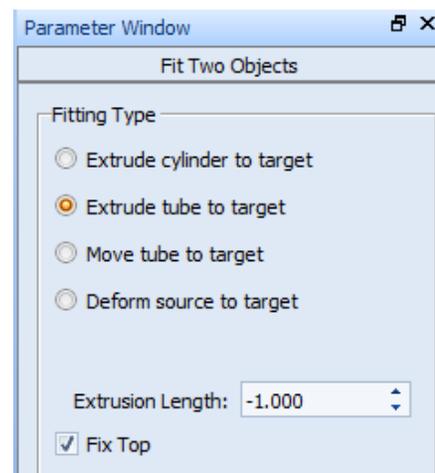
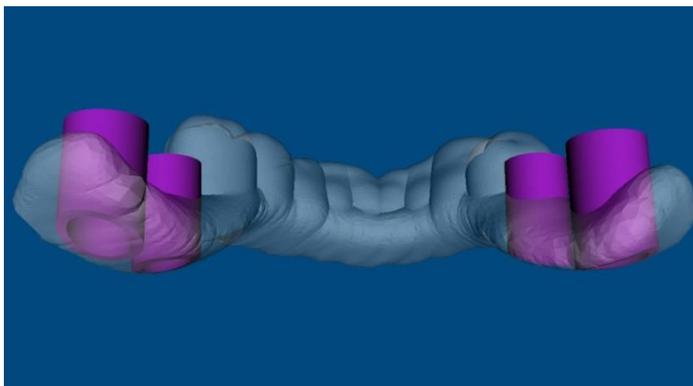
7. **Hollow Surface on Template:** This step uses the Hollow Surface command  in the Mesh Editing menu to move the surface of the template outward over a defined distance. The suggested offset distance is 2~3 mm. Please be sure that the *Create Thickness* option and the *Vary* option must be unchecked, and the *Remove Intersected Triangles* option must be checked.



8. **Fit Cylinder to Template:** This step uses the **Fit Two Objects** command  in the Mesh Editing menu to extrude each cylinder up and down. Please make sure that the *Extrude cylinder to target* option is selected. The default value of *Extrusion Length* is set to 14 mm measured from the end cap of a cylinder to the template surface.

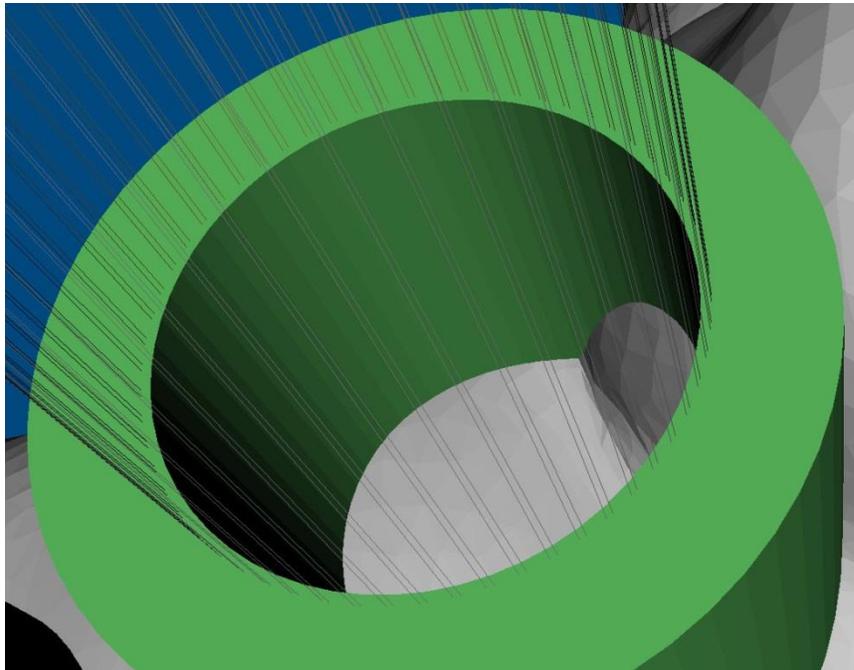


9. **Fit Tube to Template:** This step uses the **Fit Two Objects** command to extrude each tube up and down, or only extrude down if the *Fixed Top* option is selected. In this example, we checked the *Fixed Top* option and set the *Extrusion Length* to -0.1 mm measured from the end cap of a tube to the template surface. The result is shown below:



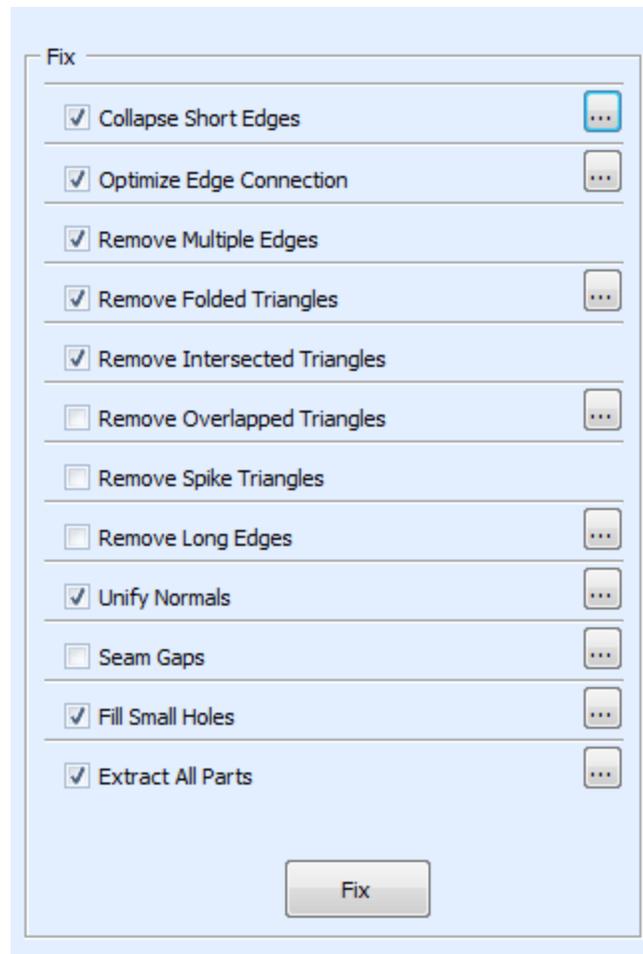
10. **Boolean Operations:** Using the Boolean commands in the Mesh Editing menu to execute the following Boolean operations on cylinders, tubes, the dental cast, and the template:
- Difference of Cylinder and Template
 - Union of Tube and Template
 - Using the **Offset Surface** command to offset the dental cast a little bit to make wearing the drill guide easier. For example, set the offset distance to 0.05mm.
 - Difference of Cast and Template

Please note that the Boolean operations will produce errors if the radius of a cylinder is exactly the same as the inner radius of a tube. You must make the radius of a cylinder slightly larger than the inner radius of a tube. You may use the **Offset Surface** command to increase the radius of each cylinder, for example, set the offset distance to 0.1mm. The result is shown below:



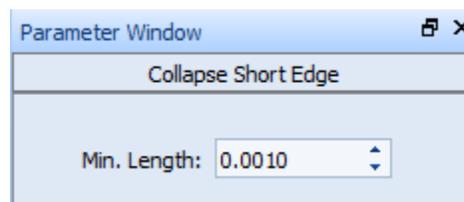
Step 3: Repair meshes

Use the Mesh Analysis Wizard  in the Mesh Repair menu to fix errors.

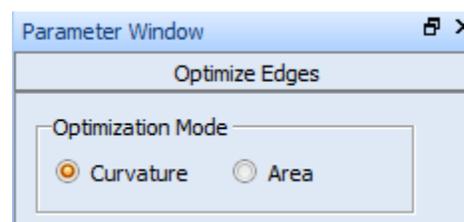


Click on one of the right side buttons  to adjust the value of parameters for each selected command:

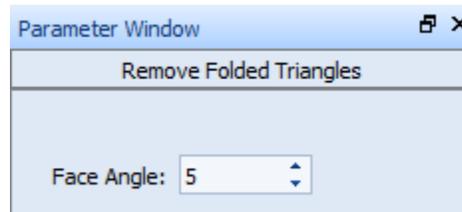
- **Collapse Short Edges:** *Merge Tolerance* is set to 0.001.



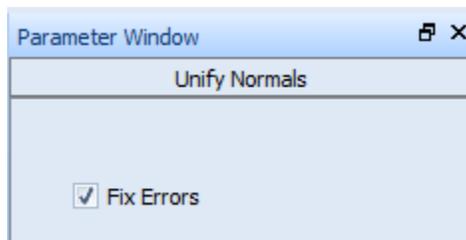
- **Optimize Edge Connection:** *Optimization Mode* is set to "Curvature".



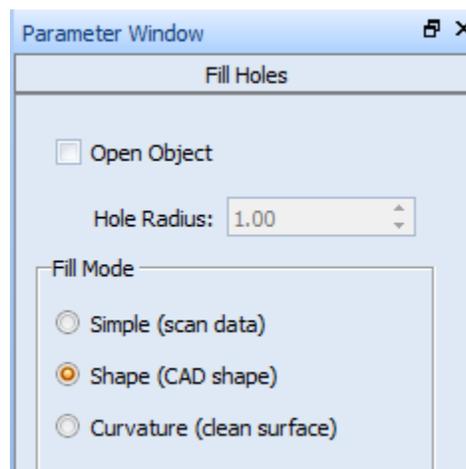
- **Remove Multiple Edges:** No parameters.
- **Remove Folded Triangles:** *Face Angle* is set to 5.



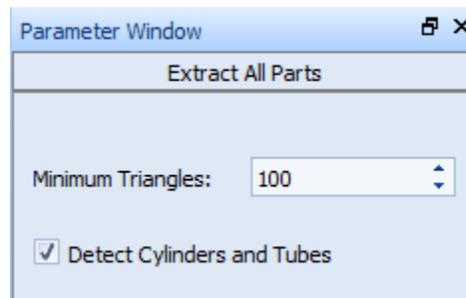
- **Remove Intersected Triangles:** No parameters.
- **Unify Normals:** The *Fix Errors* option must be selected.



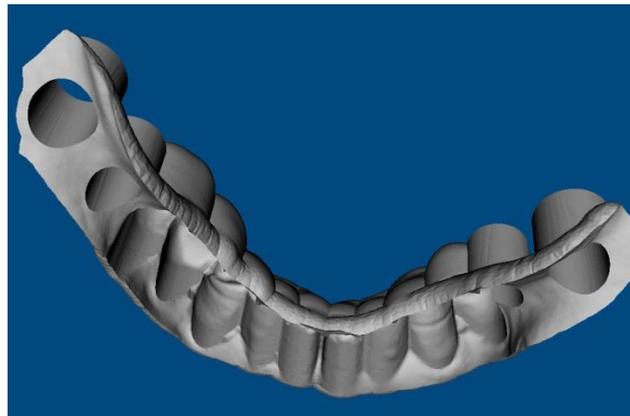
- **Fill Small Holes:** *Fill Mode* is set to "Shape based". Be sure to uncheck the "Open object" box because the template is a closed surface.



- **Extract All Parts:** The *minimum number of triangles* is set to around 100, which means an object containing fewer triangles than the defined value will be removed.



After all parameters above have been set up, click the **[Fix]** button on the Mesh Analysis Wizard. The program will execute the selected commands step-by-step. The final model of the drill guide is shown below:



End of Tutorial