



GUIDEMIA

GUIDEMIA



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1 . OVERVIEW

1.1 WHAT IS GUIDEMIA

GuideMia is a software system for dental implant treatment planning and surgical guide design. It uses the latest image processing technology, software development tools, as well as proprietary patent pending technologies to provide dental professionals an integrated advanced image-guided dental implant treatment planning software to evaluate patient's oral dental anatomy, to simulate implant placement, and to design surgical guides, which can be later on made by labs and used in dental implant treatment.

GuideMia has the following functions:

- CT image viewing and visualization. Users can view the CT scan of patient's oral-dental structure, perform measurements, and record diagnosis findings as they do with a typical DICOM image viewer.
- Simulating the implant placement. Users can simulate implant placement by adding implant geometric models onto the patient CT scan images and corresponding 3D reconstructions. Tools are provided to view and adjust implant positions and orientations.
- Planning additional treatments including bone reduction and grafting, sinus grafting, tooth extraction, etc. They will be documented as notes and images.
- Designing surgical guide models based on the oral-dental structure and the treatment plan. There are two categories of surgical guides.
 - The first one is so-called bone-borne guides, which are designed to be placed onto patients' bone and/or tooth surfaces to facilitate invasive surgery.
 - The second category is for tissue-based guides. The surgical guides are designed to fit onto patients' soft tissues (gums) and teeth so that non-invasive treatment can be performed.
- Exporting the designed surgical guides as standard STL files, which can be sent to any lab for manufacturing.
- Designing bone reduction guides and corresponding surgical guides, and exporting STL files for manufacturing.
- Creating virtual models of the oral-dental structures and implants, which will serve as study models, or bases for manually making surgical guides. Such a virtual model is called "master model" in GuideMia. Its components include bone/teeth with implant holes, soft tissues with implant holes, and duplicates of implants.
- Exporting the master model as standard STL files, which can be sent to any labs to manufacture. Restoration design and further traditional physical model based implant planning can be performed with such a master model. Conventional lab procedure can be also used to make a surgical guide based on such a model.

- Generating a treatment plan, which will include many views of the oral dental structures with implants, 2D CT scan slice images, handling and drilling sequence information, etc.

A viewer version of the software is also available. It can open project, browse implants and other objects, adjust implant locations and orientation, measure dimensions and angles, but cannot create any objects, design guides nor to save projects.

1.2 INTENDED USERS

The system is intended for dental professionals in dental offices, dental laboratories and treatment planning centers. The users can be categorized by their main responsibilities, but practically one single user usually runs through entire workflow of a case.

- Dentists/oral surgeons/physicians. They will likely focus on diagnosis tools, treatment plan reviews and adjustments, surgical guide reviews, plan approval, etc.
- Planner. They will work on data preparation, treatment planning, as well as surgical guide design.
- Surgical guide designer. More focus on surgical guide design.
- General. All system functions.

The users must be qualified to provide treatment planning services, and

- must have a good understanding of the oral dental structure, and CT image concepts,
- must be familiar with treatment planning,
- must be knowledgeable in the case preparation procedure, such as how data is acquired, how the radiographic guide is made, how the patients are scanned, etc.

Whenever patient's pathology is concerned, the users need to be radiologist or CT professionals who are licensed to read patient's pathology.

In general, GuideMia is a desktop application. There is no user type definition in the system, therefore the system design will not differentiate the users.

1.3 SYSTEM PLATFORM AND SPECIFICATIONS

The system will be eventually expected to work on Windows, Linux and Mac platforms. For the time being the development takes this into consideration, but will only support MS Windows. The supported OS include:

- Windows 7 64bit and its successors
- Windows 7 32bit and its successors

Recommended system specification:

Processor: Intel i7 CPU.

RAM: 4GB

Graphics card: 1G nVidia GTX260, GT450, etc

64 bit Windows 7

Lower end configuration will be for the viewer version only, which is a special version of the system that works as a limited version for doctors and patients to review their cases. We will target the middle to high end

desktop/laptop configurations, which are typically for small business or video game players commonly found in Dell or HP's website. Since the computer prices are constantly dropping, we do not list any details here.

1.4 CONTRAINDICATIONS

Implants should not be placed anytime when there are general contraindications associated with elective oral surgery. Absolute and relative contraindications include, but are not limited to: cardiac and vascular disease, bleeding disorders, psychological disorders, uncontrolled diabetes mellitus, mineral, bone, or connective tissue disorders, renal disease, hepatic disease, auto-immune disorders, decreased immune function due to disease or medications, infectious disorders, and adverse conditions caused by medications. Further relative contraindications include poor oral hygiene, bruxism, malnutrition, alcoholism, tobacco usage, and history of radiation therapy.

In addition, the patient needs an adequate volume of residual bone for the placement of implants of sufficient size and number to support the anticipated functional loads to which the patient will subject these implants. Narrow implants and angled abutments are not intended for use in the posterior region of the mouth.

1.5 WARNING

The software can only be used when patients have been scanned according to specific protocols and procedures, and study models have been made and scanned if necessary.

The treatment planning is based on patient's CT (or cone beam CT) scan and scan appliance (such as radiographic guide). Often time the scanning of a patient wearing a radiographic guide is necessary. Fail to properly place the radiographic guide before CT scan can cause serious errors and pose lots of risks to the surgery.

Implant treatment planning should be performed only by practitioners or lab technicians who are trained to do so. Adequate studies should be performed to examine the anatomic structures and to assess the biomechanical, functional, and esthetic requirements of each case. Radiographs or other diagnostic reviews should be performed to determine position and topography of the maxillary sinus, nasal cavities, inferior alveolar nerve, mental foramen, natural tooth positions and other anatomical features that may affect implant placement or prognosis. Consultation between the surgeon, restorative dentist, and dental laboratory is essential for success. All implants must be placed to have sufficient clearance between implants, teeth, and patients nerve structures. Risks of improper implant placement and restoration include, but are not limited to: infection, implant failure, loss of bone and soft tissue, unfavorable aesthetic result, anesthesia, dysesthesia and paresthesia in the oral and facial areas, sinus infection, dislodgement of implants and instruments in the surrounding structures, damage to adjacent teeth, non-restorable implants, fracture of implants or restorative components, and loosening of implants or restorative components.

Each implant system has unique measuring characteristics to allow full seating of the implant to the desired depth. In some instances, drill length reference lines measure longer than the stated length of the implant. It is recommended that the implant surgeon be thoroughly familiar with the specific measurement system being utilized and provide a suitable safety margin adjacent to any teeth and vital structures. Failure to recognize the difference between the actual length of the drill and radiographic measurements can result in permanent injury to the nerves or other vital structures by drilling beyond the depth intended, potentially resulting in permanent numbness to the lower lip and chin or other injuries.

Each implant system has specific design characteristics for mating implants, abutments, prosthetic components, and instrumentation including surgical kits. Combining instruments, surgical kits, and components that are not configured or dimensioned for correct mating can lead to mechanical failure of components, damage to tissue, or unsatisfactory aesthetic results.

One-hundred percent success cannot be guaranteed, no matter a treatment is planned with software or physical models. Lack of adequate quantity and/or quality of remaining bone, infection, inadequate surgical technique, poor patient oral hygiene, and generalized disease are some potential causes for failure of osseointegration, both immediately after surgery or after osseointegration is initially achieved. Pre-operative hard tissue or soft tissue deficits may yield a compromised aesthetic result or unfavorable implant angulation. With respect to children, routine treatment is not recommended until completion of alveolar growth has been verified.

1.6 PROCEDURAL PRECAUTIONS, SURGERY

The applicability of the surgical guides must be verified before the surgery. Quality assurance effort must be made to ensure the surgical guide is made according to the designed model and to the treatment plan. This includes trying the model onto diagnostic models, and on patient's anatomy. If a guide is found not fitting properly on the patient's anatomy, or cannot be properly secured, it must not be used for the treatment. The surgical guides should be visually inspected and evaluated. Any possible structure that can cause stress concentration should be identified and adjusted.

All efforts must be made to minimize damage to the host tissue. In particular, special attention must be paid to thermal and surgical trauma and to the elimination of contaminants and sources of infection. The surgical procedure requires a high degree of precision and care. Any divergence from the principle of least possible trauma at implant installation increases the risk of failure to establish osseointegration. All drilling procedures should be performed at maximum 1000-2000 RPM (or follow the manufacturer's instructions) with copious irrigation, with or without surgical guide designed by the system, with or without surgical kits provided by implant manufacturers. The use of sharp drills, sufficient irrigation, an in-and-out drilling motion, short cutting cycles, waiting for the bone to cool, and use of pilot drills in successively increasing sizes are essential. Please refer to our web site for the specific sequence of drills for each implant type and size.

An appropriate follow-up protocol should be followed.

1.7 CAUTION

The use of this device is restricted to, or by the order of, licensed physicians or dentists, and per prescriptions of the licensed physicians or dentists.

2 . DENTAL IMPLANT TREATMENT PLANNING

2.1 TREATMENT PLANNING WORKFLOW

GuideMia covers the entire workflow of treatment planning:

- 1) Preparation. This includes importing the patient's CT scan and additional references. Anatomical structures are modeled from CT scan. This typically includes bone, teeth, nerve channels, etc. With GuideMia's patent pending technology, Radiographic Guides or Scan Appliances are made for accurate treatment planning. Optical scans of stone models, patient intra-oral scans, etc. are also imported into the system and aligned with anatomical structures for further planning.
- 2) Image Viewing/Diagnosis. In addition to treatment planning, the GuideMia software has diagnosis tools as well. With tools to measure and archive diagnostic findings, GuideMia can help ensure safer treatment planning.
- 3) Planning. Implant selection, placement, adjustment, analysis, etc. are all involved in this step.
- 4) Simulation. There are always errors in the clinical output of the implant procedure regardless of the data sources and planning technology. With simulation tools in GuideMia, the users can better evaluate their treatment plans with extreme error conditions.
- 5) Design. Users can design Surgical Guides as they like with their choices of surgical kits.
- 6) Manufacturing. GuideMia certified dental labs can make surgical guides from the STL files exported by GuideMia with no or trivial post processing.

This workflow is illustrated by Fig. 1. The steps or components are shown as text blocks. The arrows going into blocks from the left side are the data inputs. The outputs go out of the right side. The arrows pointing to the bottom of the blocks are the "support" factors such as technology and additional inputs. The arrows to the top are the controlling factors, for example, the results of a plan simulation will be used to determine if the surgical guide design can be performed or not.

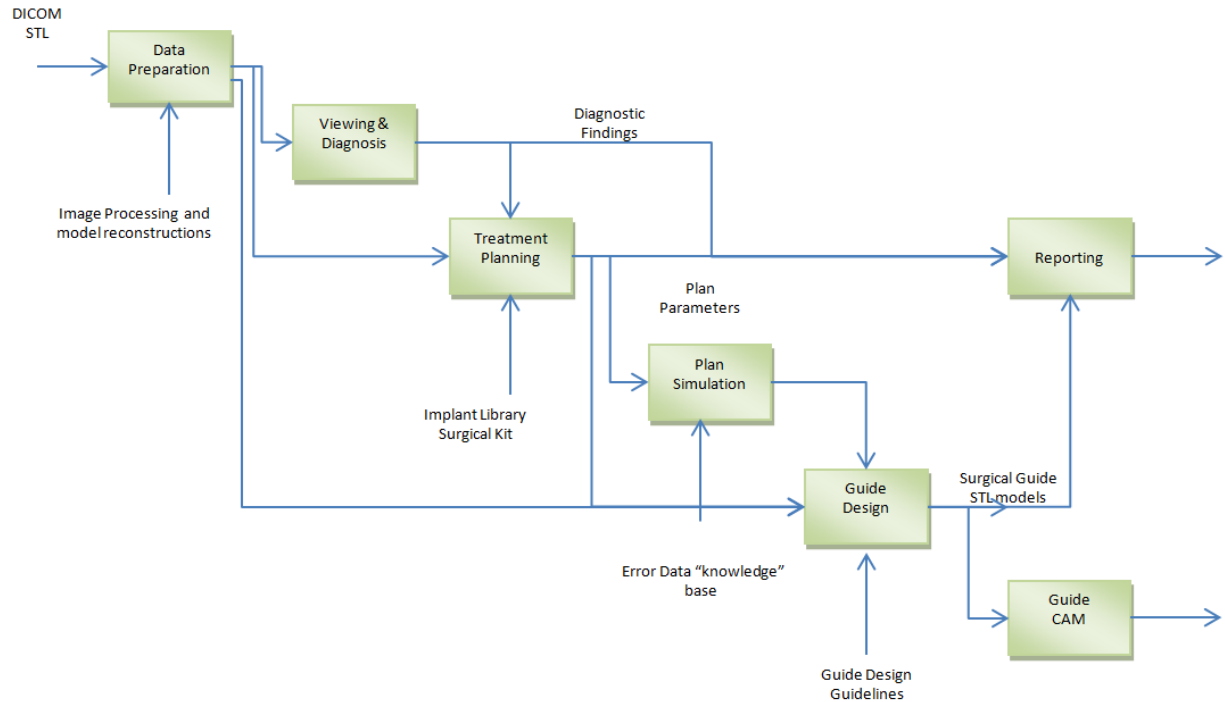


Figure 2.1. The overview of treatment planning workflow

2.2 SURGICAL GUIDES

Surgical guides are used to improve the accuracy and safety of a treatment so that implants can be placed correctly for the best possible esthetics and surgical outcome. As illustrated in Fig. 2, a surgical guide has the following basic elements:

- an adaption surface, which fits onto the patient's anatomy,
- drilling holes with sleeves inserted, which comply with the treatment plan and guide the actual drills, and
- optional form features like irrigation windows, screw holes, anchor pin holes, etc.

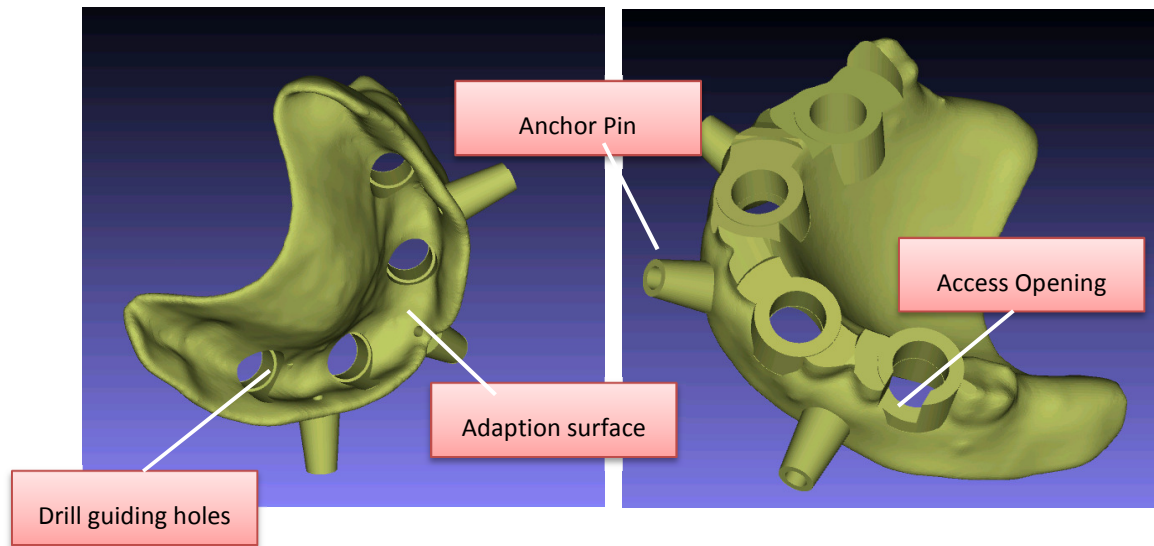


Figure 2.2. The form features of surgical guides

When a bone-borne guide is designed, the geometric model of the patient bone/teeth structure is created from the CT scan. A 3D geometric model with a thickness of about 2-3 mm is derived. This model can fit onto patient's bone/teeth just like a denture. Then "guide drilling holes" are created on this model. Sleeves will be inserted into the holes. At the surgery time, the guide will be put onto patient's bone/teeth, and the holes will guide the drills through.

Tissue-based guides are designed to fit onto patient's soft tissues (gums) and teeth. In order for the models to fit, the system can use any geometric models with a duplication or approximation of the tissue and tooth surfaces. This includes but is not limited to the following:

- Prefabricated denture-like guides, often referred as radiographic guides. A digital model of this kind of guide is obtained by CT scan and surface reconstruction.
- Stone/plaster models. The digital models are acquired through optical scans.
- The patient's Intra-oral scans.
- Impressions. The digital model can be from CT scan or optical scan.

Surgical guides are designed to be used with surgical kits. Implant manufacturers design and make their surgical guides according to their implant specifications, and they also have the version of kits that are specially designed for image guided surgery. The goals of surgical kits are basically to ensure proper drilling sizes, orientations, depths, as well as the drilling sequences. Surgical guides will need to be designed according to the implants and surgical kits. When no surgical kits are available for implants used in a case, the surgical guides will be designed for pilot drills only.

2.3 GLOSSARY

Radiographic Guide: A denture-like model that has radiographic markers and fits onto patient's teeth and/or soft tissue.

Treatment Planning: The process to select implant type, make and model and size, and to preview the implants together with patient's oral structure, and to adjust the implant locations and orientations.

Scan Template: Same as Radiographic Guide.

Segmentation: The process or operation to separate certain structure from a CT scan data set.

Nerve Tracking: The process to follow the nerve channels on a CT dataset and to create surface models of the channels in order to simulate the nerves in patients' oral dental structure.

Surgical Guide: A model that embodies implant treatment plan with implant holes and drilling sleeves, can fit onto a patient's oral-dental anatomy, and is used to guide the drilling operations for implant surgery.

Master Model: A model that consists of a patient's bone/tooth structure, and optionally, the soft tissues, with implant holes added. It can be used for case study, further treatment planning, as well as surgical guide fabrication.

Bone Reduction Guide: A model designed to guide the bone reduction process, which has a base model fitting onto patient's bone structure. and an opening that exposes the bone area to be removed.

Optical Scan: A process or approach to acquire geometric models of physical objects. Alternatively, this term refers to the resulted models that normally are stored as STL files.

STL File: a file format native to the stereolithography CAD software created by 3D Systems. This file format is supported by many other software packages; it is widely used for rapid prototyping and computer-aided manufacturing. STL files describe only the surface geometry of a three dimensional object without any representation of color, texture or other common CAD model attributes. The STL format specifies both ASCII and binary representations.

Rendering: the process of generating an image from a model (or models in what collectively could be called a scene file), by means of computer programs. A scene file contains objects in a strictly defined language or data structure; it would contain geometry, viewpoint, texture, lighting, and shading information as a description of the virtual scene. The data contained in the scene file is then passed to a rendering program to be processed and output to a digital image or raster graphics image file.

Volume Rendering: a set of techniques used to display a 2D projection of a 3D discretely sampled data set. A typical 3D data set is a group of 2D slice images acquired by a CT, MRI, or MicroCT scanner. Usually these are acquired in a regular pattern (e.g., one slice every millimeter) and usually have a regular number of image pixels in a regular pattern.

Surface Rendering: a set of techniques to display the geometric surface of a 3D dataset. While volume rendering displays each points of the dataset in the 3D space, surface rendering only deals with the geometric surface.

Snapshot: a tool or the results of the tool, generated from the tool in GuideMia, which capture the displayed image of a rendering window as well as the display parameters that are used to create the image, such as lighting and camera settings.

System Recovery: a process that tries to recover the project data and operation status from temporal files after system crash or any kind of abnormal termination of GuideMia session.

Axial View: one of the three cross section views of a CT scan dataset. It is parallel to XY plane of the coordinate system of the dataset. If required, it also includes cross section curves of any surface models.

Sagittal View: one of the three cross section views of a CT scan dataset. It is parallel to YZ plane of the coordinate system of the dataset. If required, it also includes cross section curves of any surface models.

Coronal View: one of the three cross section views of a CT scan dataset. It is parallel to XZ plane of the coordinate system of the dataset. If required, it also includes cross section curves of any surface models.

Assembly View: one of the two 3D views in GuideMia. It displays the patient's CT scan, radiographic guide CT scan, implants, as well as any other generated or imported 3D models.

Segment View: or current object view, one of the two 3D views in GuideMia. It displays the current working object or object group, which is one of the objects or all the implants in the assembly view.

Virtual Tooth: a geometric model imported from a library of STL files, which represents a tooth and can be placed in 3D views as a reference to help treatment planning.

Virtual Tissue Model: a geometric model generated based on CT scan dataset to simulate the actual soft tissues and tooth surfaces. Since this virtual model is similar to a stone model that typically includes soft tissue and tooth surfaces, the model is called virtual tissue model. It is also called virtual tissue model.

Tissue-borne Surgical Guide: or tissue level surgical guide, a category of surgical guides that are directly placed onto patients' soft tissues and/or tooth surfaces for the purpose of non-invasive surgery.

Bone-borne Surgical Guide: or bone level surgical guide, a category of surgical guides that are placed onto patients' jaw bone and/or tooth surface for invasive surgery, in which the surgeon will peel patients' soft tissues (gum).

Arch Curve: a curve that is used to outline the overall shape of the arch of either lower jaw (mandible) or upper jaw (maxilla), and to create the panoramic view of a CT scan dataset.

Placement Widget: a GUI tool helping position geometric models in a 3D space. It typically has handles, axis, and planes.

Surgical Kit: a set of tools and instruments for drilling and implant placements in dental implant procedures.

Drilling Sequence: a sequence of drilling operations to accomplish one implant hole. The first drill is called pilot drill.

Drilling Sleeve: a metal tube inserted into surgical guides to guide the drilling operations.

Safety Zone: an area in the 3D space surrounding an implant. There should be no interference with adjacent tooth roots, implants, nerves, sinuses, etc.

3 . GET STARTED

3.1 SYSTEM INSTALLATION AND CUSTOMIZATION

The installation is simple. GuideMia is mainly distributed through online downloading. You can download the software from our website as instructed.

The installation package is an .msi file on Windows. Double click the file will launch the installation wizard. You will need to select the language and the installation folder. Please note that you can always change GuideMia's working language by going to the menu items under "Help".

Due to Windows security reason, users will need to set GuideMia to run as Administrator. In order to do so, go to system Desktop, find GuideMia icon, right click, and select Properties from the pop up menu, then in the Property dialog as below, turn on "Run this program as an administrator".

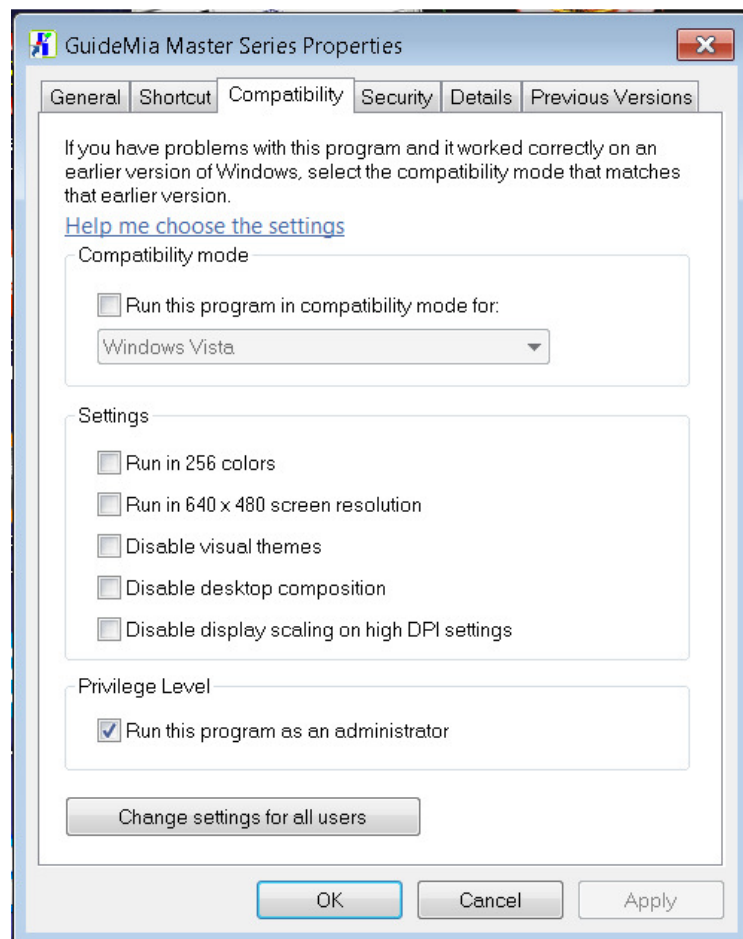


Figure. 3.1 Set to Run GuideMia as administrator

Also, latest computers may come with two graphics card. Users are advised to set GuideMia to run on the high end graphics card. Please refer to your computer's graphics settings for more details. The following is the setting for computers with nVidia system.

Start nVidia control panel by right click on your desktop, go to manage 3D settings tab, and make sure your Preferred graphics processor is set to High-performance NVIDIA processor.

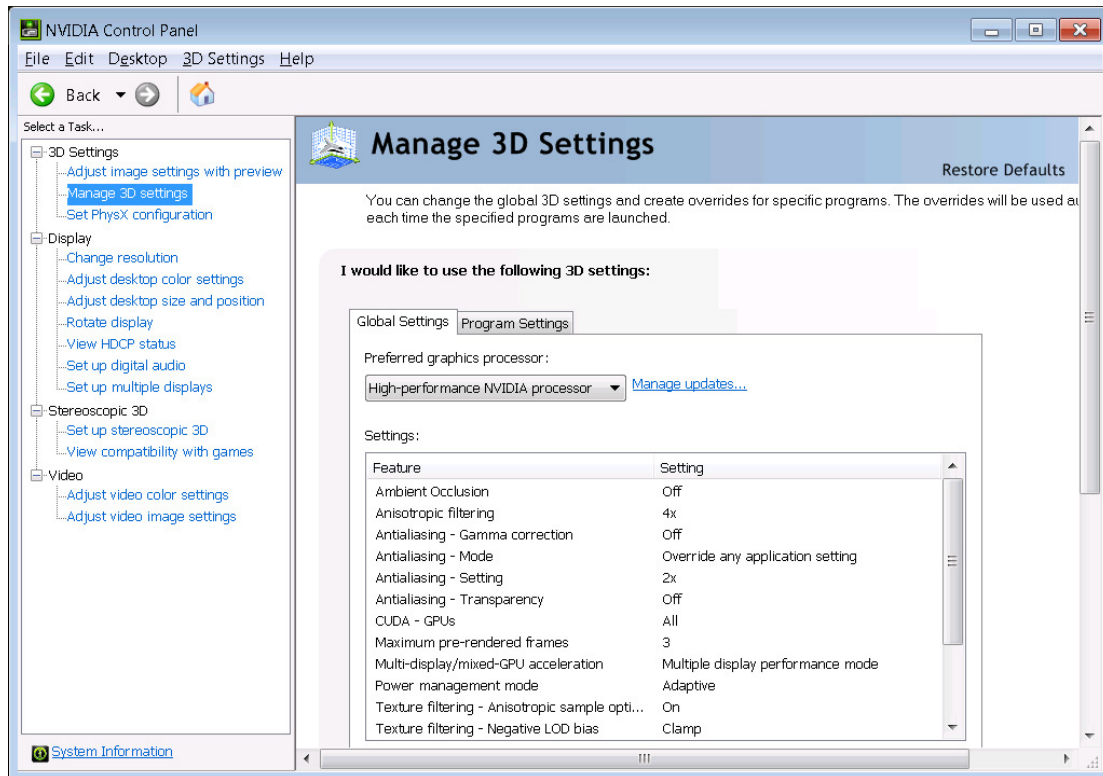


Figure. 3.2

In addition, some computers may not come with good graphics settings. If you are seeing your GuideMia displaying STL models with artifacts as in Fig. 3.3, please make change the image settings of nVidia control panel to prefer "Balance between performance and quality" or "Quality".

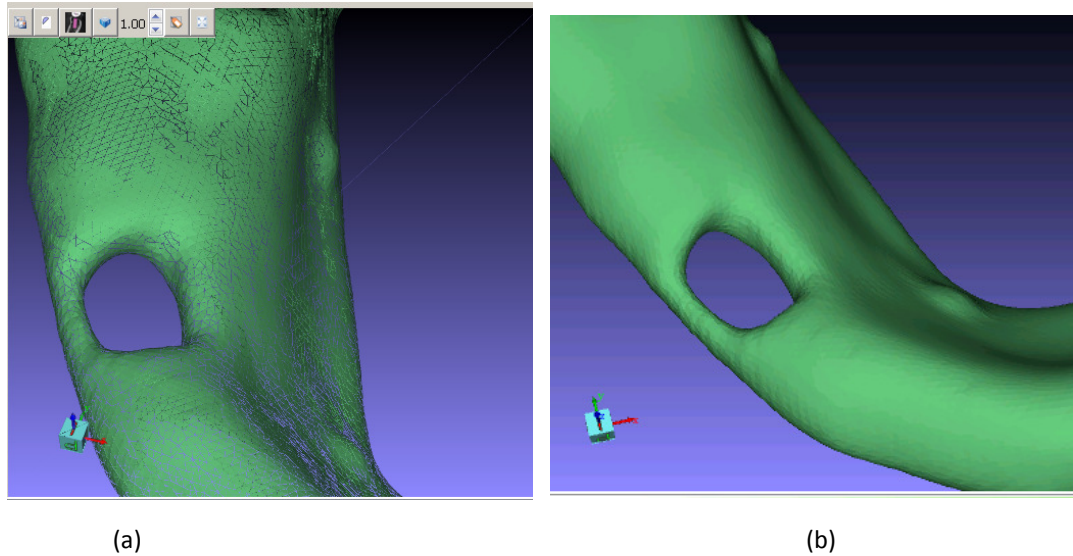


Figure. 3.3. STL model display. (a) with artifacts due to graphics card settings (b) expected display.

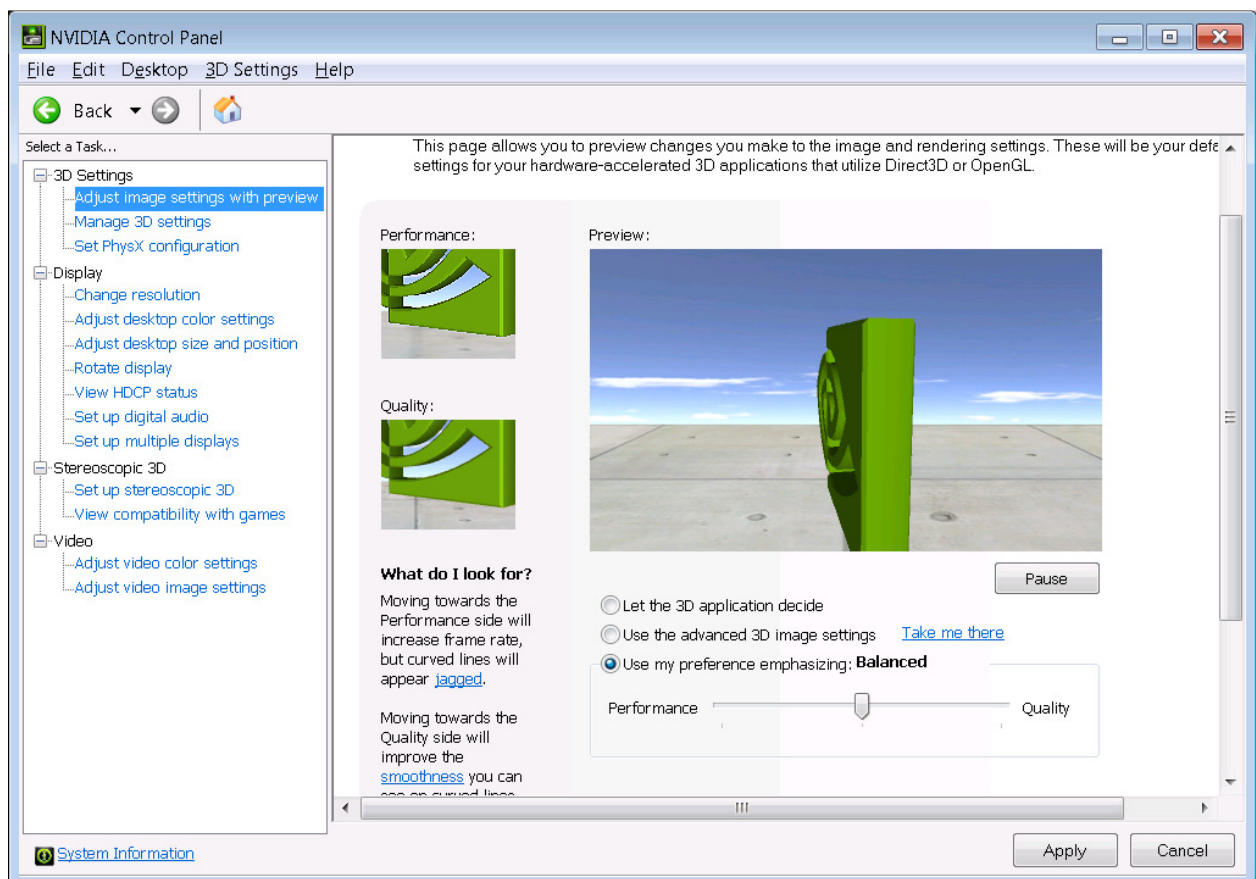


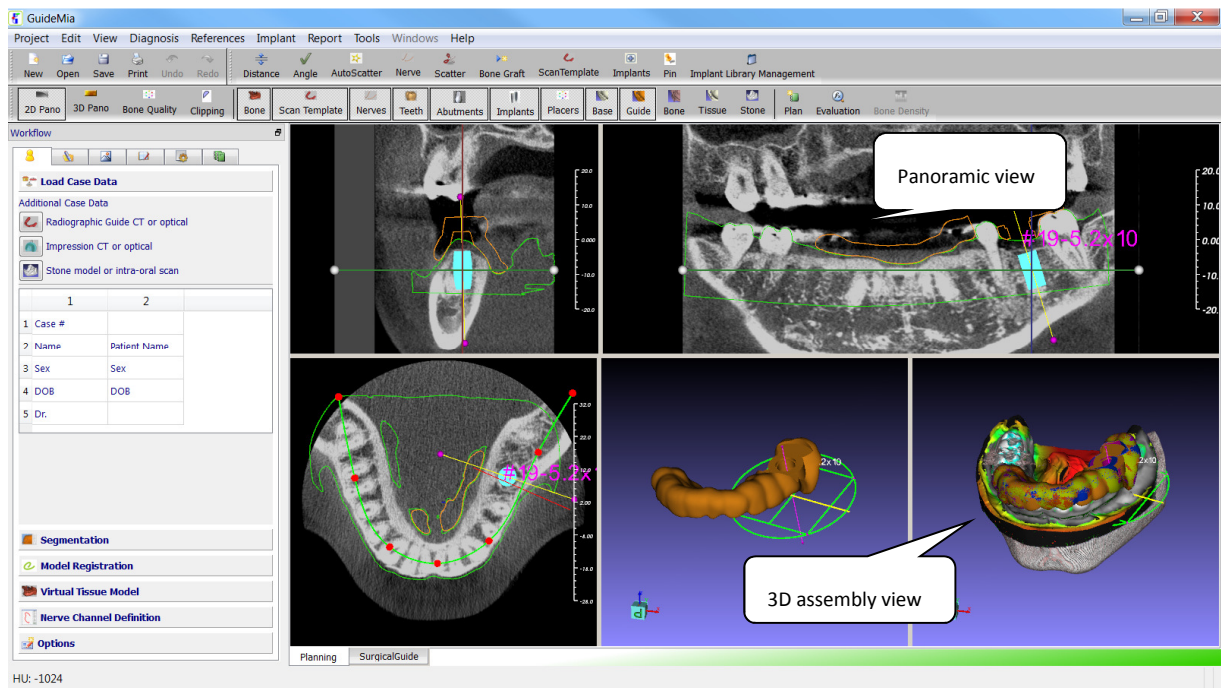
Figure. 3.4 Graphics card settings

First time you start GuideMia, you will be asked to activate your license file or start trial. Contact us for your license file and related issues.

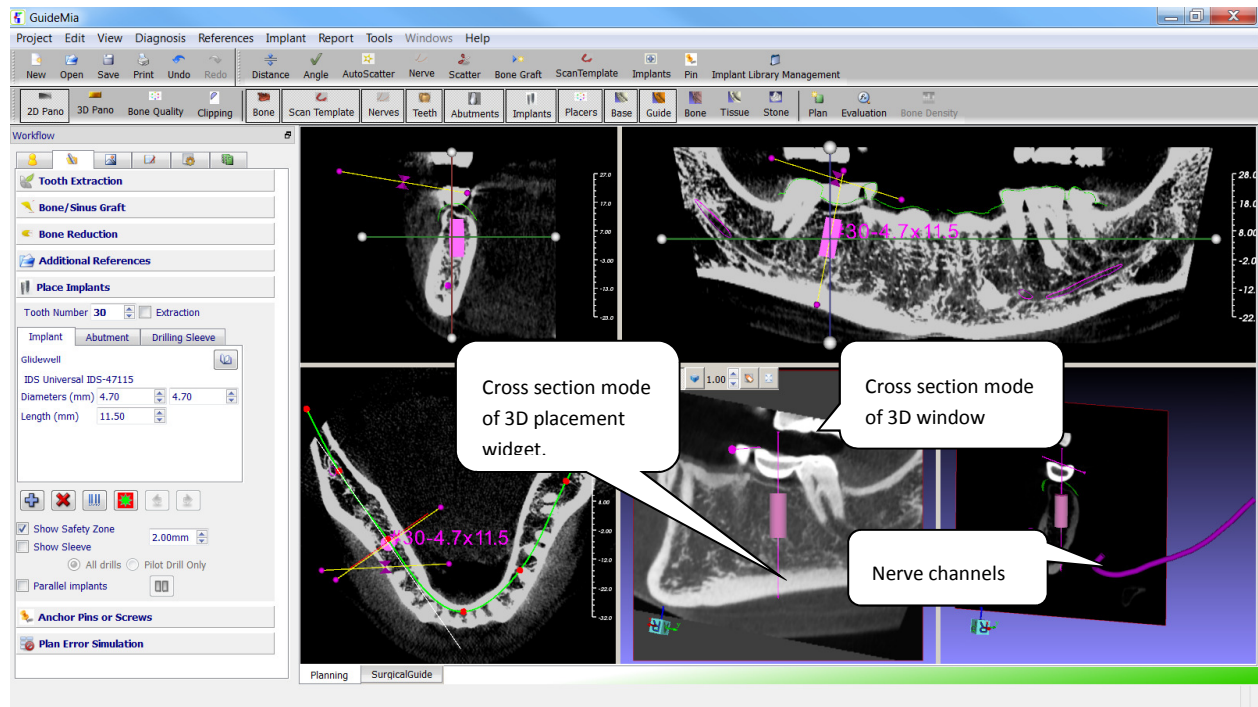
GuideMia will generate treatment plan reports. The reports can be customized with customer's logo. Users will need to place a file called customerlogo.png in GuideMia installation folder so that the reports will show the logo accordingly.

3.2 SYSTEM AT A GLANCE

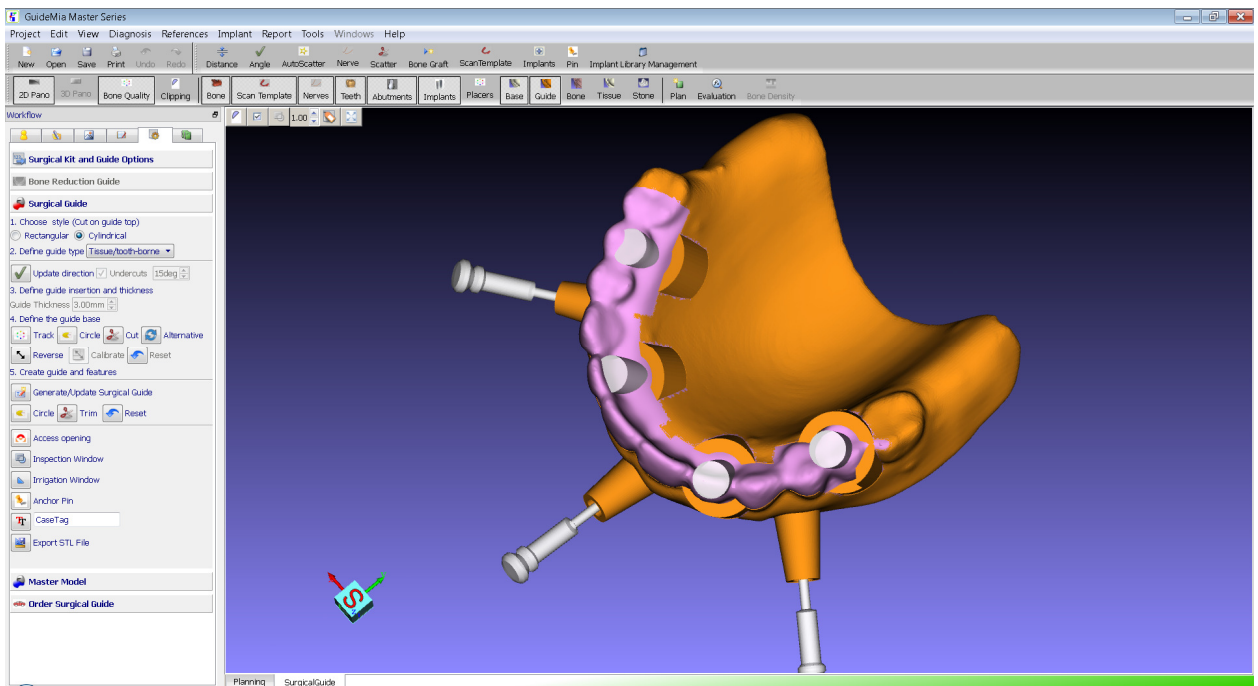
The following pictures show the system layout. Fig. 3.5(a) and (b) are the normal layout for implant treatment planning, Fig. 3.1(c) is the window for surgical guide design, and Fig.3.1(d) is the system layout for GuideMia viewer.



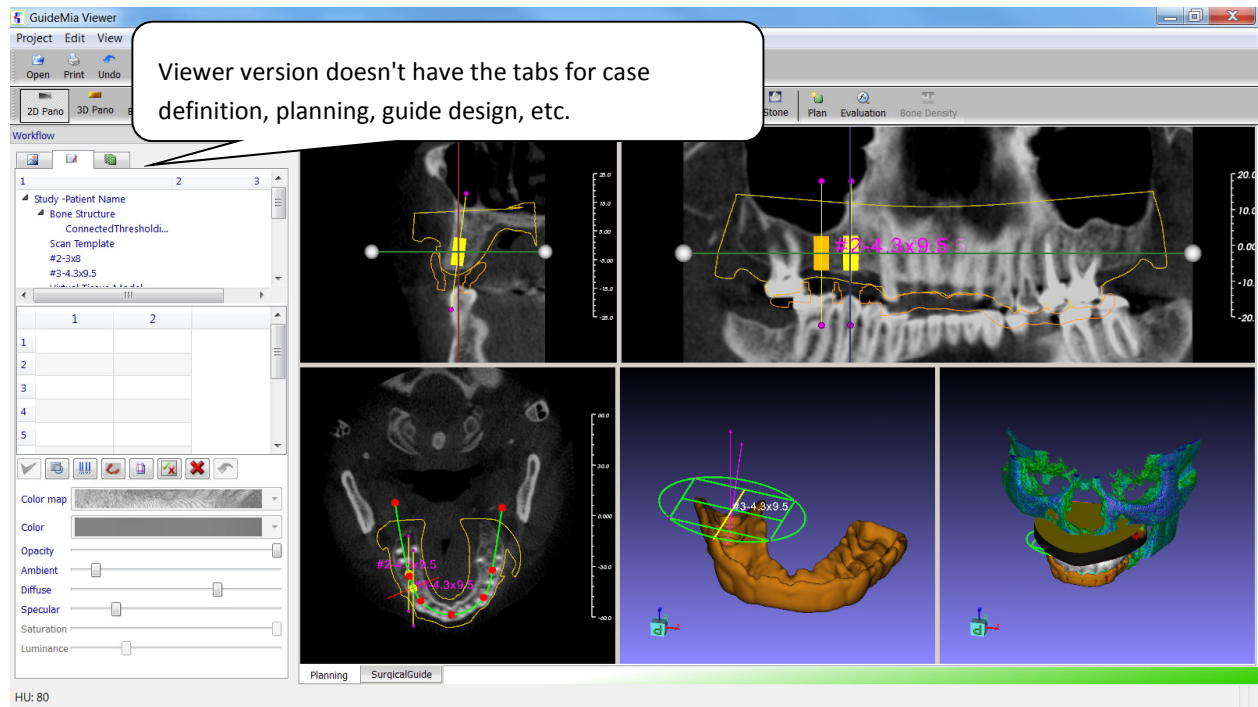
(a)



(b)



(c)



(d)

Figure 3.5. GuideMia user interface layout. (a) Treatment planning. (b) Alternative treatment planning layout. (c) Surgical guide design. (d) View version user interface.

The user interface has the following components. Detailed descriptions will be given later.

1. System menu bar with menus like Project, Edit, View, etc
2. Tool bars with functions that are frequently used
3. Task panel with the following pages as steps of a workflow:
 - a. Case definition
 - b. Treatment Planning
 - c. Snapshot navigator
 - d. Model navigator
 - e. Surgical guide design
 - f. Report generation
4. Image windows for treatment planning
 - a. Axial view
 - b. Sagittal view
 - c. Coronal view
 - d. 3D assembly view

- e. 3D current object view
5. Graphics window for surgical guide design

3.3 FILE SYSTEM

GuideMia deals with the following file types:

1. DICOM series, which is basically CT scan datasets. GuideMia is compliant with DICOM standards, and supports DICOM files from all vendors.
2. IMG file, which is a GuideMia proprietary file format. An IMG file is a combined form of a DICOM series. GuideMia uses IMG to store the results of bone segmentation. This file is not for the users to manipulate.
3. STL file, also a standard file format. GuideMia can import and export geometric models as STL files. For importing GuideMia support both binary and ASCII format. For exporting, it outputs binary format. Depending on the license options, the exported STL files may or may not be standard STL file format.
4. XML file, only for the implant library.
5. SGC file, which is a GuideMia proprietary file format for surgical kit configurations.
6. Treatment planning web page files include an HTML page and image files. There are also temporary XML files when the system is generating treatment plan web page.

3.4 MY FIRST GUIDEMIA CASE

In this section, a simple yet comprehensive workflow will be introduced. After this chapter, you will be familiar with the following:

- System user interface layout
- Basic user interactions in 2D and 3D windows.
- Minimum steps to plan a dual scan case with radiographic guide.

The example used in this chapter is available upon request. The users should be able to use their own cases to run through this workflow without issues. The following conditions are used to select a case to run this minimum workflow:

- Patient scan should be free of large metal artifacts or scatters.
- The radiographic guide markers are relatively clear from the bone structure or scatters. The markers themselves should not have much scatters. The size of the markers should be between 1.5mm-3mm. Spherical shapes are preferred. Long cylindrical markers should be avoided.
- Less than 3 teeth are missing.

Note: In the reminder of this document, left mouse button is referred as MB1, middle button MB2, and right button MB3.

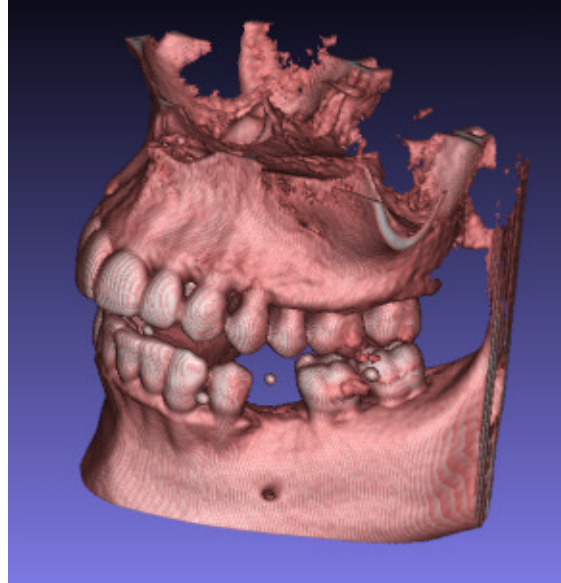
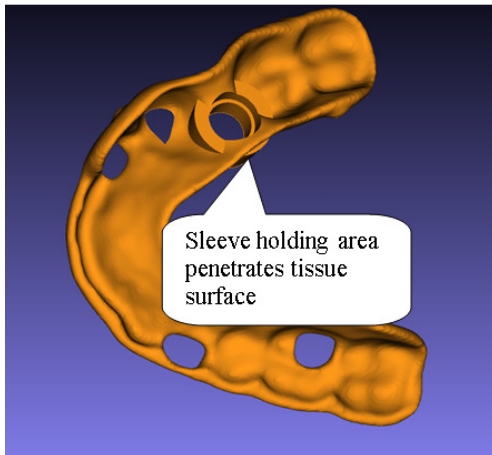


Figure 3.6. Sample patient scan with radiographic markers

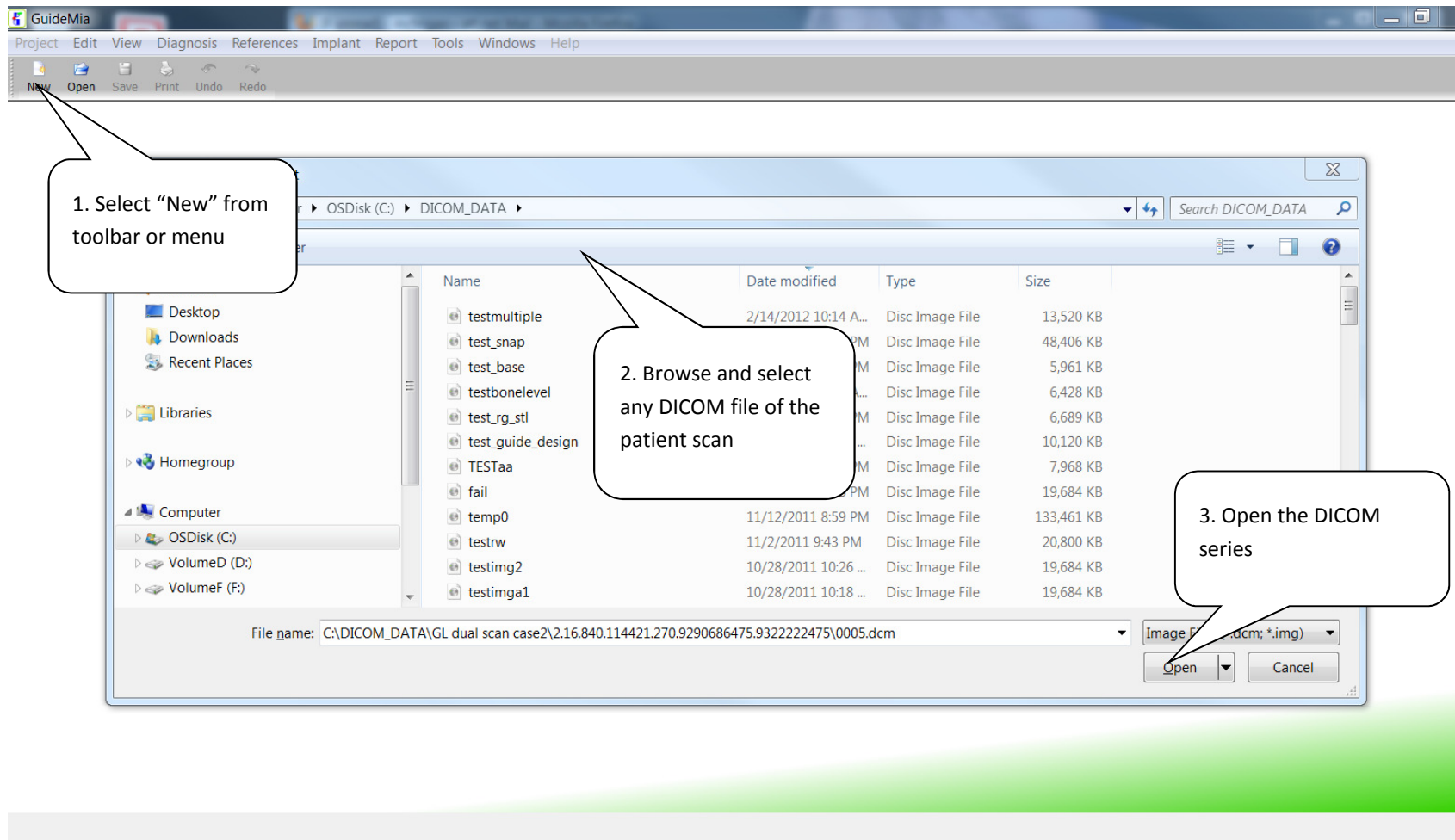
The treatment planning steps are briefly described below. They are all illustrated in the screen shots and the accompanying notes. See other chapters for more details or more thorough procedures.

- Step 1. Create a project by opening a DICOM datasets. The DICOM files of a scan must be placed into one single directory. No other DICOM files should present in this directory.
- Step 2. Initialize the image windows and manipulate the displays. As illustrated by the pictures, perform the following operations:
 - a. Zoom and Pan in all views
 - b. Rotate in 3D views
 - c. Threshold changes in 2D views. Look at the status bar of the application. The window/level value is shown there, as well as the thresholds. For bone structure, the thresholds will be above 300 and more depending on the patient's bone density. For radiographic markers, the lower threshold value will need to be in the 2000 range depending on the materials of the markers.
 - d. Arch curve manipulation
 - e. Region of interest manipulation. It is important that the region of interest will contain the radiographic markers before you go to the next step.
 - f. Slice line handles
 - g. Mouse wheel, or CTRL + MB1 drag and drop to change 2D slices.
- Step 3. Load DICOM files of radiographic guide scan. The DICOM files must be in a different folder than the patient scan.
- Step 4. Upon radiographic loading, the guide is automatically registered with the patient CT scan. The information message box shows the registration error, which is an average deviation value between the markers on patient CT scan and the radiographic guide scan.
- Step 5. Segmentation. Step 5 is to create segmented models for the bone structure and the radiographic guide. In this chapter only the very essential operations are used.
 - a. Essentially the segmentation of bone structure is based on the image processing techniques of connected thresholding. It includes the following steps:

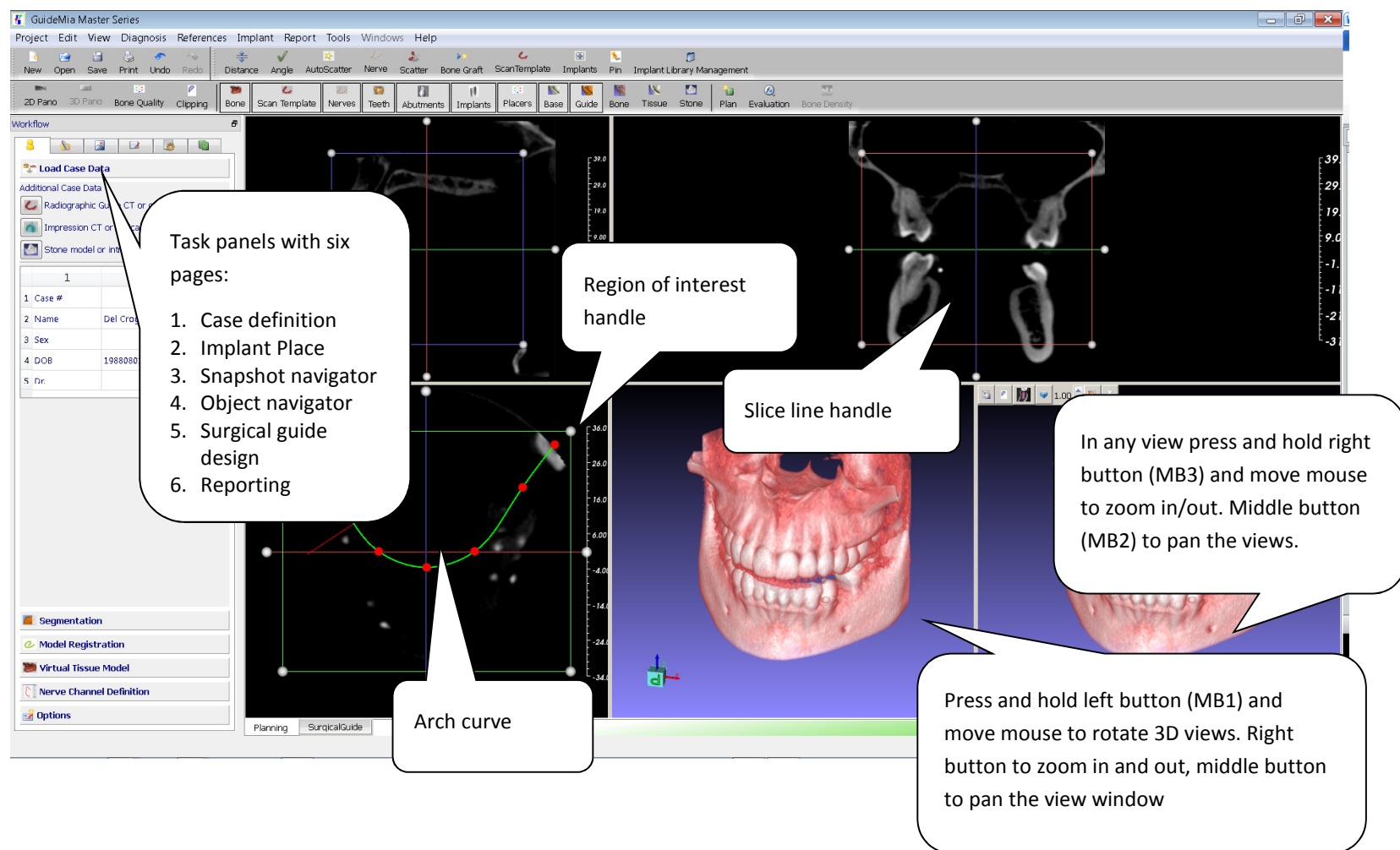
- i. Adjust the region of interest. Use the region box handles in the 2D views to adjust.
 - ii. Adjust the thresholds for the filtering. There is no definite rule to determine the bone thresholds. Depending on the patient's bone density, the lower threshold can be as low as 200 Hounsfield unit, or as high as 900. The good news is that for dual scan cases this segmentation is mostly for the purpose of viewing. Unless a bone level surgical guide is desired, there is no need to have the model better represent the actual bone structure.
 - iii. Specify a seed point on either of the 2D views.
- b. The segmentation of radiographic guide is a lot simpler. Users can just adjust the threshold to segment the radiographic guide.
- Step 6. Select implant for placement. In this example, we will just place one implant. See the picture for the operation details. The implant selection and library management dialog can let you select your implant, update implant selection, or manage library.
- Step 7. Place implants. Implants can be initially placed onto any of the 2D or 3D graphic views by a single mouse click. Each implant will have its placement widgets in all the five image windows. The details of placement widgets will be introduced later. Step 6 to 7 can be repeated as needed. Every operation on the placement widgets will be propagated to other windows. There are three kinds of placement widgets:
- a. 2D Placement widgets. A 2D widget has an axis and two handles.
 - b. 3D Placement widgets. As shown in the pictures, a 3D placement widget has a circular dial, a square with X and Y axis, Z axis with handles, etc.
 - c. 3D Placement widgets in cross sectional mode. As shown in the current object window, a widget of this kind is constrained on the cross section plane, or plane widget.
- Step 8. Surgical guide design. It is extremely simple for this case to design the surgical guide because it is all automatic. Just follow the instruction on the corresponding screen shots.
- Step 9. Generate report.
- Step 10. You can save the project, and exit. This concludes our very first example.

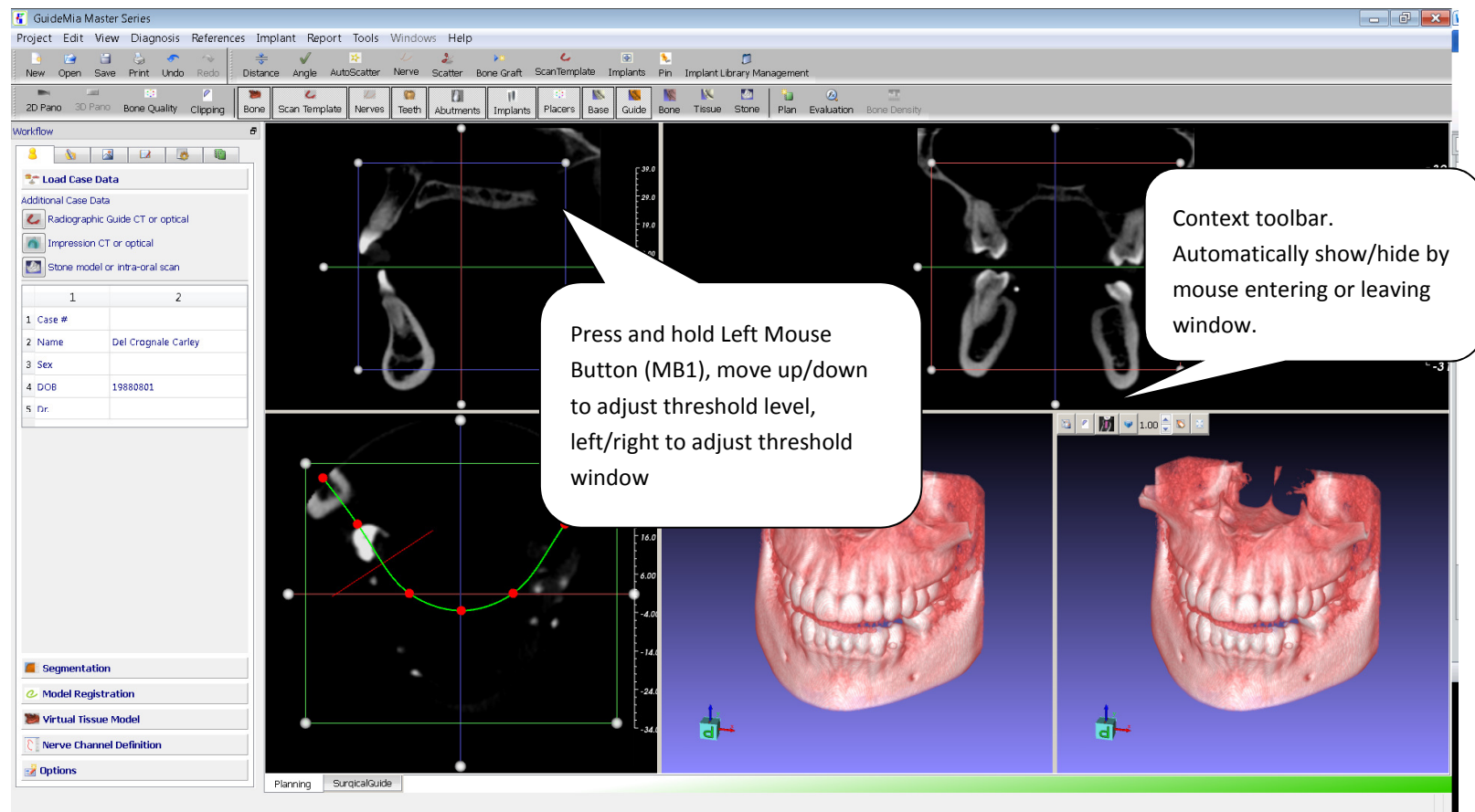
**Note:**

It is very common that there is not enough clearance in the implant site to create the form features for drilling sleeve. The picture in the left shows a typical situation. Please refer to Chapter 7 for the procedure to design surgical guides for this case.

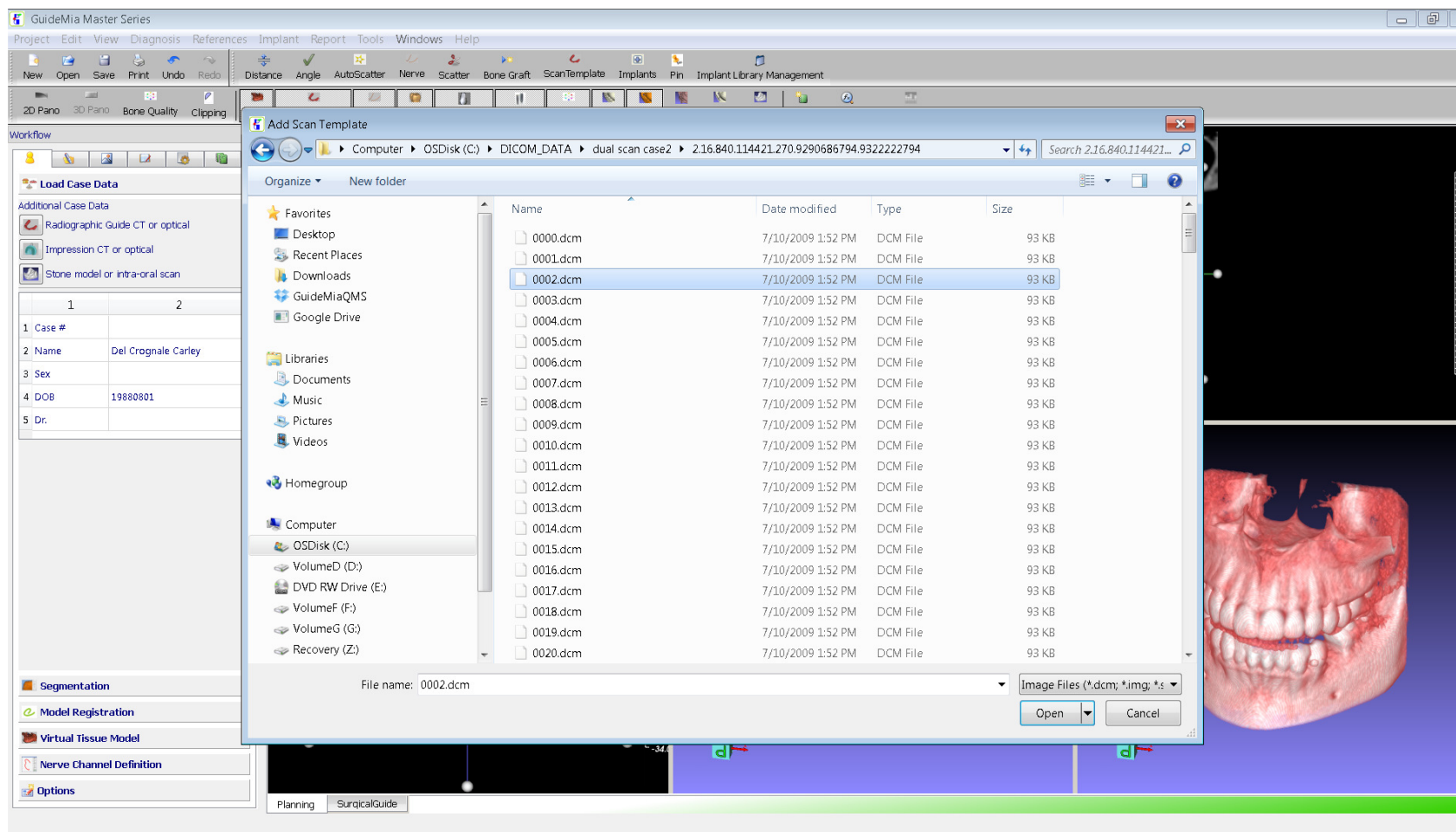


Step 1. Create a Project

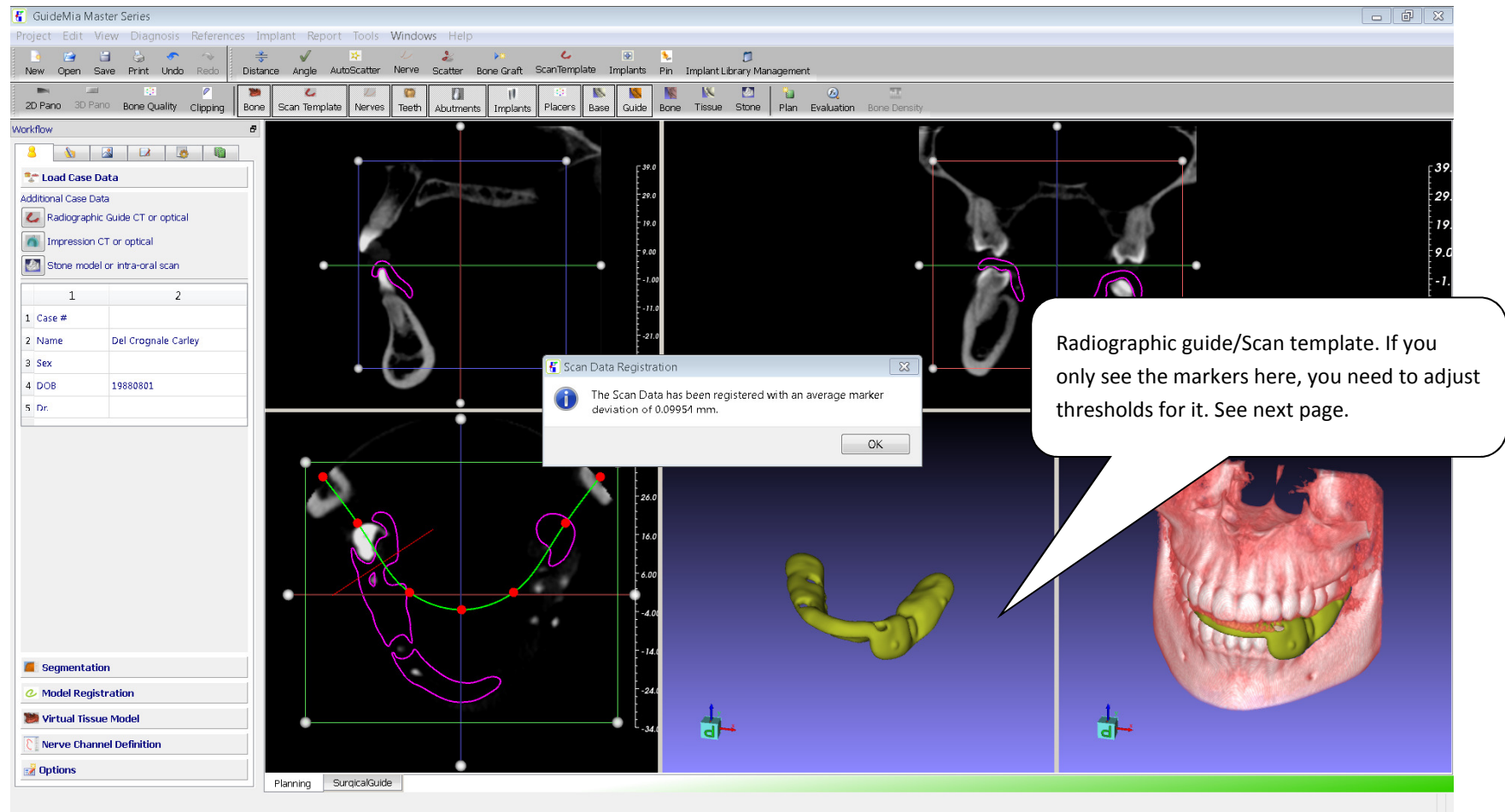




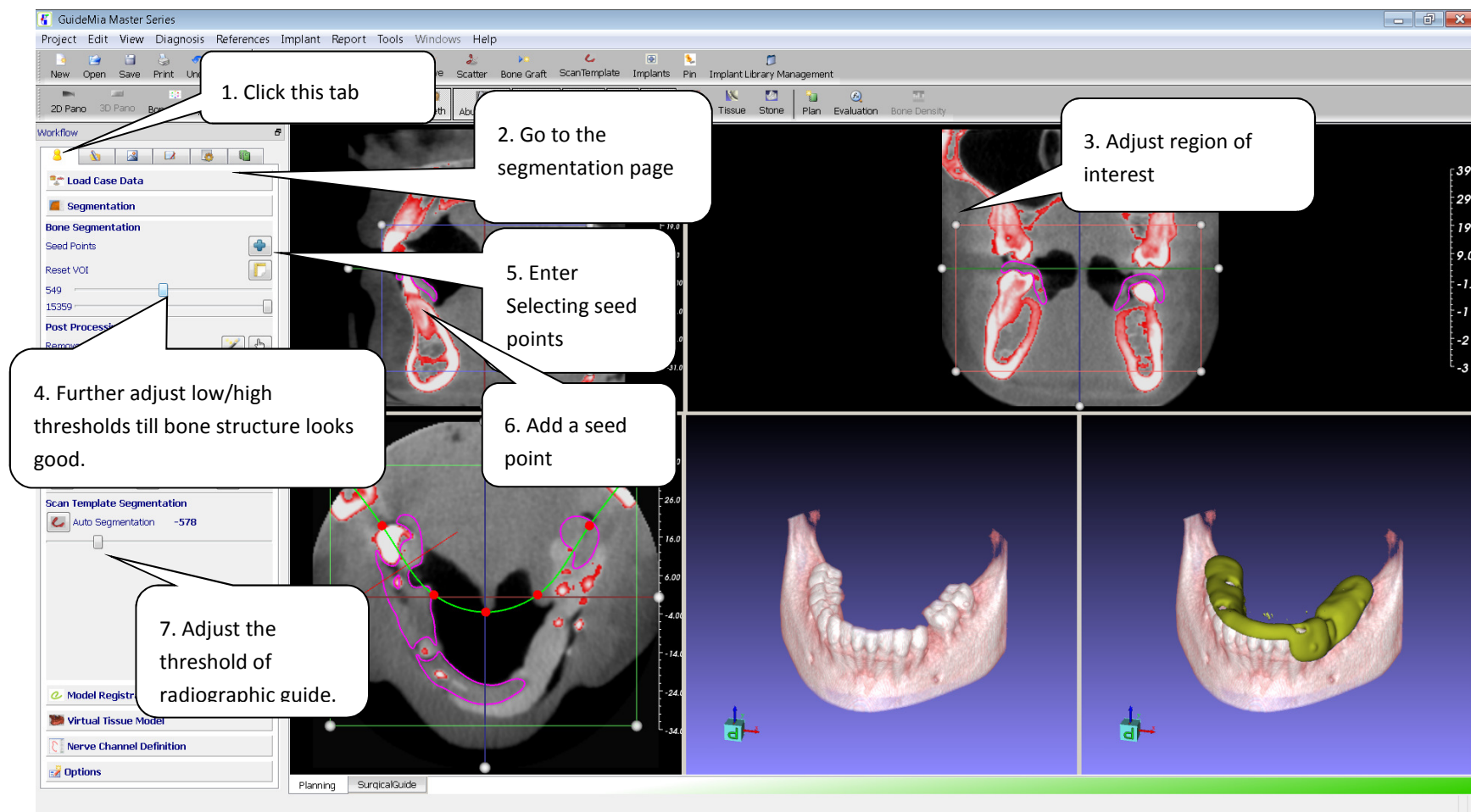
Step 2. Window manipulations



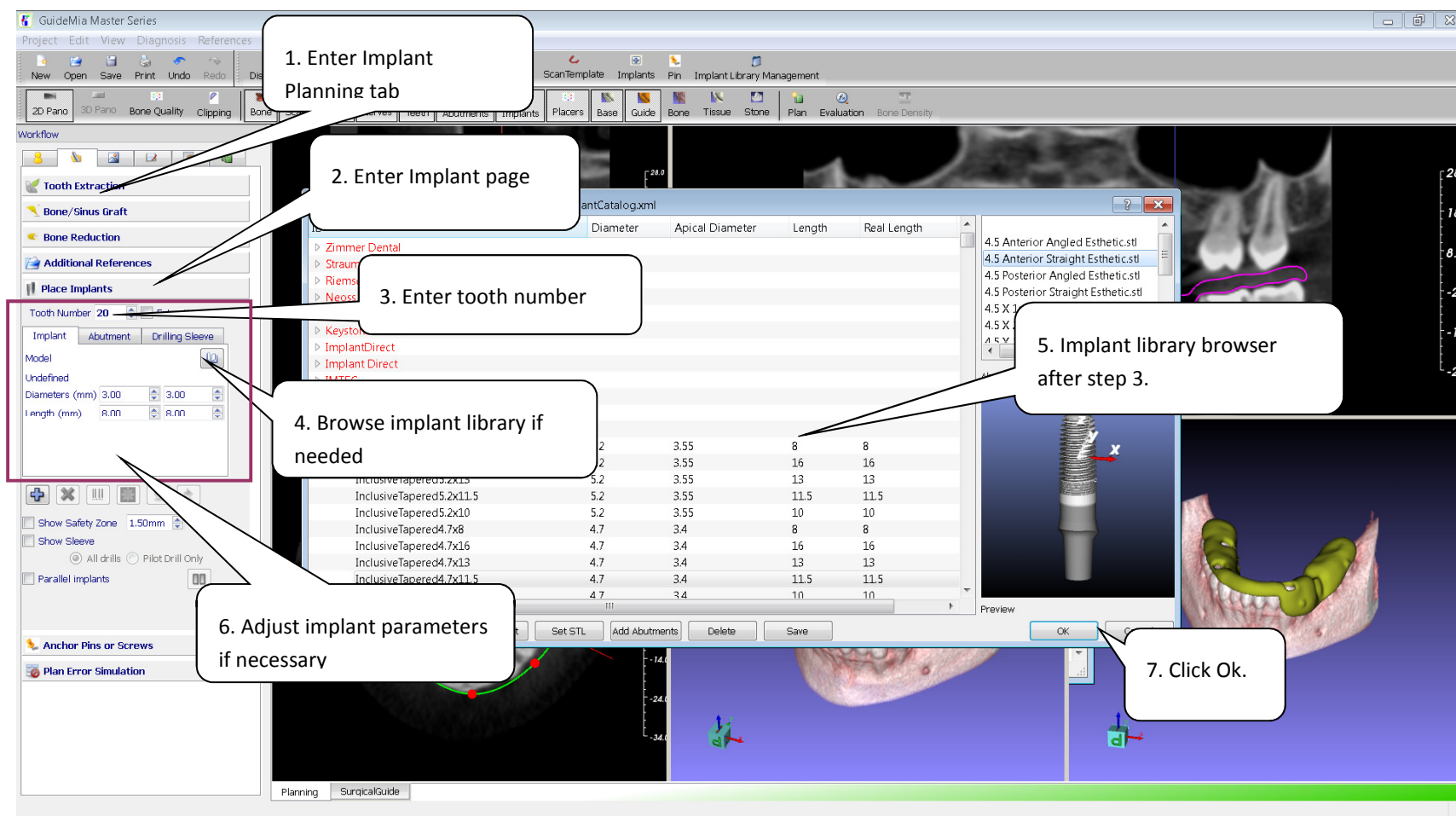
Step 3. Load scan of radiographic guide, or, scan template. The DICOM files must be in a different folder than the patient scan.



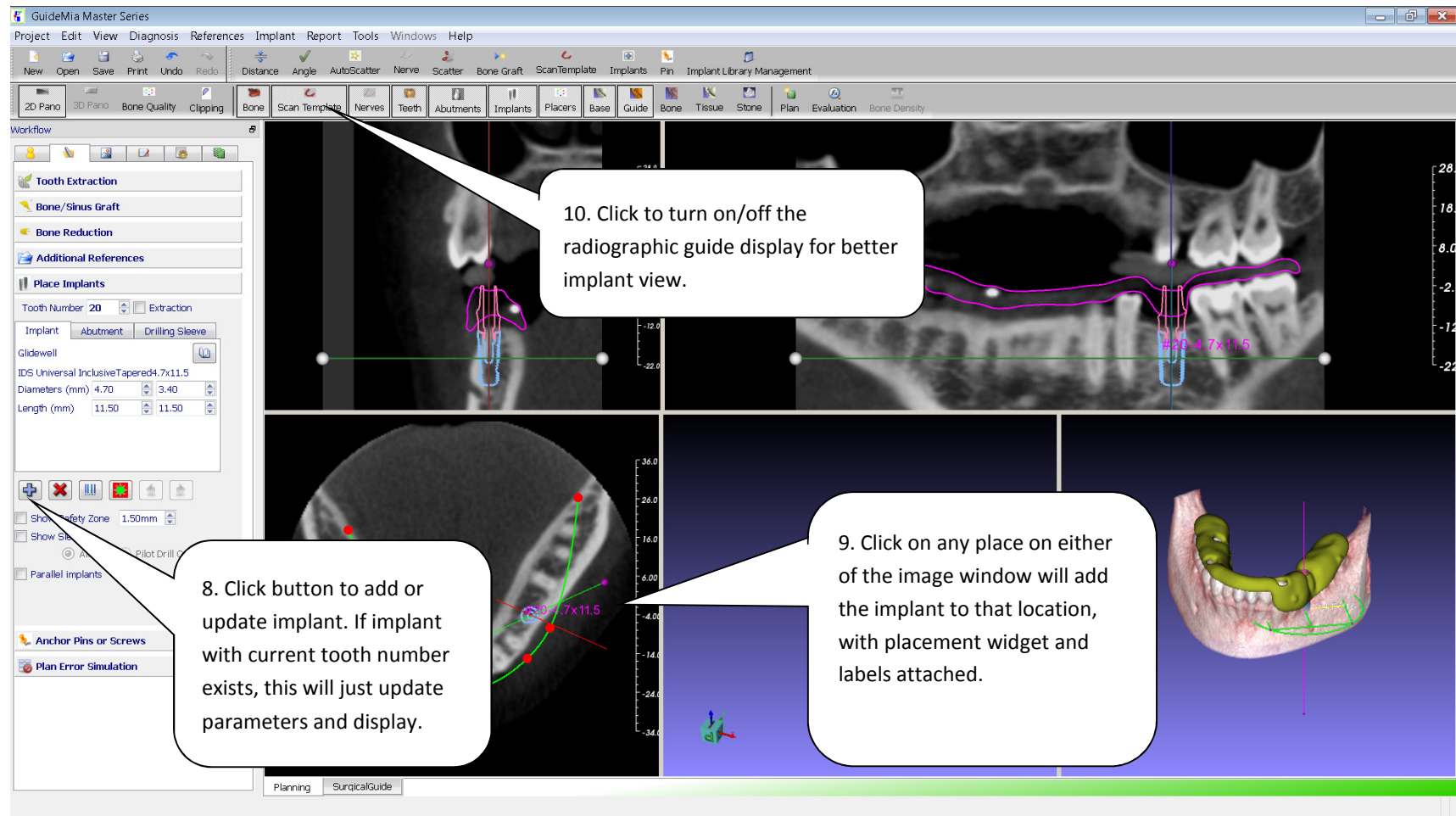
Step 4. After loading radiographic guide, or scan template, registration of the guide and the patient scans are automatically performed.



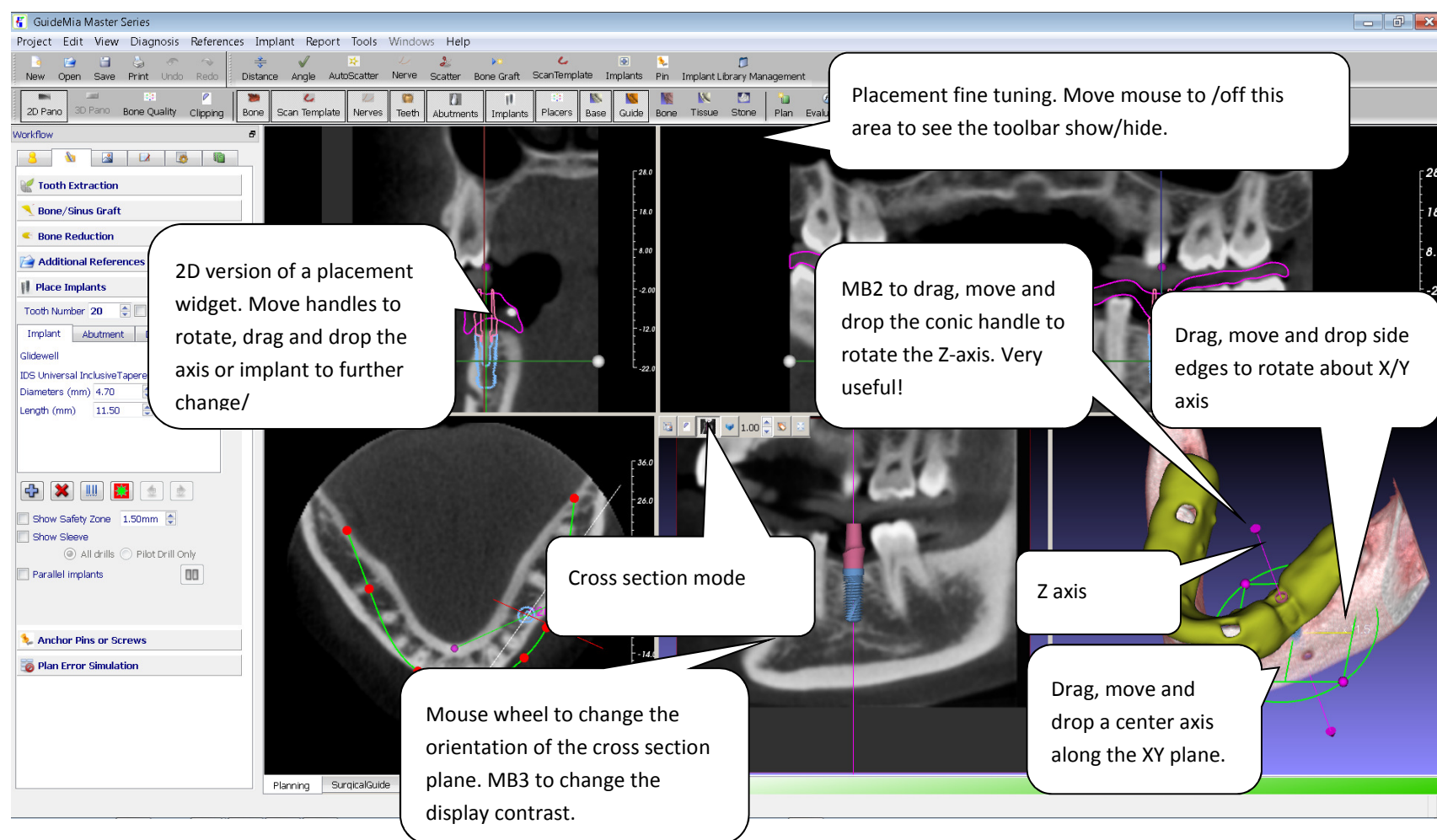
Step 5. Segmentation of bone structure and radiographic guide.

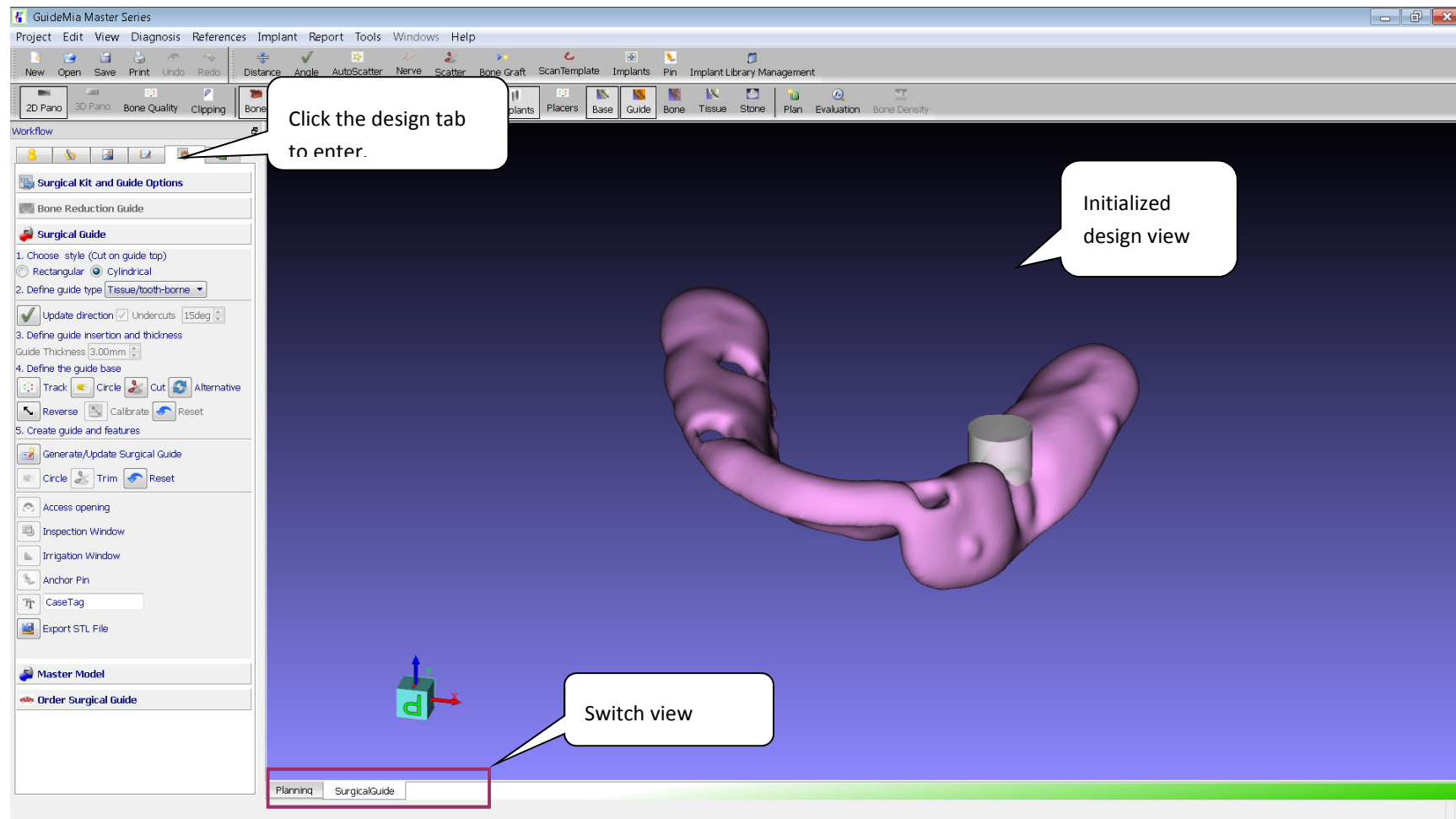


Step 6: implant placement - select implant

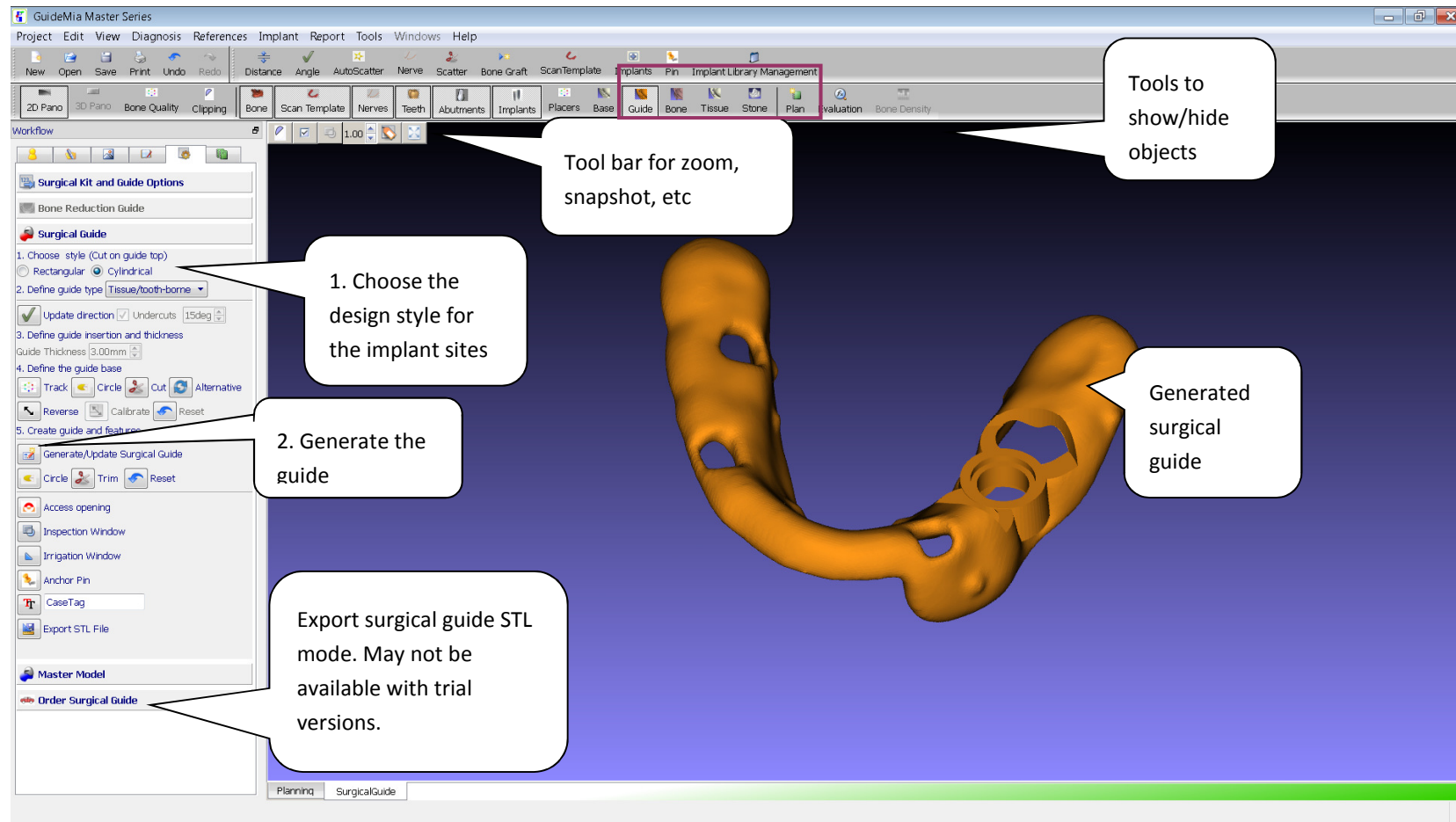


Step 6: implant placement - place implant

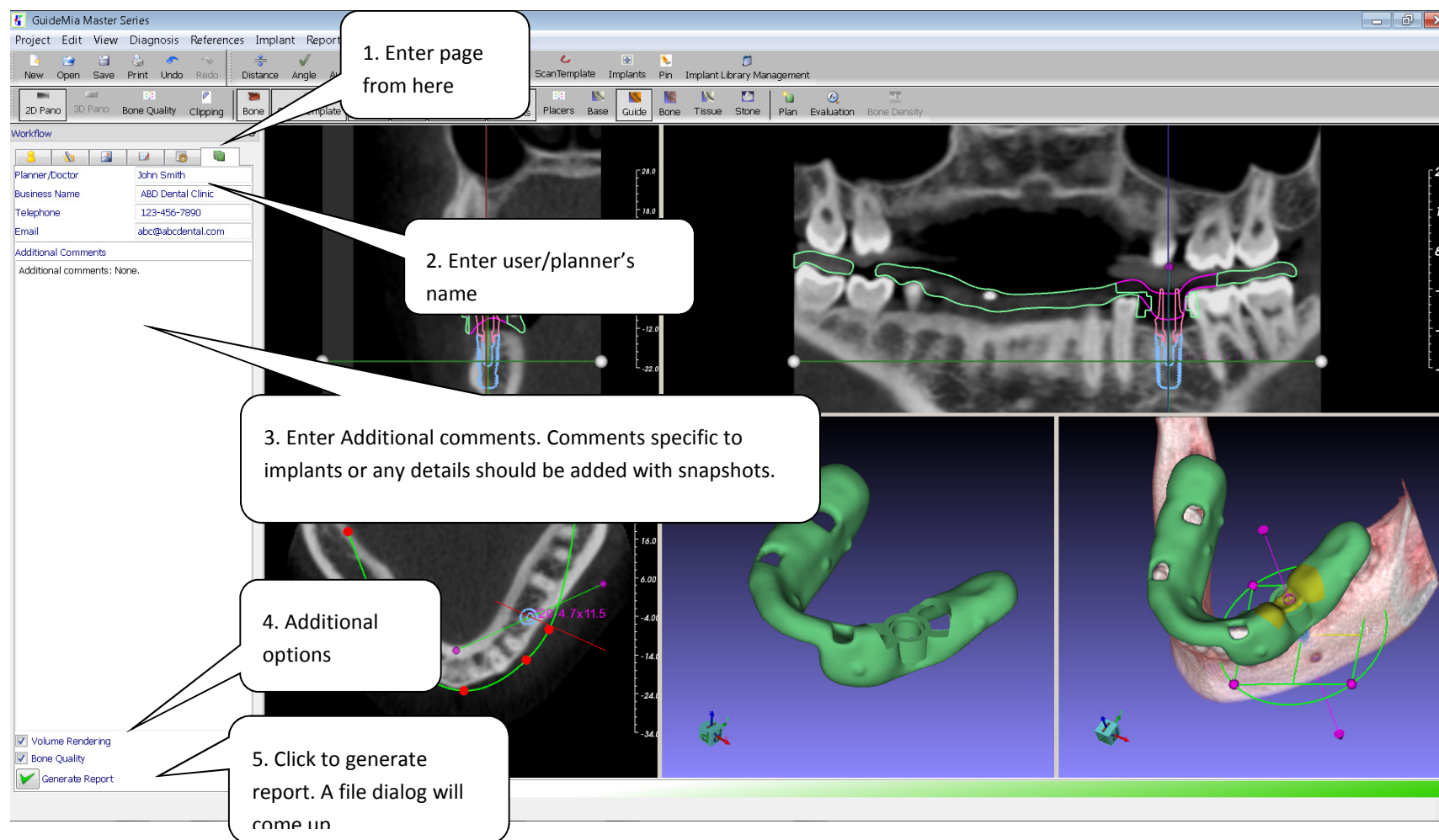
**Step 7. Adjust Implants.**



Step 8. Surgical guide design. There can be a warning or error message when entering this step. Just accept it, and proceed.



Surgical guide designed.



Step 9. Generate report.



First page of the report

GUIDEMIA© IMPLANT TREATMENT PLAN

John Smith
ABD Dental Clinic
Tel: 123-456-7890
email: abc@abcdental.com

Patient Name	Del Crognale Carley
Sex	
DOB	08/01/1988
Case Number	Undefined
Planning Date	Sun May 26 2013

Visit www.guidemia.com
for a complete sample of a
treatment plan report.

Plan Overview

Implant List

ToothNumber	Implant Diameter	Apic Diameter	Implant Length	Implant Make	Implant Part#
20	4.7	3.4	11.5	Glidewell	InclusiveTapered4.7x11.5

Sample report.

4 . GUIDEMIA SCANNING PROTOCOLS

4.1 SCANNING PROTOCOLS OVERVIEW

The following is an overview of the supported scanning protocols. The items listed next to each of the protocols specify what kind of clinical cases the scanning protocols can be used, and what the basic requirements are. Except radiographic guides or dentures, GuideMia does not require or endorse scanning appliances or trays or help bodies of any kind. Please contact us to make sure your specially made appliances can be supported.

CT scan and intra-oral scan

- Tooth/gum level surgical guide
- Patient does NOT have crowns, implants and other metal or ceramic artifacts close to implant sites, or, at least has two or more complete tooth surfaces that will not interact with X-ray scatters.
- Partially edentulous cases only, good tooth support needed

CT scan and optical scan of stone model

- Tooth/gum level surgical guide
- Patient does NOT have crowns, implants and other metal or ceramic artifacts close to implant sites, or at least has two or more complete tooth surfaces that will not interact with X-ray scatters.
- Partially edentulous cases only, good tooth support needed

Dual scan with radiographic guide or denture

- Tooth/tissue level surgical guide
- Patient may have crowns, implants and other metal or ceramic artifacts close to the implant sites
- Both fully or partially edentulous cases

Dual CT scan with stone model

- Tooth/gum level surgical guide
- Patient does NOT have crowns, implants and other metal or ceramic artifacts close to implant sites, or at least has two or more complete tooth surfaces that will not interact with X-ray scatters.
- Partially edentulous cases only, good tooth support needed

Single CT Scan

- Bone/tooth level surgical guide
- Patient does NOT have crowns, implants and other metal or ceramic artifacts close to implant sites.
- Both fully or partially edentulous cases. Partially edentulous cases must have good tooth support. Fully edentulous cases with very loose bones are not recommended.

4.2 CT SCAN AND INTRA-ORAL SCAN PROTOCOL

4.2.1 PATIENT PREPARATION

1. Patient must remove all metal prosthesis, as well as metal jewelry that might interfere with the region to be scanned.
2. Patient's bite should be secure with cotton pads or other highly radio-translucent material (such as polyethylene) . Avoid using any radio-opaque material that will prevent tooth surface from being segmented in CT data processing.
3. Upper and lower teeth should not touch each other during the scan.
4. Recommended space between two jaws is 5-10mm.
5. Patient should be in a static position, and must not move or swallow during the scan acquisition.

4.2.2 PATIENT SCANNING INSTRUCTIONS

The occlusal plane should be parallel to the plane of image slice generated, with no tilt.
The height must be set in order to center the occlusal plane in the field of view (FOV).
In case that both arches need to be treated, please provide a separate scan for each arch.



4.2.3 CT SCAN PARAMETERS AND RECONSTRUCTION

Recommended CT scan slice thickness: 0.2mm-0.5mm. Smaller thickness will require higher end hardware systems when using GuideMia Treatment Planning Software.

Please contact your CT scanner technical support for the scanning parameters and reconstruction settings.

4.2.4 CT SCAN DATA

DICOM files will be generated and made available for GuideMia.

4.2.5 INTRA-ORAL SCAN

1. Scan the patient's preparation area, preferably, full arch
2. Consult your scanner's manual for settings
3. The scanned area needs to have 3-5 mm margin beyond the tooth surfaces
4. For implant site tooth setup. In case there are multiple units, and the case justifies a virtual tooth setup, use scanner or CAD software to virtually place the teeth, and save the diagnostic model as a different STL file
5. For immediate tooth extraction cases, if possible, it is recommended to use scanner or CAD software to remove the tooth (not including the root area) that will be extracted, and save as a different STL file
6. Step 4 and 5 can be combined

7. The antagonist scan is recommended for both restoration and implant planning purposes

4.2.6 INTRA-ORAL SCAN DATA

1. It is recommended, if possible, to have your scanner software trim the scan results along the edges, but the trimmed model will need to maintain the said margin
2. Diagnostic models can be designed with CAD software and made available for GuideMia
3. STL file should be generated and made available for GuideMia
4. If possible, STL models can be inspected with third party software or GuideMia for overlapping, self intersections, holes, etc.
5. The STL model resolution depends on various factors and scanner settings. The STL file size between 5-20MB is normally acceptable.

4.3 CT SCAN AND OPTICAL SCAN OF STONE MODEL PROTOCOL

4.3.1 PATIENT PREPARATION

1. Patient must remove all metal prosthesis, as well as metal jewelry that might interfere with the region to be scanned.
2. Patient's bite should be secure with cotton pads or other highly radio-translucent material (such as polyethylene). Avoid using any radio-opaque material that will prevent tooth surface from being segmented in CT data processing
3. Upper and lower teeth should not touch each other during the scan.
4. Recommended space between two jaws is 5-8mm.
5. Patient should be in a static position, and must not move or swallow during the scan acquisition.

4.3.2 PATIENT SCANNING INSTRUCTIONS

The occlusal plane should be parallel to the plane of image slice generated, with no tilt.
The height must be set in order to center the occlusal plane in the field of view (FOV).
In case that both arches need to be treated, please provide a separate scan for each arch.



4.3.3 CT SCAN PARAMETERS AND RECONSTRUCTION

Recommended CT scan slice thickness: 0.2mm-0.5mm

Please contact your CT scanner technical support for the scanning parameters and reconstruction settings.

4.3.4 CT SCAN DATA

DICOM files will be generated and made available for GuideMia.

4.3.5 OPTICAL SCAN OF STONE MODEL

1. Scan the patient's preparation area, preferably, full arch.
2. Consult your scanner's manual for settings
3. The scanned area needs to have 3-5 mm margin beyond the tooth surfaces
4. Scan the stone model first
5. For implant site tooth setup. In case there are multiple units, and the case justifies a physical or virtual tooth setup, perform one of the following:
 - Add tooth on the physical model and scan it after step 4
 - Using scanner or CAD software to virtually place the teeth, and save as a different STL file
6. For immediate tooth extraction cases, it is recommended to perform either of the following
 - Remove the tooth area from stone model, and do an extra scan of the model
 - Using scanner or CAD software to remove the tooth that will be removed, and save as a different STL file
7. Step 5 and 6 can be combined
8. The antagonist scan is recommended for both restoration and implant planning purposes

4.3.6 INTRA-ORAL SCAN DATA

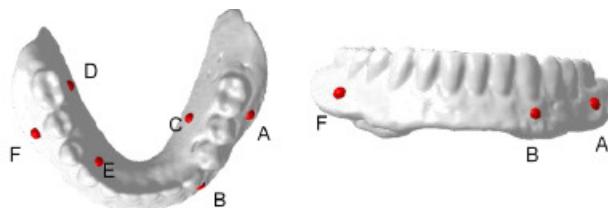
1. It is recommended to have you scanner software trim the scan results along the edges , but the trimmed model will need to maintain the said margin.
2. Diagnostic models can be designed with CAD software and made available for GuideMia
3. STL file should be generated and made available for GuideMia
4. If possible, STL models can be visually inspected with third party software or GuideMia for overlapping, self intersections, holes, etc.
5. The STL model resolution depends on various factors and scanner settings. The typical STL file sizes are 5-20MB.

4.4 DUAL SCAN WITH RADIOGRAPHIC GUIDE OR DENTURE

4.4.1 PREPARATION OF THE RADIOGRAPHIC GUIDE

A successful case begins with the creation of a properly and carefully designed Radiographic Guide.

The Radiographic Guide will communicate the desired restorative outcome to the entire treatment planning team before the surgery begins.



1. Design the radiographic guide with prototype of restorations. The following is a checklist
 - a. Teeth are properly chosen and placed
 - b. No metal or any other radio-opaque component or material
 - c. Thickness should be 2.5-4mm
 - d. Buccal flanges have enough extension for radiographic markers and anchor pins
 - e. Fit properly on patient's anatomy
2. Add radiographic markers. Gutta percha markers or radio-opaque glass beads or similar can be used.
 - a. 6-8 markers are recommended
 - b. 1.5-2.5mm size, spherical shape. Not cylindrical, no special designs with special geometries.
 - c. Place half on lingual side, half on buccal side
 - d. Do not evenly distribute the markers
3. Make a bite registration
 - a. Use radio-translucent material

4.4.2 PREPARATION OF THE RADIOGRAPHIC GUIDE FROM A DENTURE

1. Examine the denture of your patient to decide if you can use it as a radiographic guide.
2. The ideal denture should have:
 - a. Teeth of proper size, shape and length
 - b. Well established occlusion
 - c. Buccal flanges wide enough for gutta-percha markers and retentive pins positioning
 - d. Hard relines only
 - e. Secure and close fit to soft tissue and patient cast
 - f. No radio-opaque or metal materials
3. Adding radiographic markers to the denture is same as radiographic guide

4.4.3 SCANNING INSTRUCTION

1. The radiographic guide must be placed properly and firmly on patient mouth, and the patient needs to bite the registration properly.
2. Take a CT scan of the patient wearing the radiographic guide.
3. Take a CT scan of the radiographic guide only.

4.4.4 SCAN DATA

DICOM file sets for both scan should be made available to GuideMia

4.5 DUAL CT SCAN WITH STONE MODEL

4.5.1 PATIENT PREPARATION

See the same section of "CT Scan and Intro-oral Scan Protocol".

4.5.2 PATIENT SCANNING INSTRUCTIONS

See the same section of "CT Scan and Intro-oral Scan Protocol".

4.5.3 STONE MODEL SCANNING INSTRUCTION

The stone model should be scanned in a position similar to its position during the patient scan.

The stone model should be supported by a highly radio-translucent material.

No supporting material should be placed onto tooth surfaces.

Recommended CT scan slice thickness: 0.2mm-0.5mm

Please contact your CT scanner technical support for the scanning parameters and reconstruction settings.

4.5.4 SCAN DATA

DICOM file sets for both scan should be made available to GuideMia

4.6 SINGLE SCAN PROTOCOL

4.6.1 PATIENT PREPARATION

See the same section of “CT Scan and Intro-oral Scan Protocol”.

4.6.2 PATIENT SCANNING INSTRUCTIONS

See the same section of “CT Scan and Intro-oral Scan Protocol”.

5 . SYSTEM FUNCTIONS

This chapter gives all the details of the system window layout, and functional items. It serves as a general reference for system functions. Section 5.1 describes the overall windows layout of the application. Section 5.2 lists all the menu items. Almost all the menu items have their counterparts in the treatment planning workflow task panel, therefore just little details are given from the menu items. Section 4.3 listed the toolbars. Toolbar icons all correspond to system menu items. Each of the image windows has a toolbar, which is only displayed when the mouse moves into the window. 3D windows also have pop-up menus. They are introduced in section 4.4 and 4.5. Section 6 is the workflow task panel, which covers everything in a treatment planning.

5.1 WINDOWS LAYOUT

The following picture is a screenshot of the system. The image window has five split areas, i.e., axial view, sagittal view, coronal view, 3D assembly view, and 3D segment view (or, current object view). It has a status bar, menus and toolbars. Image views will have their own tool bars. This is the window layout for most of the time the system is running.

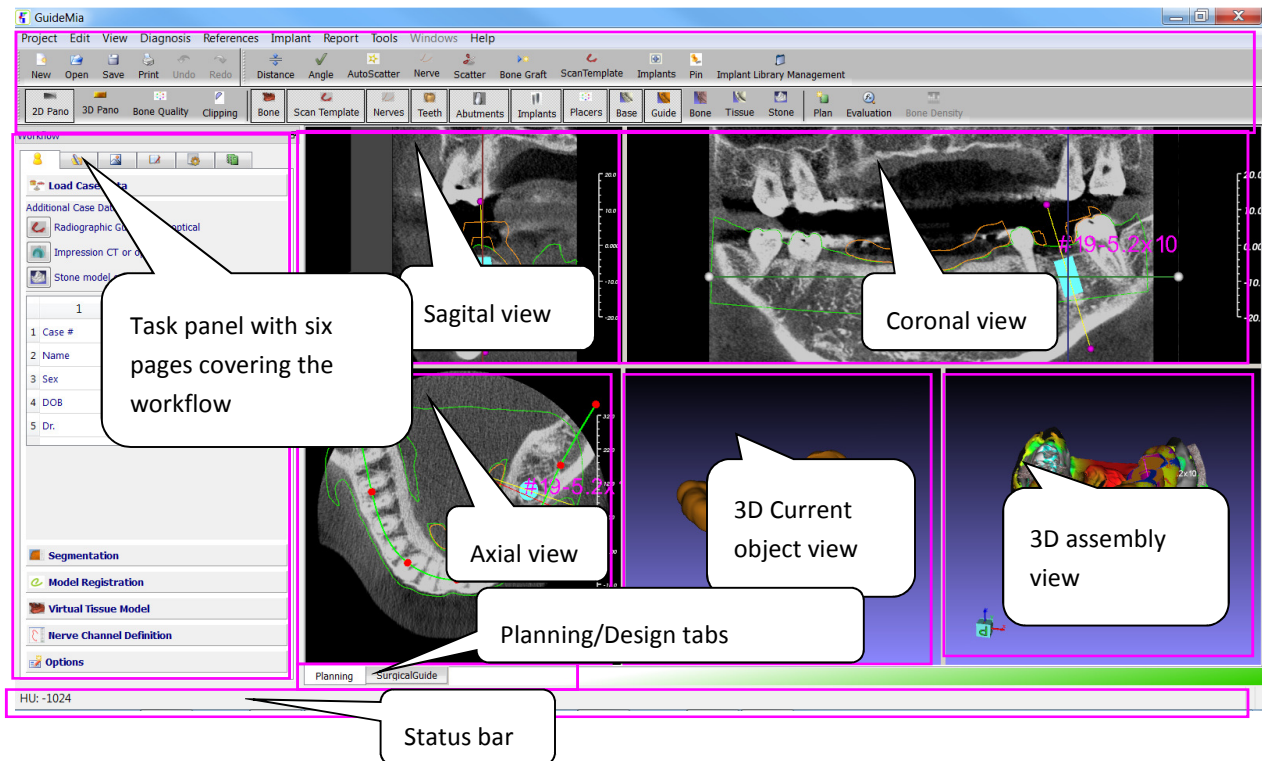


Figure 5.1. System UI layout - treatment planning mode

The following is the window layout for surgical guide design.

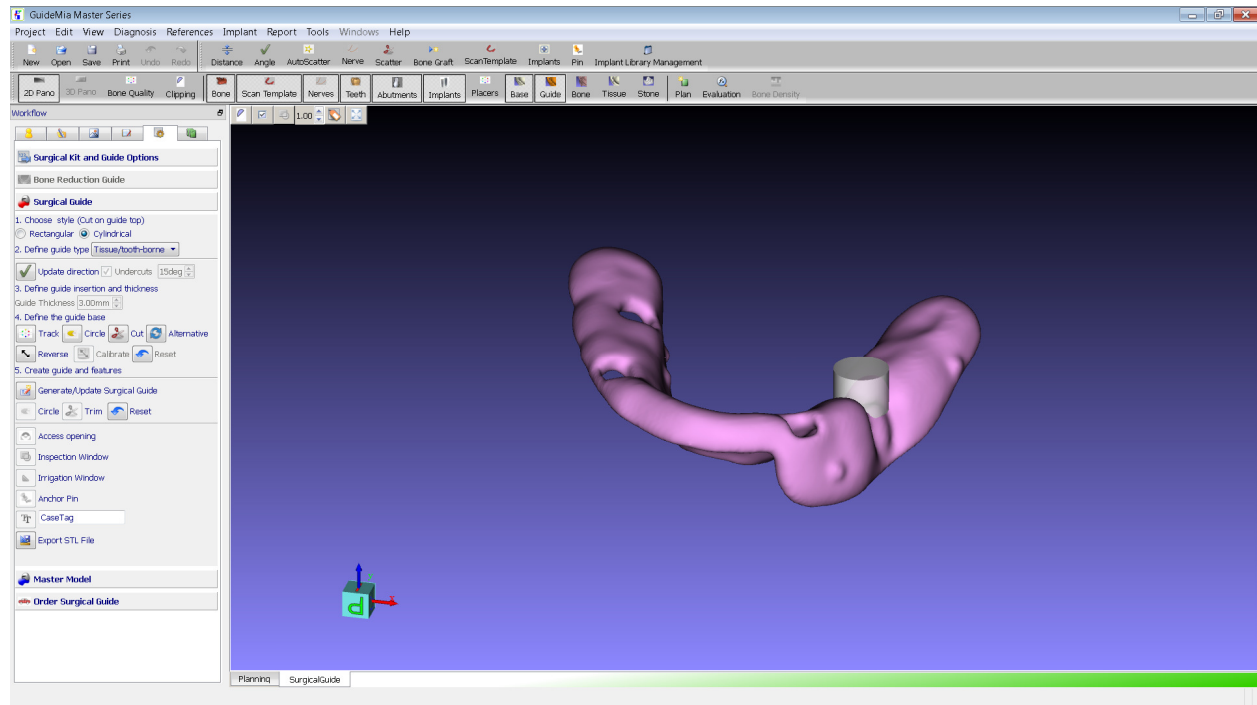


Figure 5.2. System UI layout - guide design mode

5.2 SYSTEM MENU

The system menu has the following sections: Project, Edit, View, Diagnosis, References, Implants, Report, Tools, Windows and Help. For functions specifically available in certain image views, we will have toolbars for them.

5.2.1 PROJECT MENU

The menu items are listed in the following table.

Menu	Description
	New. This will create a new case by DICOM files, and initialize the image views. A normal file selection dialog pops out. Users can browse and select any one of the DICOM files of a patient scan. The entire series will be loaded.
	Open. This will open an existing project and initialize the image views.
	Save. This will save the working project.
	Save as. This will save the working project as a .pie file with a file name dialog.

	Print. This will print the image views.
	Export. This menu has four items: 1) "Export DICOM series" will export working image data into DICOM series. 2) "Export STL file" will export working object as STL file. 3) "DICOM to IMG file" will export DICOM series as a single proprietary .img file, which encapsulates DICOM header information and all slice data. 4) "Scan template, Implants and sleeves". This function exports a combination of the named components into one single STL file, which is for third party surgical guide design purpose.
	Close. This will close the working project.
	Exit. This will close project and exit GuideMia.

The following are a couple of screenshots showing you the user interface when a project is initialized from a DICOM set, or an existing project is loaded.

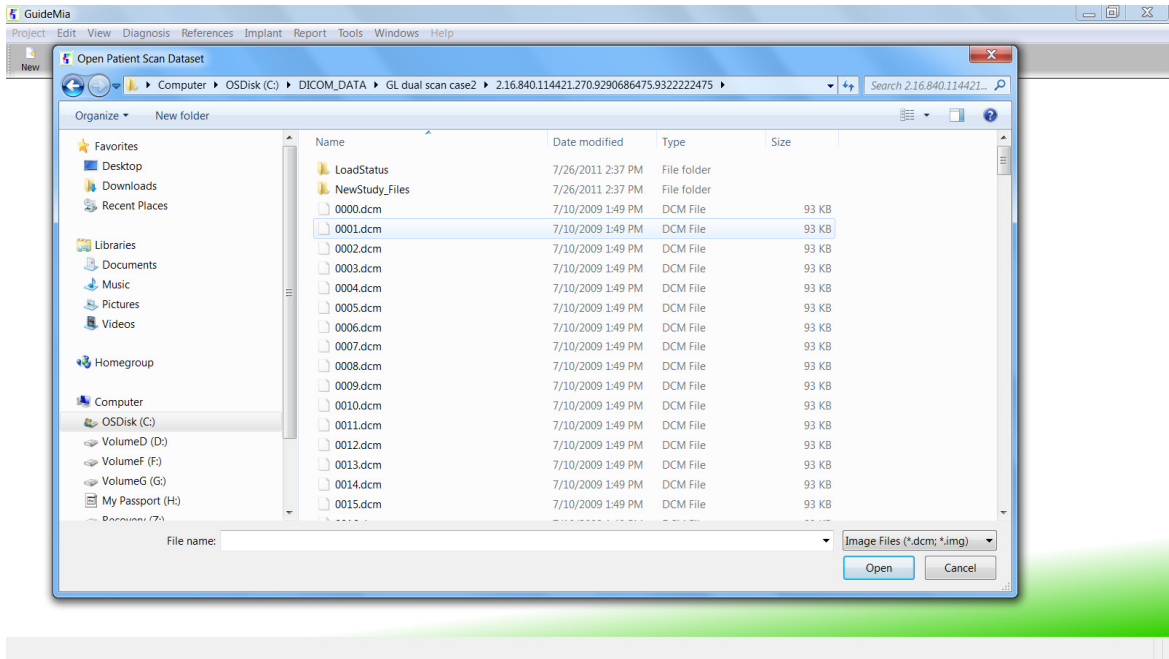


Figure 5.3. File open dialog for Project/New

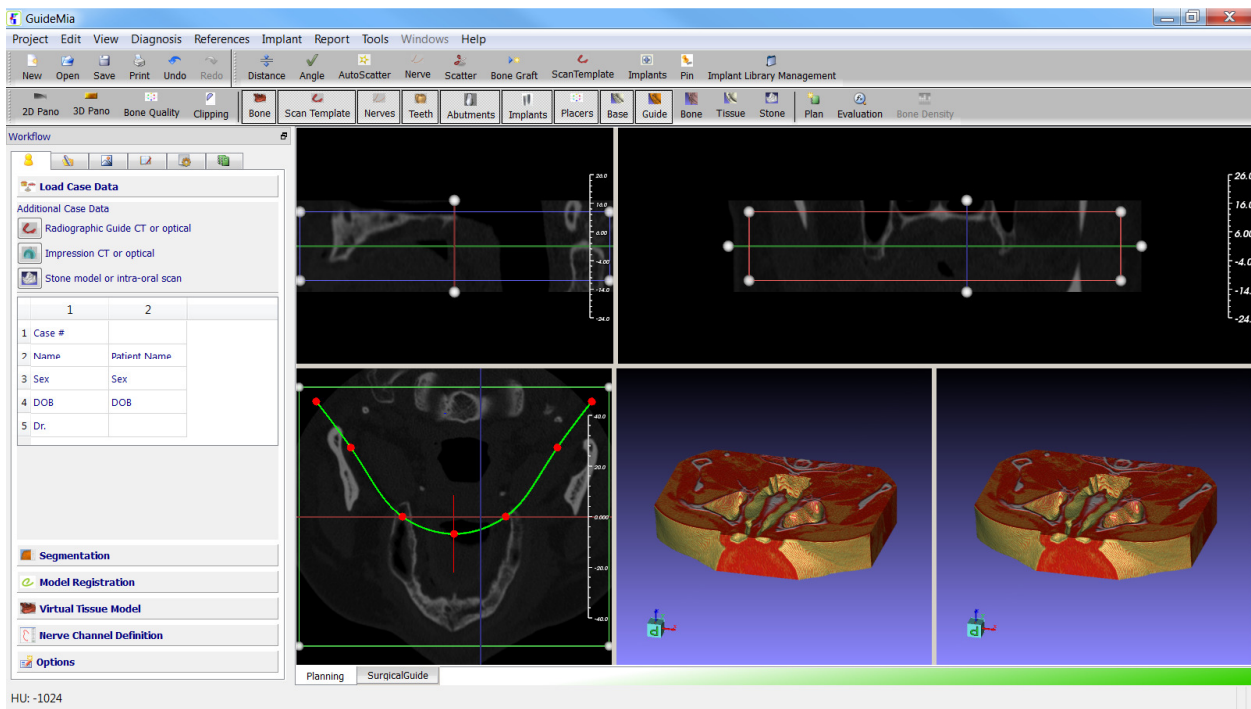


Figure 5.4. User interface upon project initialization.

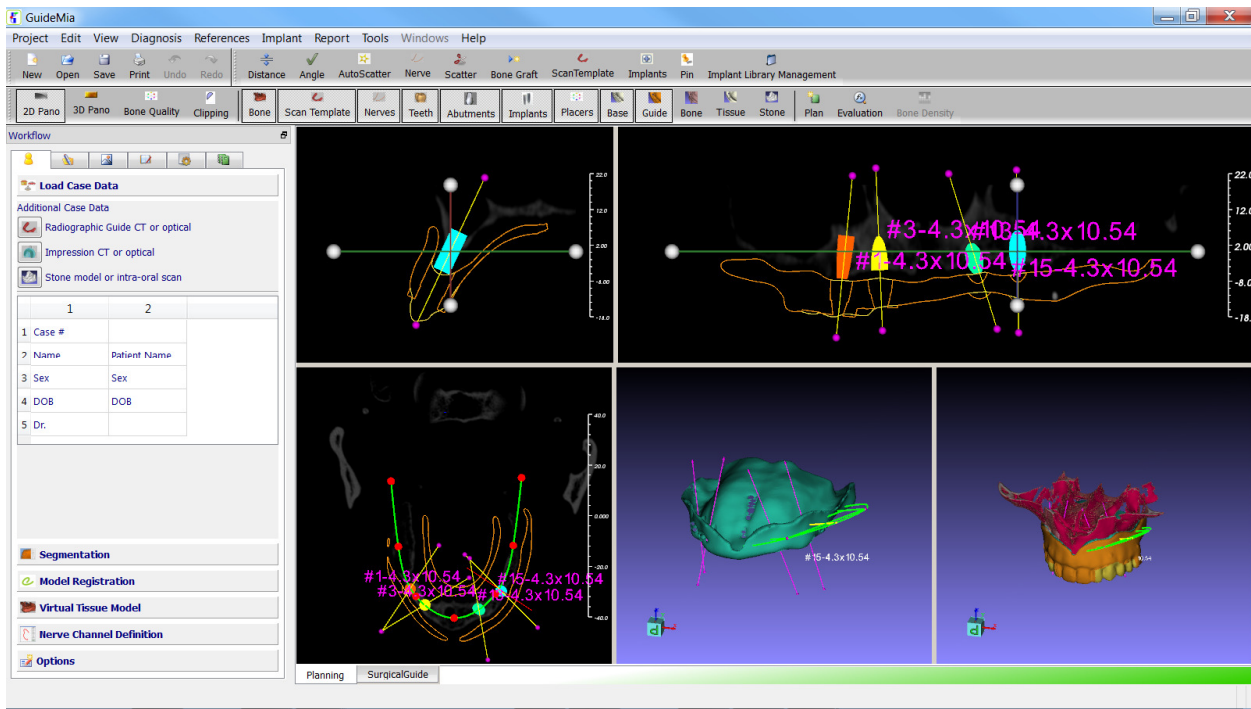
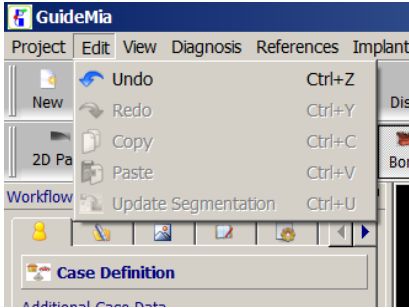
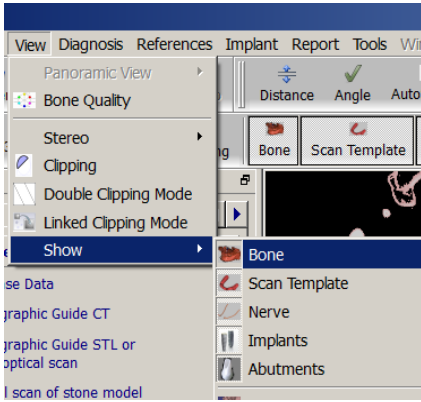


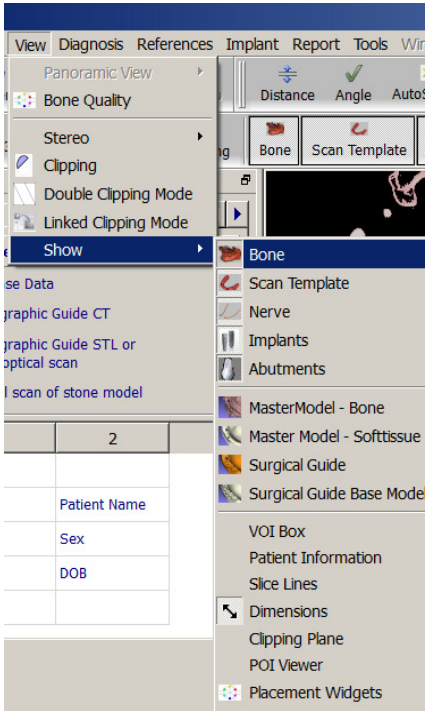
Figure 5.5. Upon project open.

5.2.2 EDIT

Menu	Description
	Undo. This will undo the last operation.
	Redo. This will redo the last operation.
	Copy. Not implemented at this time.
	Paste. Not implemented at this time.
	Update Segmentation. This will update current object by the threshold values in 2D views if the current object is segmented from CT image data, such as bone structure, tooth segmentation, etc.

5.2.3 VIEW

Menu	Description
	<p>Panoramic View. This will turn on/off panoramic mode of image views. It has two sub menu items:</p> <ol style="list-style-type: none"> 1) 2D. Show panoramic mode in sagittal and coronal views. 2) 3D. Not implemented at this time.
	Bone quality. This will turn on/off the display mode of “Bone quality” in both 2D and 3D views.
	Stereo. This will turn on the stereo display mode. The actual effect depends on hardware configurations. Among the supported modes, red/blue mode is the basic one.
	Clipping. This will turn on/off one or two clipping planes and clip 3D views. Only one clipping plane is supported now.
	Double clipping mode. This will enable two clipping planes.
	Linked clipping model. Not implemented at this time.
	Show. This is a submenu for operations to hide/show specific objects. It has the following items.



- Bone.
- Scan template, or, radiographic guide
- Nerves
- Implants
- Abutments
- Master Model - Bone
- Master Model – Soft tissue
- Surgical guide
- Surgical guide base model
- VOI box
- Patient information
- Slice lines
- Dimensions (incl. distances and angles)
- Clipping Plane
- POI viewer
- Placement widget

The following are some screenshots that can help understand some basic behavior of the system.

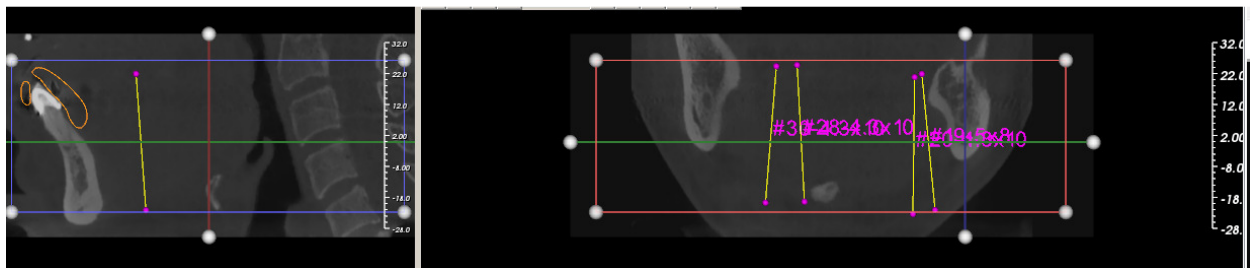


Figure 5.6. Normal 2D views

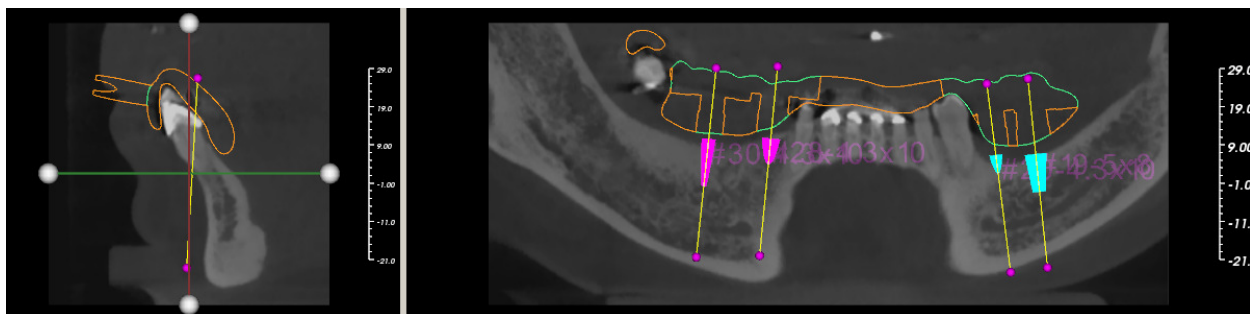


Figure 5.7. Panoramic 2D views

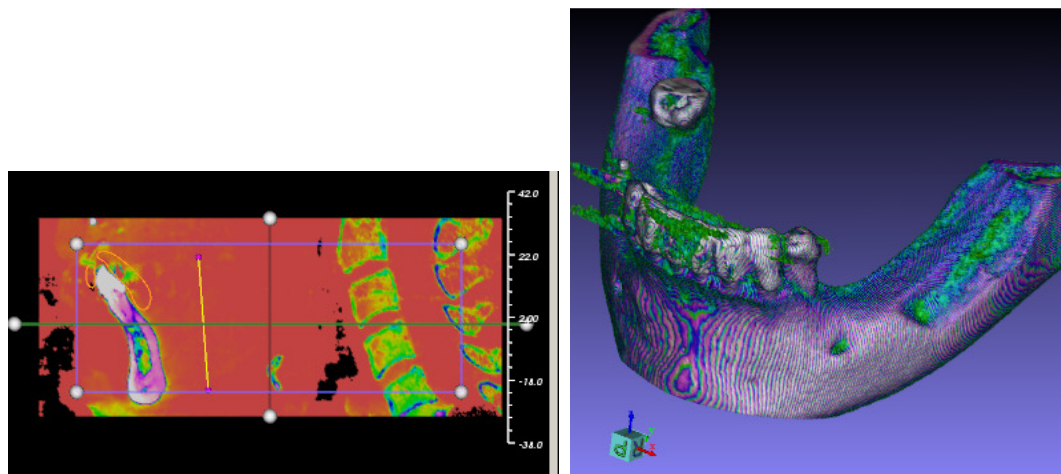


Figure 5.8. Bone quality views - 2D and 3D



Figure 5.9. Stereo mode in 3D window - Red blue mode

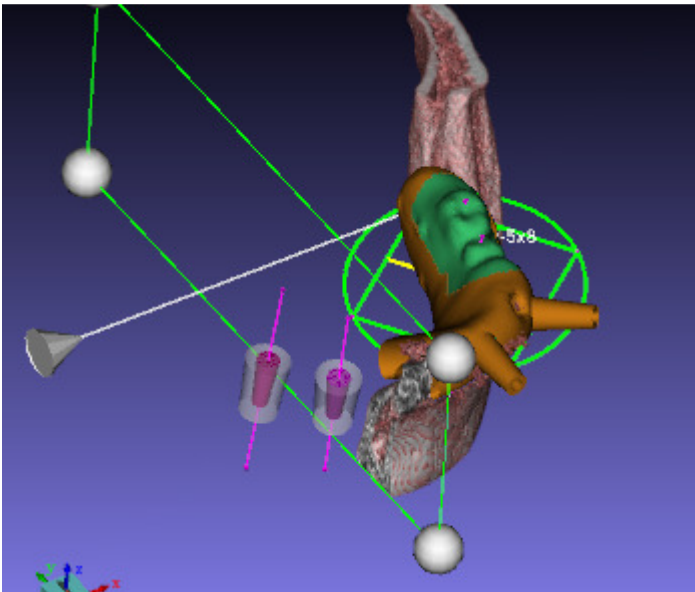


Figure 5.10. Assembly view clipping mode

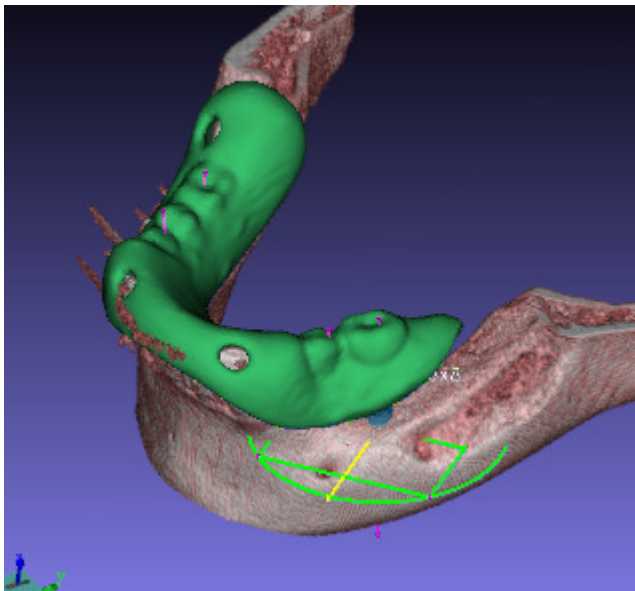
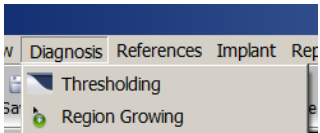


Figure 5.11. Bone model and Radiographic Guide

5.2.4 DIAGNOSIS

Menu	Description
	Thresholding. Filter CT image and create an object from the result, such as bone structure, teeth, etc. This is a generic tool other than the segmentation tools found in the task panels.

	Region growing. Not implemented at this time. This is a generic tool other than the segmentation tools found in the task panels.
	Distance in all 2D and 3D views. See Figure 4.13-4.14.
	Angle in all 2D and 3D views. See Figure 4.13-4.14.
	Neighborhood viewer. See Figure 4.15

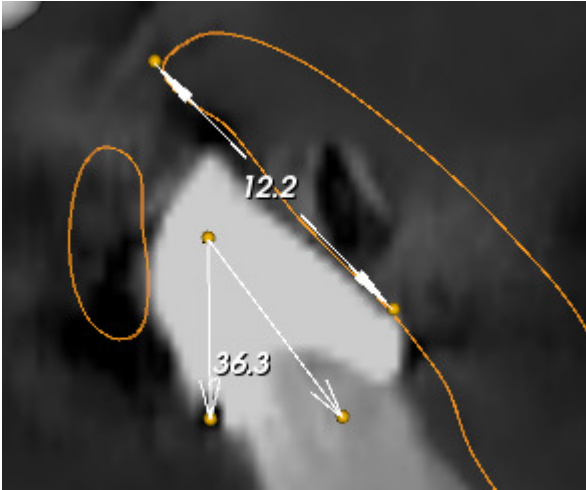


Figure 5.12. Distance and Angle in 2D

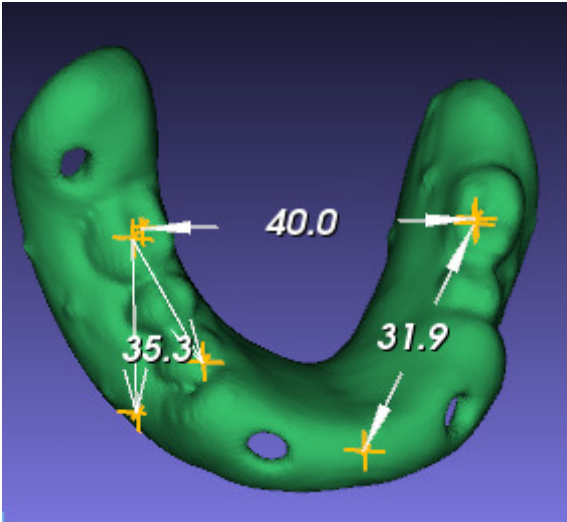


Figure 5.13. Distance and Angle in 3D

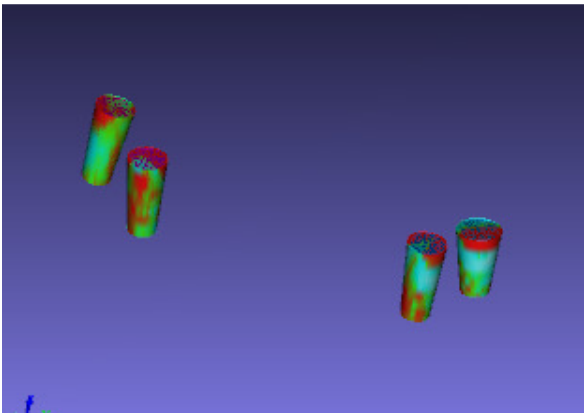
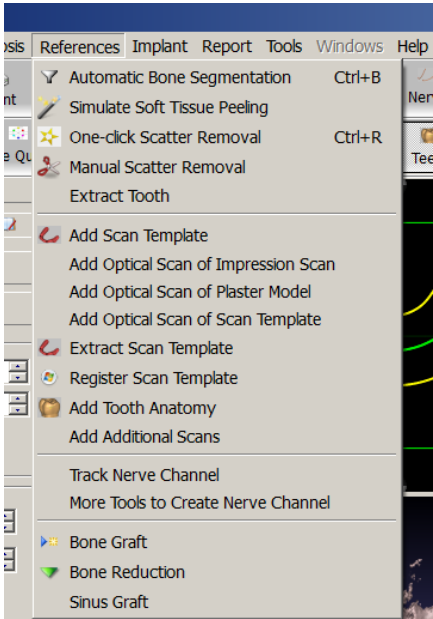


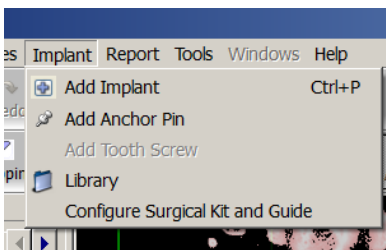
Figure 5.14. Neighborhood viewing. Implant adjacent areas are shown in color map indicating bone quality. This window dynamically changes to show the areas with different offset to the original implant tool body.

5.2.5 REFERENCES

Menu	Description
	Automatic Bone Segmentation. This is an advanced tool to automatically segment bone structure with threshold values automatically determined.
	Simulate Soft Tissue Peeling. See corresponding tool in task panel.
	One-click Scatter Removal. See corresponding tool in task panel.
	Manual Scatter Removal. See corresponding tool in task panel.
	Extract Tooth. See corresponding tool in task panel.
	Add Scan Template. See corresponding tool in task panel.
	Add Optical Scan of Impression. See corresponding tool in task panel.
	Add Optical Scan of Plaster Model. See corresponding tool in task panel.
	Add Optical Scan of Scan Template (radiographic guide). See corresponding tool in task panel.
	Extract Scan Template. See corresponding tool in task panel.

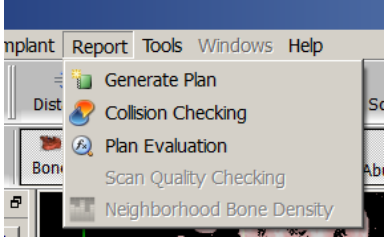
	Register Scan Template. This will bring up the tool box in task panel.
	Add Tooth Anatomy. See corresponding tool in task panel.
	Add Additional Scans. See corresponding tool in task panel.
	Track Nerve Channel. See corresponding tool in task panel.
	More tools to create Nerve Channel. See corresponding tool in task panel.
	Bone Graft. See corresponding tool in task panel.
	Bone Reduction. See corresponding tool in task panel.
	Sinus Graft. See corresponding tool in task panel.

5.2.6 IMPLANTS

Menu	Description
	Add Implant (Enter the task panel of adding implant, see section 6.5)
	Add Anchor Pin
	Add Tooth/Bone Screw
	Implant Library Management
	Configure Surgical Kit and Guide

5.2.7 REPORTS

Menu	Description
	Generate Plan

	Collision Checking
	Plan Evaluation
	Scan Quality Checking
	Neighborhood Bone Density Checking

The “Plan Evaluation” function will perform a plan checking, and warn the users of any potential problems in the treatment plan. The underlying function will be also invoked when the user enters into the surgical guide design step or generating treatment plan.

The following is a screen capture of the validation result. The items included in the report are listed here.

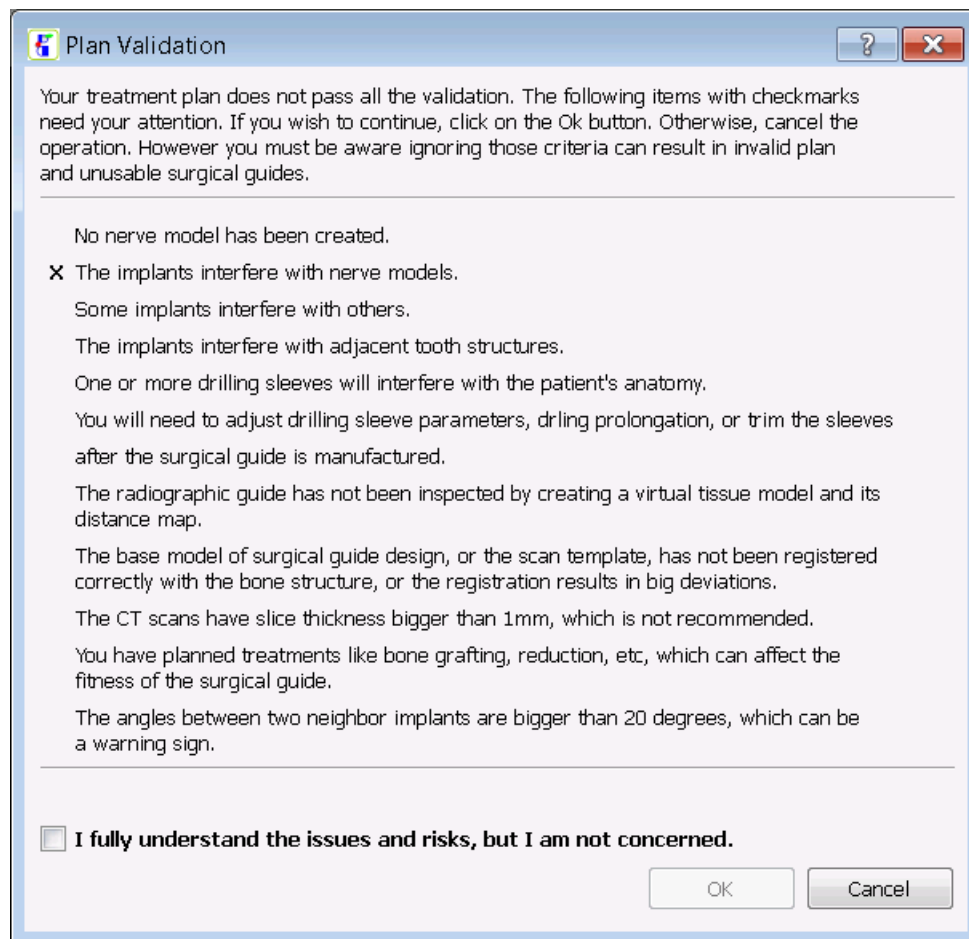


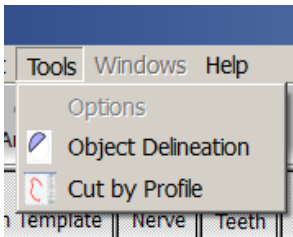
Figure 5.15 Plan validation report

- No nerve model has been created. This only applies to mandible cases. It needs some attention if the treatment plan does not include a nerve model.

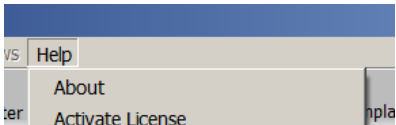
- The implants interfere with nerve models. When the nerve models are present, the system will perform a collision detection.
- Some implants interfere with others.
- The implants interfere with adjacent tooth structure.
- One or more drilling sleeves will interfere with the patient's anatomy. You will need to adjust drilling sleeve parameters, drilling prolongation, or trim the sleeves after the surgical guide is manufactured.
- The radiographic guide has not been inspected by creating virtual tissue model and its distance map. This means that the user may not have inspected whether the radiographic guide has been properly placed at the CT scanning time.
- The base model of surgical guide design, or the scan template, has not been registered correctly with the bone structure, or the registration results in big deviation.
- The CT scans have slice thickness bigger than 1mm, which is not recommended.
- You have planned treatments like bone grafting, reduction, etc, which can affect the fitness of the surgical guide.
- The angles between two neighbor implants are bigger than 20 degrees, which can be a warning sign.

In case any of these items are reported in the dialog, the surgical guide design or plan reporting cannot continue unless the user fully understand the issue and wish to proceed.

5.2.8 TOOLS

Menu	Description
	Options
	Object Delineation. Use mouse to track a profile and extract the image data within the profile. See the tooth extraction in section 6.6.2.
	Cut by Profile. Use mouse to track a profile and remove the image data within the profile.

5.2.9 HELP

Menu	Description
	About. This is the "About GuideMia" dialog.
	Activate License. This lets the user activate or update a license file.

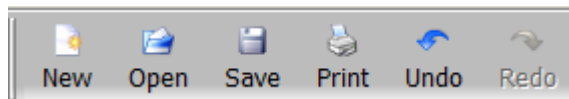
	Choose Language for Next Session.
--	-----------------------------------

5.3 TOOLBARS

There will be toolbars corresponding to system menu, and by default, they show the most commonly used menu items. Customization tool will be available too.

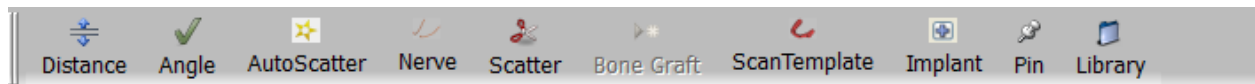
The following toolbars will be implemented:

Standard: common file and editing items



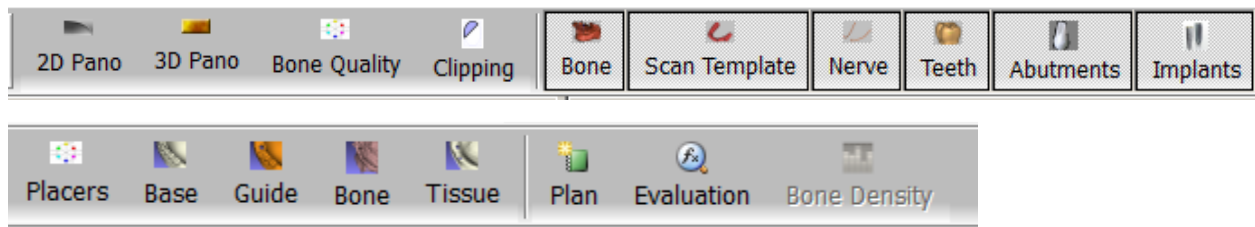
The items are corresponding to items with the same names in the system menu.

Tools: items from the tools menu






The items are corresponding to items with the same names in the system menu.





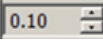

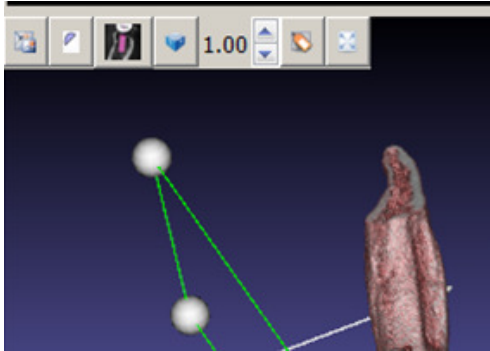







View: major items in the view menu



The items are corresponding to items with the same names in the system menu.

5.4 IMAGE WINDOW TOOLBARS

UI	Description
When there is no placement widget (no object's position is being adjusted)	 Maximize/Normalize 2D View
	 Update 3D views
	 Color Mode

 <p>When there is placement widget (one or more objects position is being adjusted)</p> 	 Create Snapshot  Fit View  Adjust the step length/angle for fine tuning placement widgets.  <p>Translate (four directions) and rotate (two rotation directions) the current placement widget and underlying object.</p>
	 Maximize/Normalize 3D View  Toggle Clipping Mode  Toggle Cross section mode  Toggle between Surface Rendering and volume rendering Mode  Change 3D window opacity  Create Snapshot  Fit View

The following figures illustrate the system behavior of these functions.

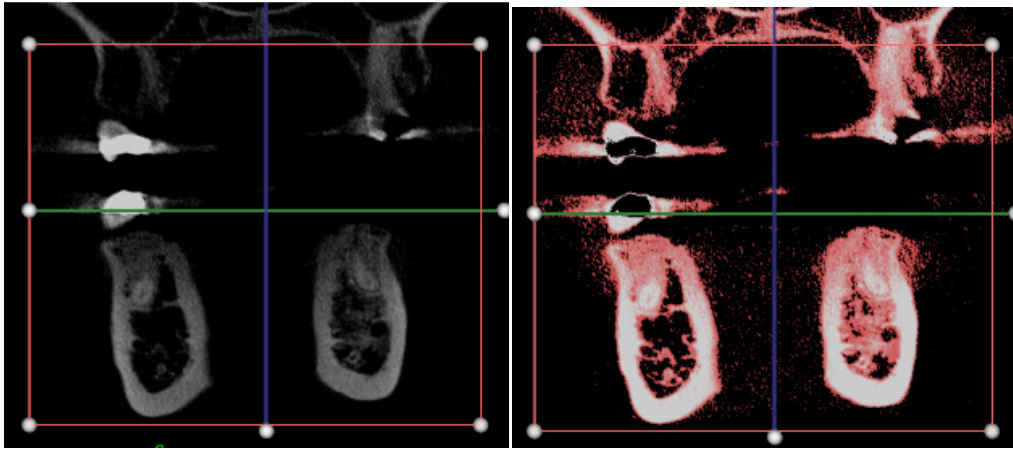


Figure 5.16. 2D color mode and black/white mode

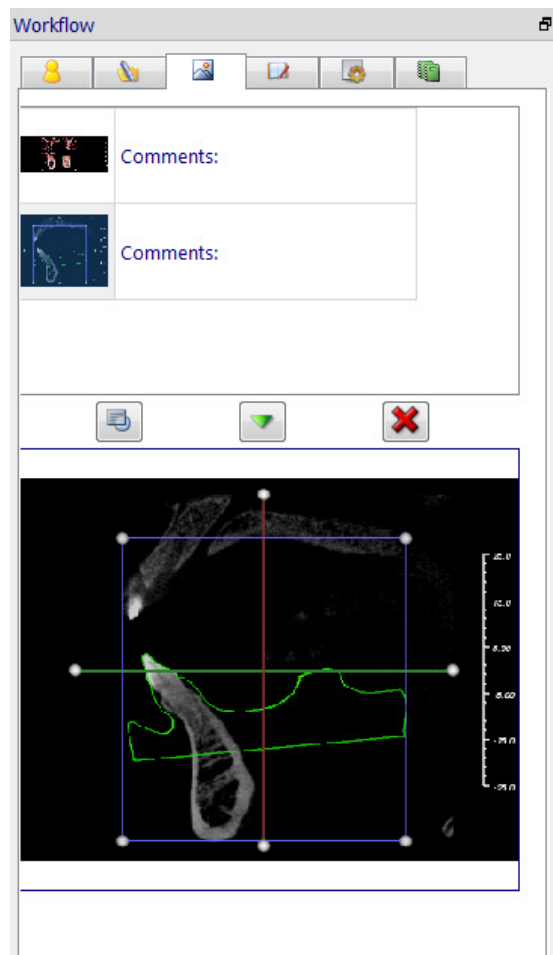


Figure 5.17. 2D snapshots in snapshot navigator

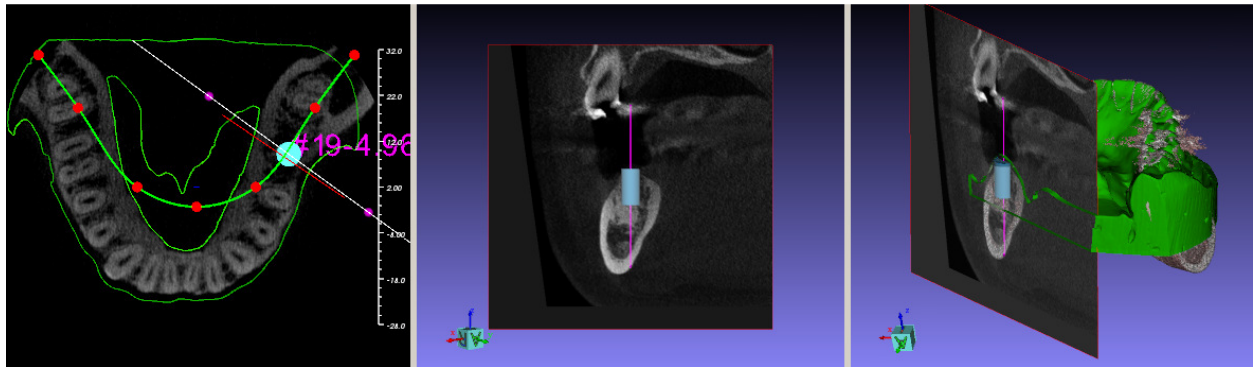


Figure 5.18. Cross section mode in 3D views. The axial view has a cross line corresponding to the image plane of the "working" 3D view

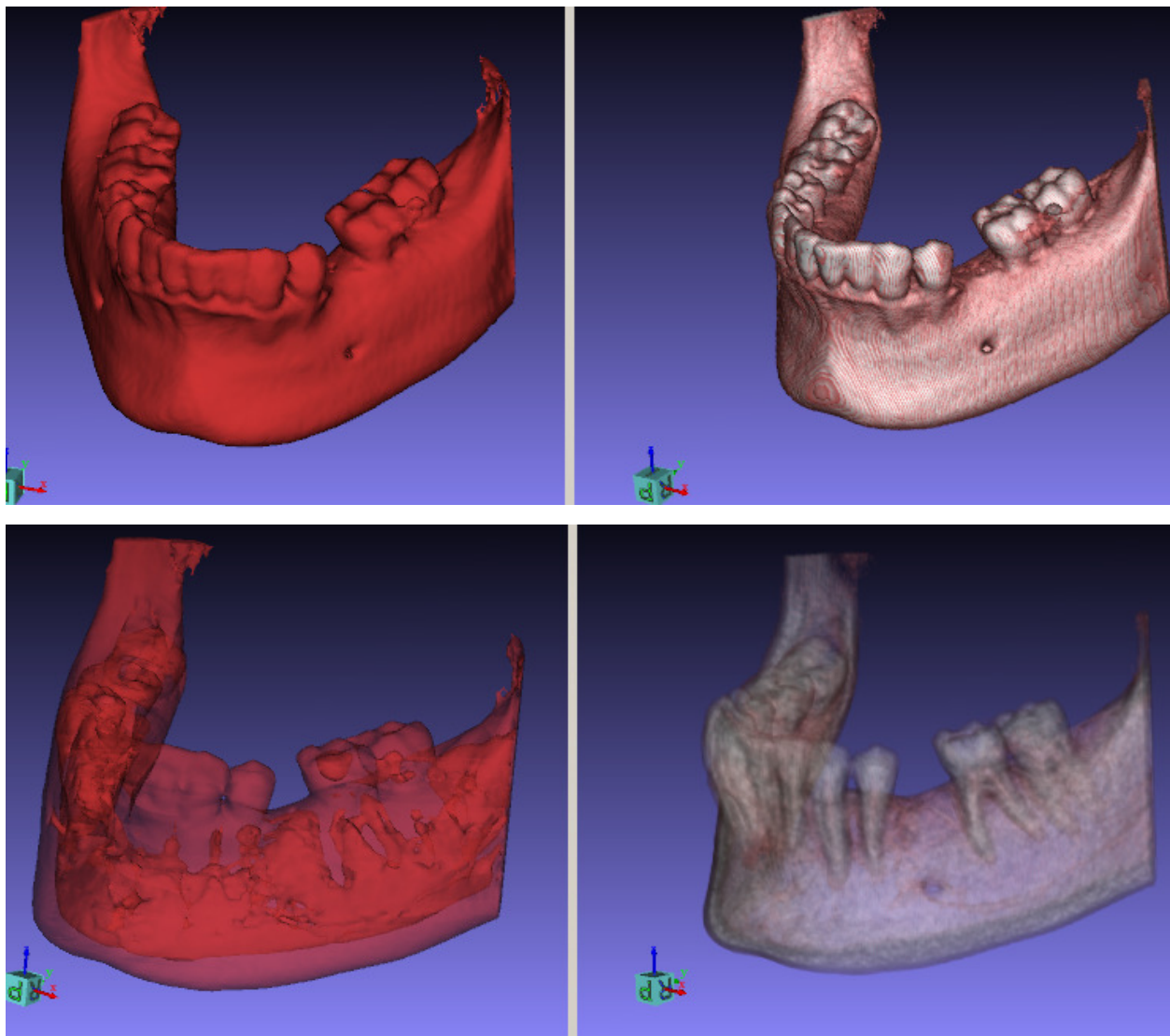
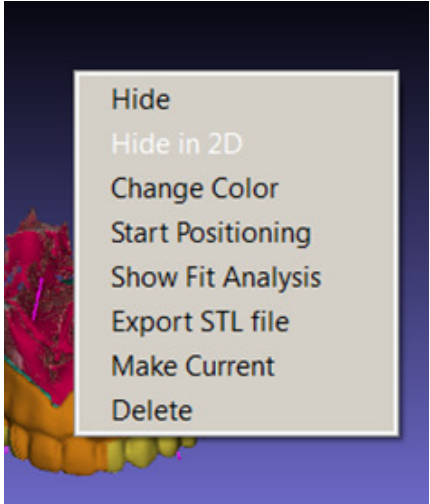


Figure 5.19. 3D Display mode with opacity less than 1.

5.5 OTHER IMAGE WINDOW INTERACTIONS

UI	Description
	Hide. Hide the object under the mouse cursor in current window.
	Hide (Show) in 2D. Hide or show the cross section of the underlying object in all 2D views. "Hide" or "Show" is displayed according to the actual status of the object.
	Change Color. Pop up the color selection window.
	Start Positioning (or Lock Positioning). This will show (or hide) the placement widget of the underlying object and start (or lock) the positioning.
	Show Fit Analysis. This only applies to surgical guide models. The function will show a surgical guide with a color map indicating the distance between the guide and patient anatomical structure.
	Export STL file. Write STL file for the underlying surface model. This is only available with Guide Design license is available.
	Make Current. Show the underlying object in the 3D "Object Window", and make it as current working object.
	Delete. Delete underlying object.

The following picture is the color selection dialog. It supplements the predefined color set. Figure 4.20 shows the implant placement, and Figure 4.21 shows a surgical guide with its fitting analysis.

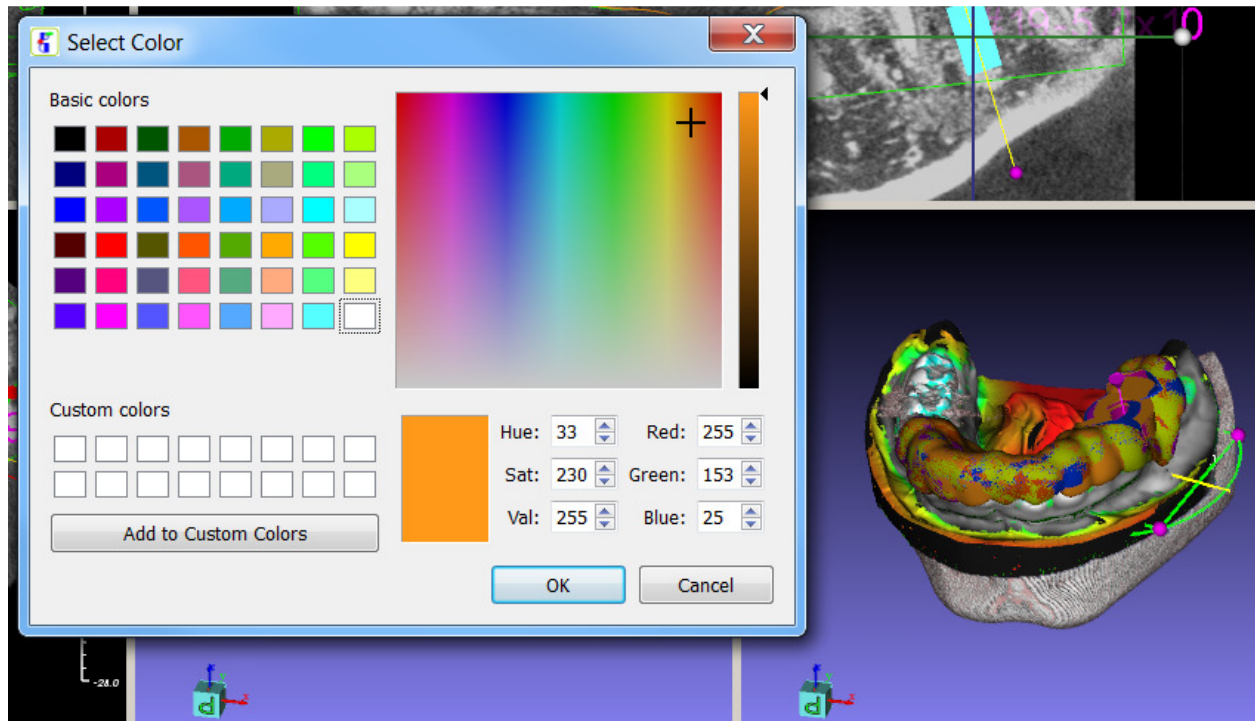
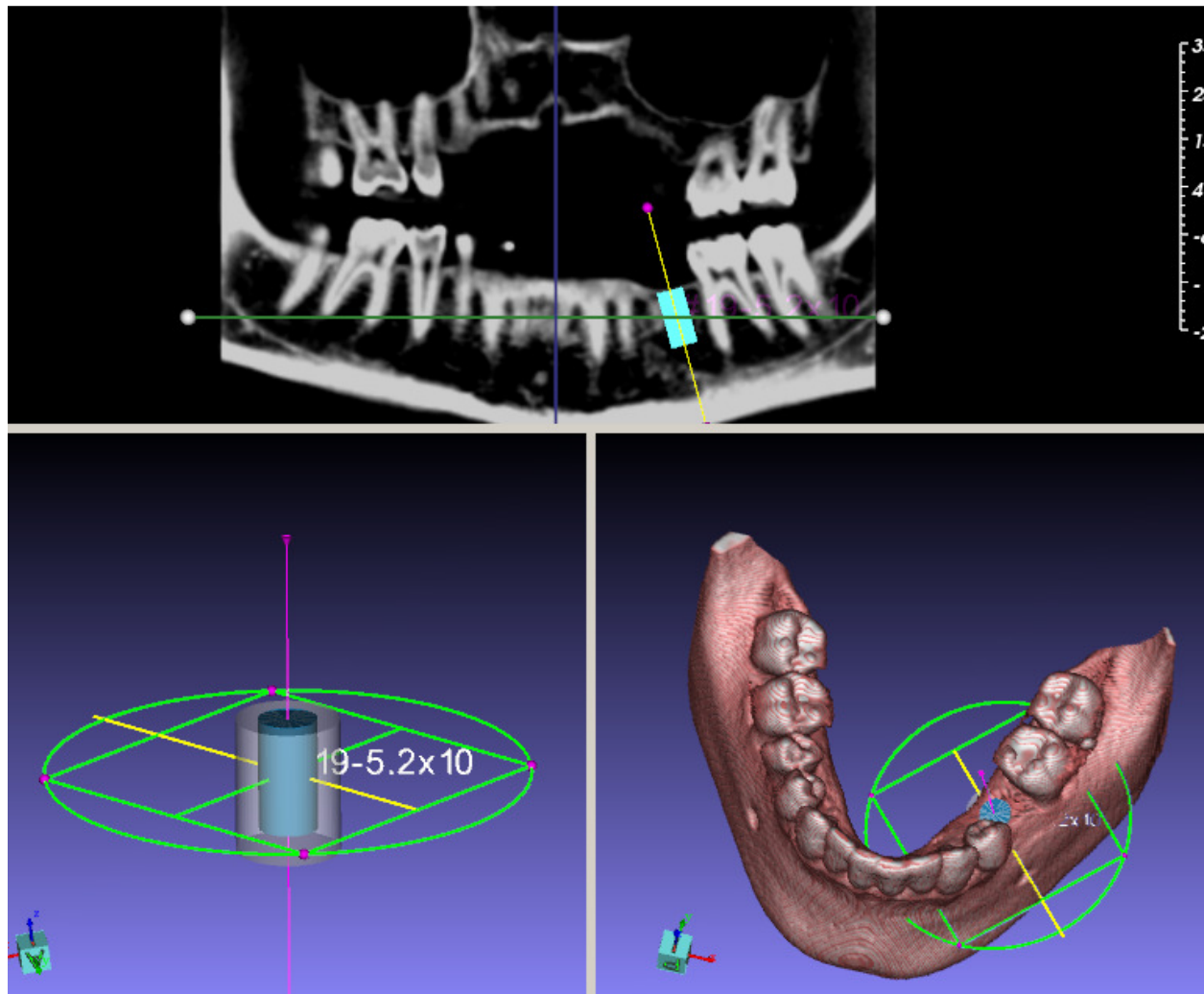
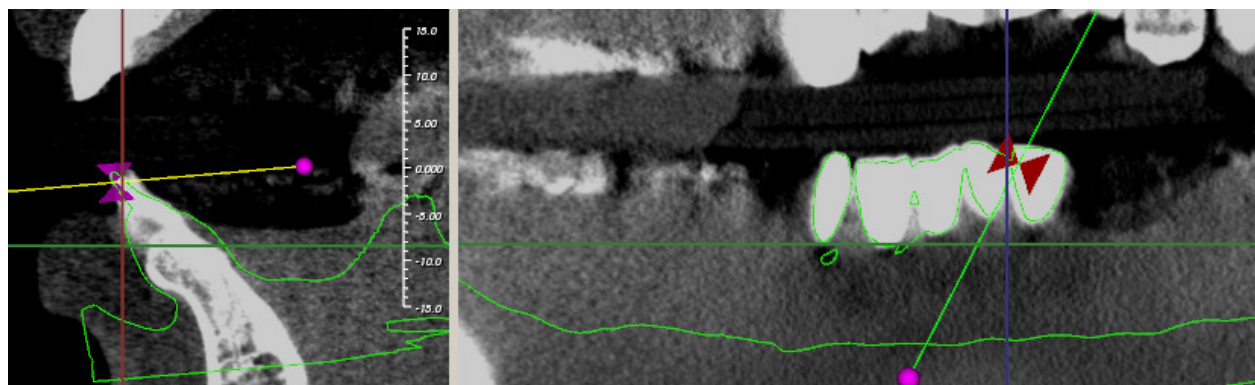


Figure 5.20. Color selection dialog.



(1) Implant. The placement widget can be shown and hidden



(2) Other surface model. The placement widget can be relocated by MB2 to move the two triangle handles.

Figure 5.21. Object and placement widgets

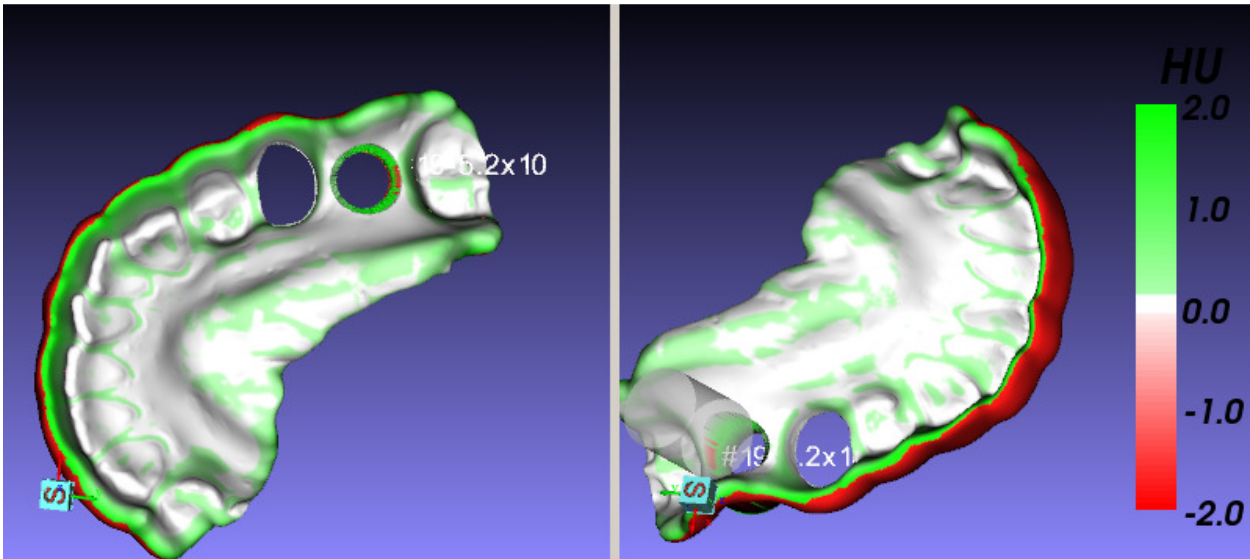





Figure 5.22. Surgical guide fit analysis.

The "Scalar bar" in the right side defines the how the "distance" is mapped to color. The "distance" is between a point on the surgical guide and the model that is used as the base for surgical guide design, such as a stone model for tissue-based guide or bone model for bone-level surgical guide.

5.6 WORKFLOW

Together with the image views is a system workflow panel, which can be resized and docked. The system functions listed in the above are organized in six panels, or six steps, of a treatment planning workflow. Some functions in this workflow panel are not found in the system main menus.

5.6.1 CASE DEFINITION

UI	Description
	 Radiographic Guide CT or optical F1.33.
	 Impression CT or optical
	 Stone model or intra-oral scan
	Show and display patient information, and define a case number.

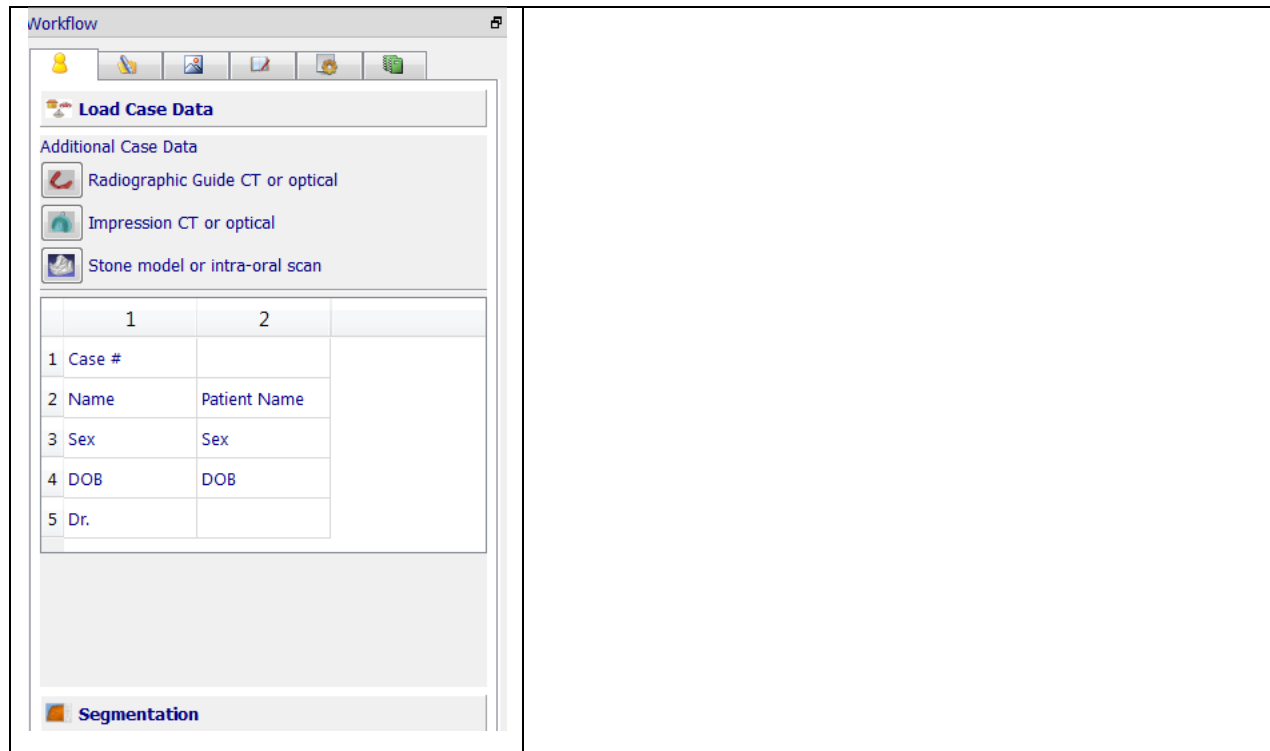
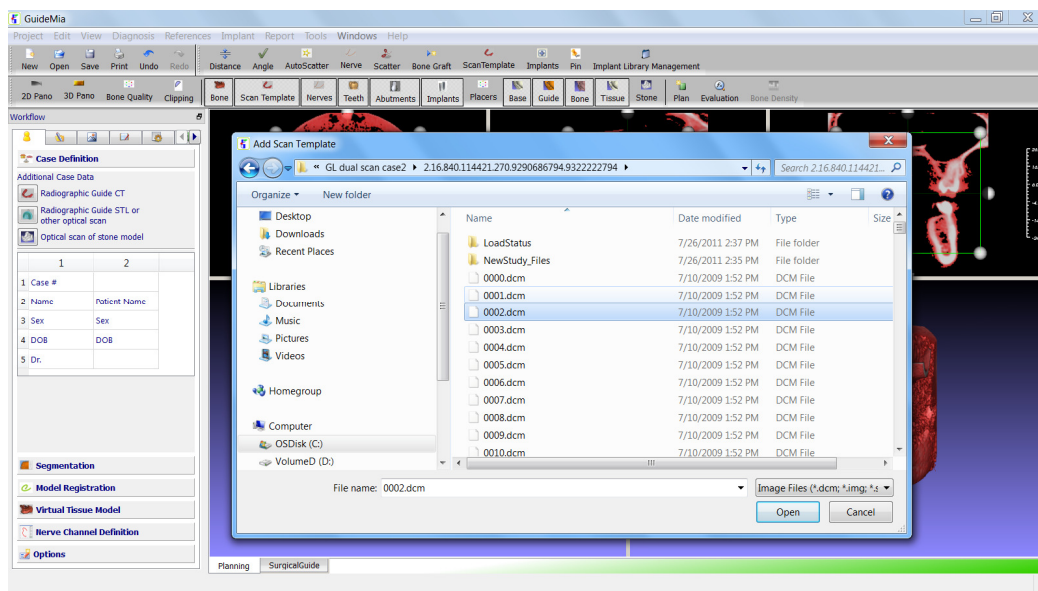
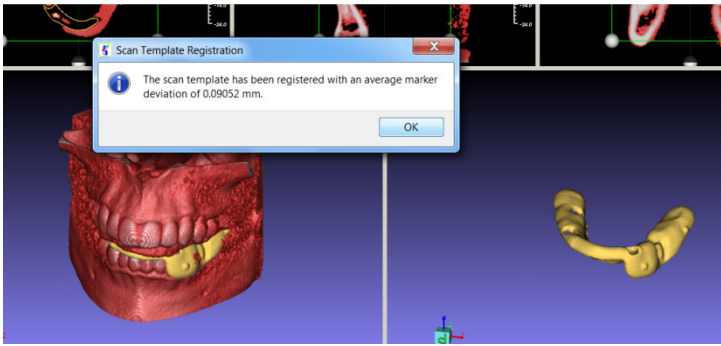


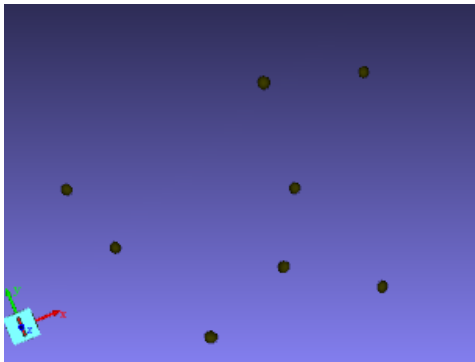
Figure 5.23, 5.24 are some screenshots for the registration functions.



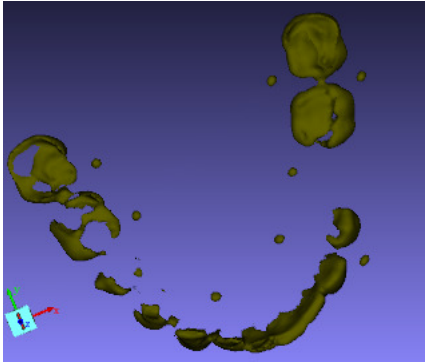
(1)



(2)



(3)



(4)

Figure 5.23. Add radiographic guide. (1) Add radiographic guide dialog. (2) Radiographic guide automatically registered with patient scan. (3) Extracted scan markers on scan template. (4) Markers and some other areas with high density from patient CT scan.

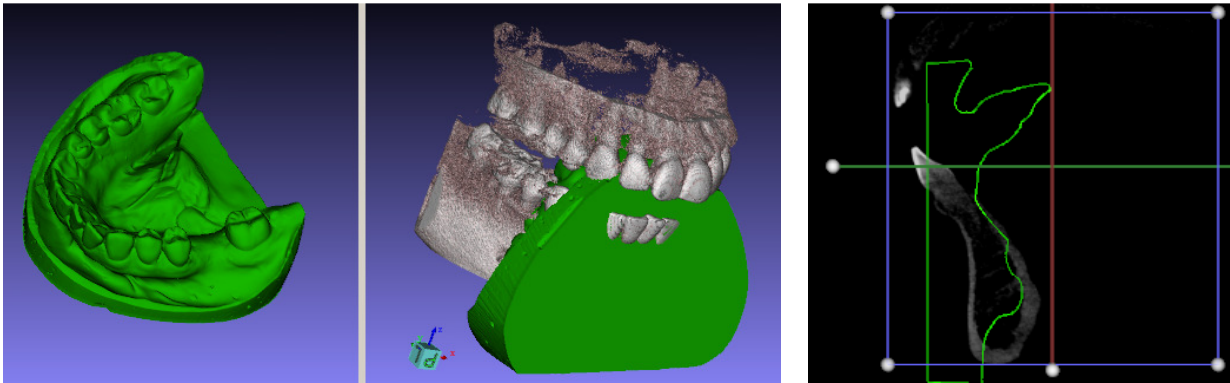
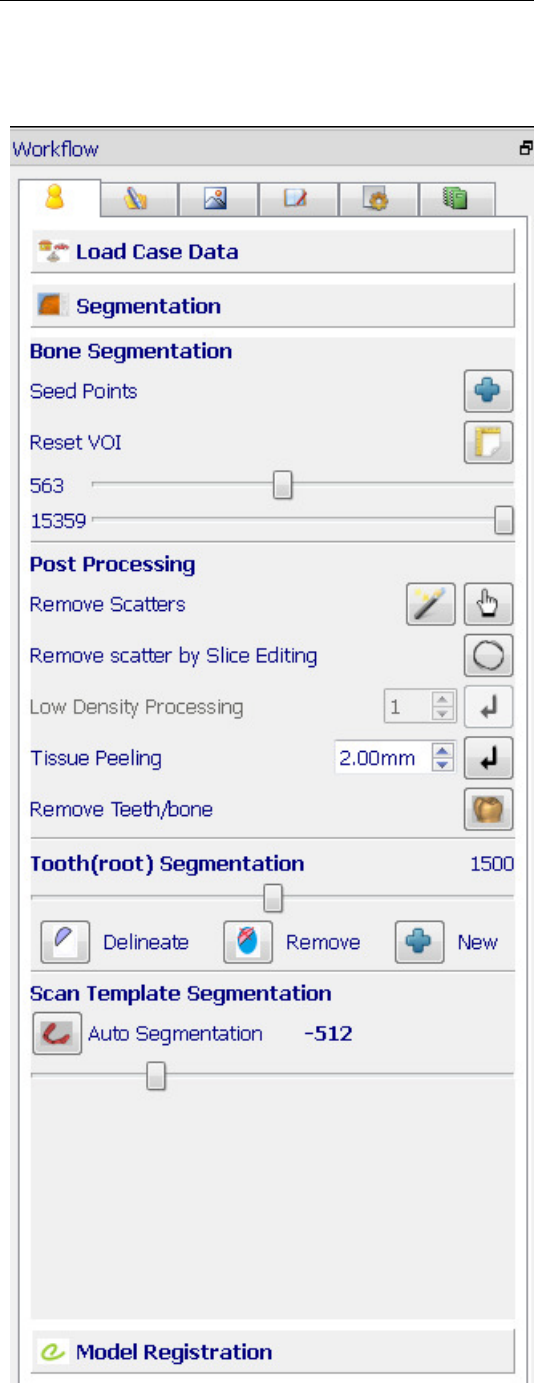




















Figure 5.24. Add stone model or intra-oral scan

5.6.2 SEGMENTATION

UI	Description
----	-------------

	 Specify seed points for bone segmentation.
	 Reset Volume of Interest
	 Adjust threshold values for bone segmentation.
	 Automatic scatter removal. This will initiate the operation or increase the strength of existing operation.
	 Manual scatter removal.
	 Slice editing. Trace an area on 2D slice views and remove the pixels from the bone segmentation results. The first time the button is pressed, system enters the function. Then users can circle an area on a slice view, and click the cut button as shown in the following toolbar to remove the circled pixels. After all the slice editing is done, users click this button again to exit the tool. 
	Low Density Processing. (Not implemented for now)
	 Set the bone low density level. 0 means normal, no processing is needed. 4 for extremely low density cases.
	 Perform the processing.
	Perform surface peeling simulation.
	 Set the tissue thickness the simulation will use.
	 Perform surface peeling. F1.29

	 Remove tooth areas from the bone structure by circling an area on 3D view.
	Tooth(root) Segmentation  Create/Update tooth segment by changing the low threshold value.
	 Delineate an area of a tooth segmentation. Use mouse button to circle tooth structure of interest in the current working object view.
	 Remove an area of a tooth segmentation. Use mouse button to circle and remove an area from a tooth segmentation in the current working object view.
	 Create a new tooth segmentation.
	Auto Segmentation  Automatically segment radiographic guide and create surface model.
	Segmentation -514  Adjust the low threshold value for segmentation of radiographic guide.

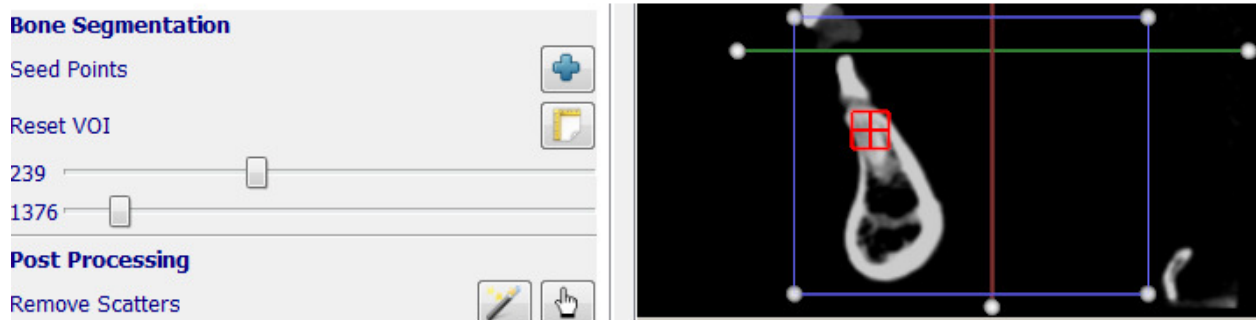
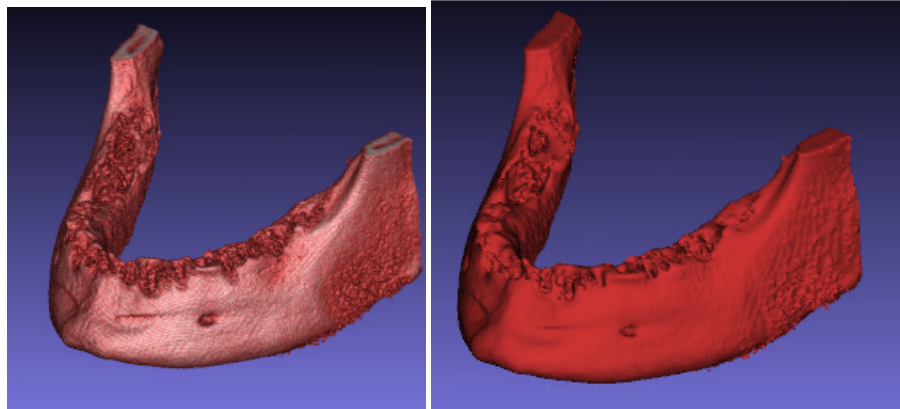
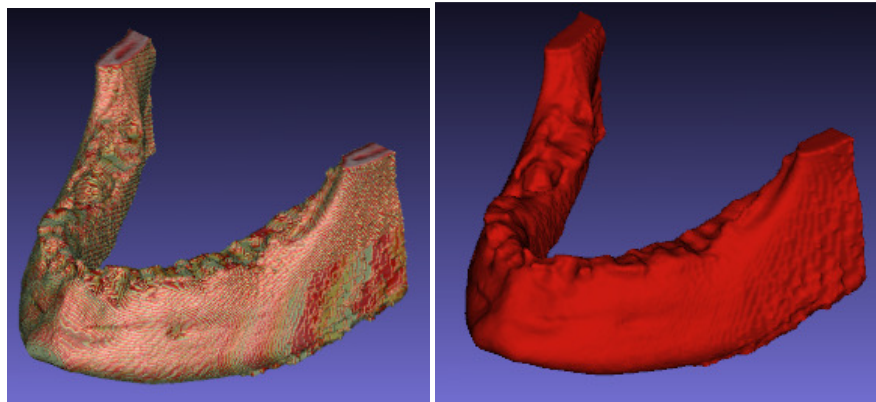


Figure 5.25. Bone segmentation

As shown in Figure 4.25, Region box, Seed point, Thresholds are the three inputs of the bone segmentation. In Figure 4.26 the effect of soft tissue peeling simulation can be compared with the models with just thresholding. Figure 4.27-4.30 shows some additional functions.

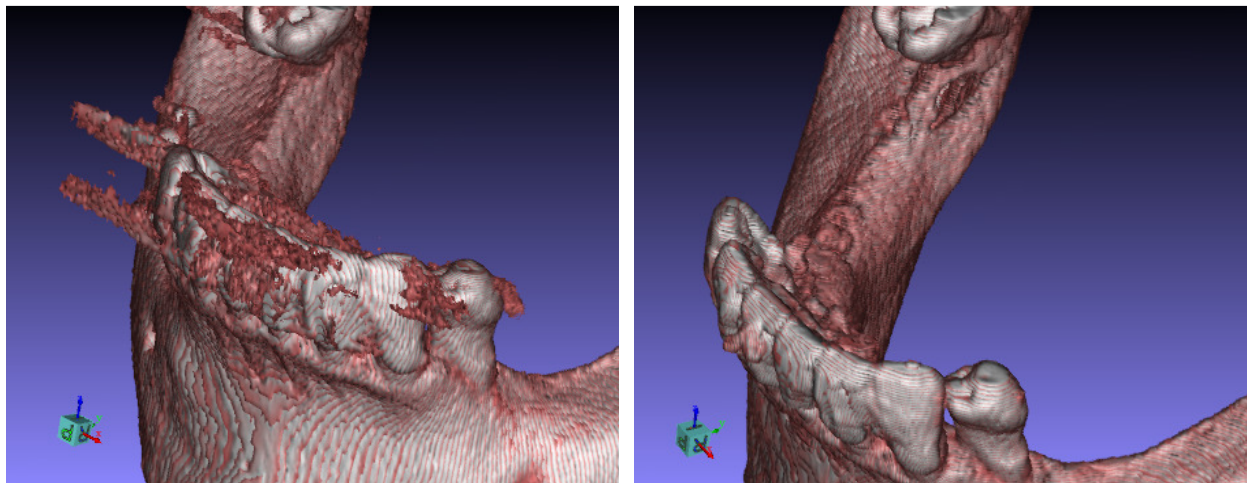


(a)



(b)

Figure 4.26. Thresholding vs. soft tissue peeling simulation.



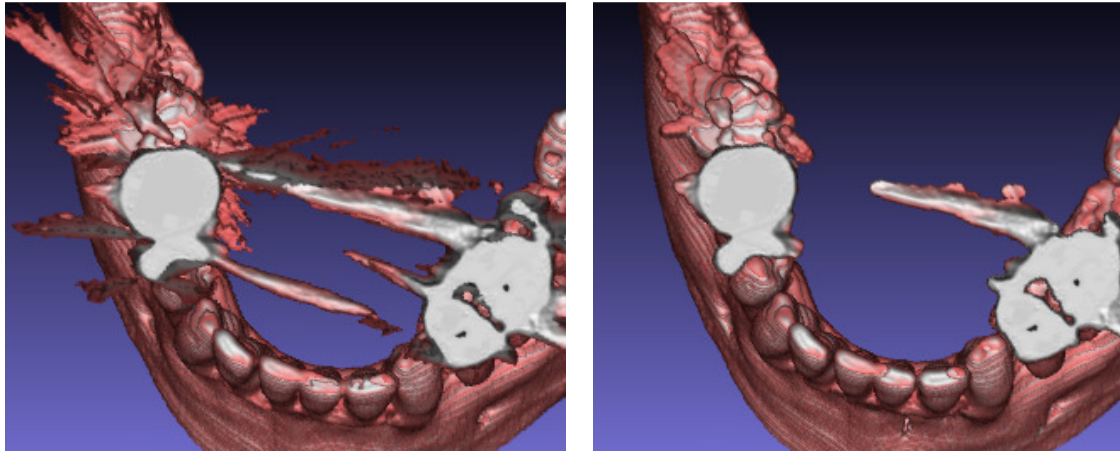


Figure 4.27. Automatic scatter removal. Before and after.

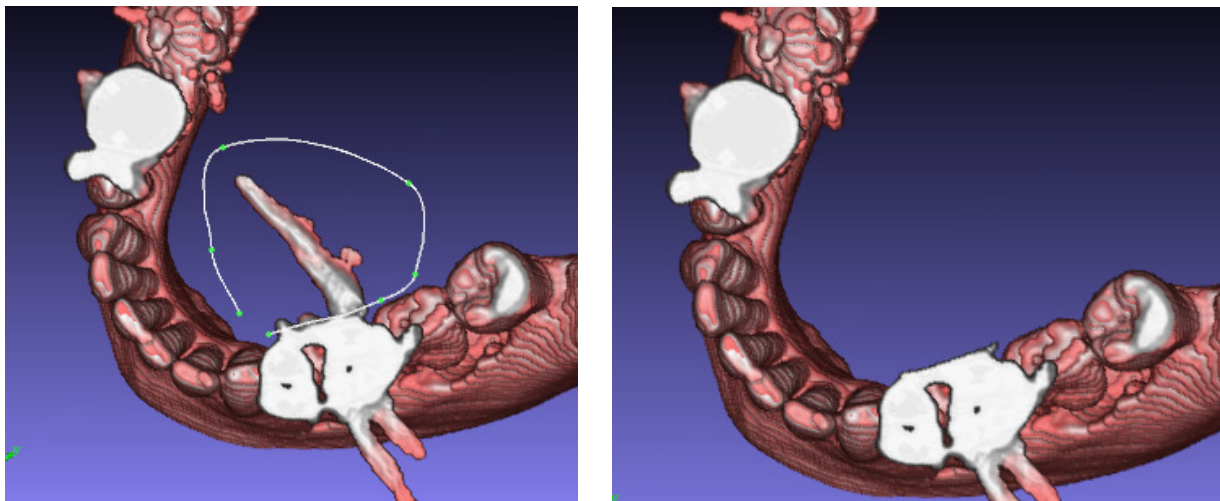


Figure 4.28. Manual scatter removal

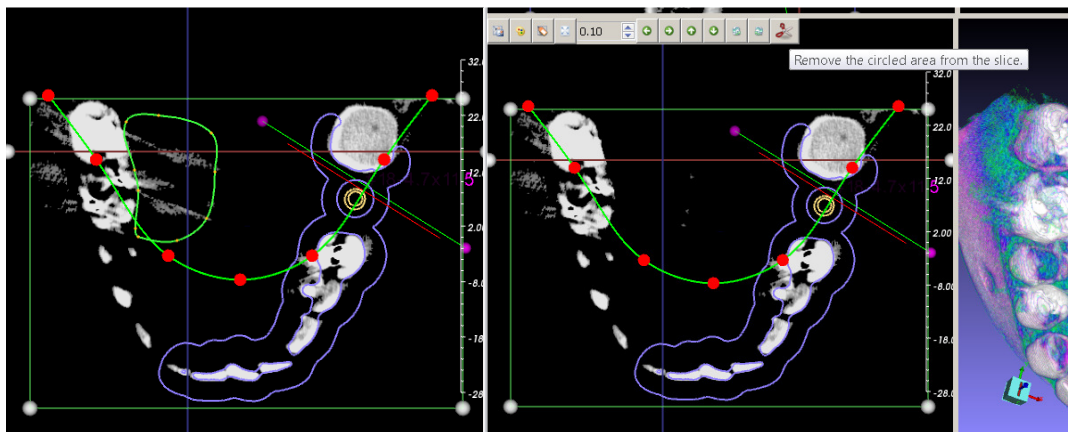


Figure 4.29 Slice editing of Bone Segmentation

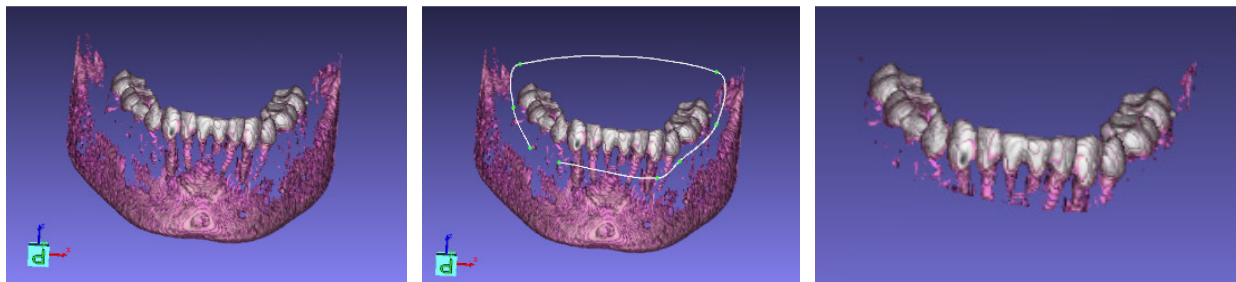


Figure 4.30. Tooth segmentation

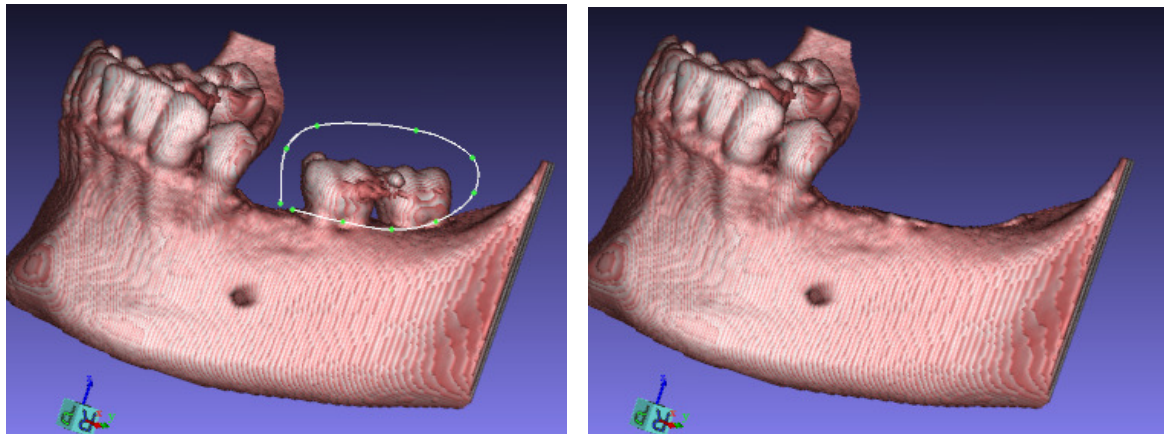


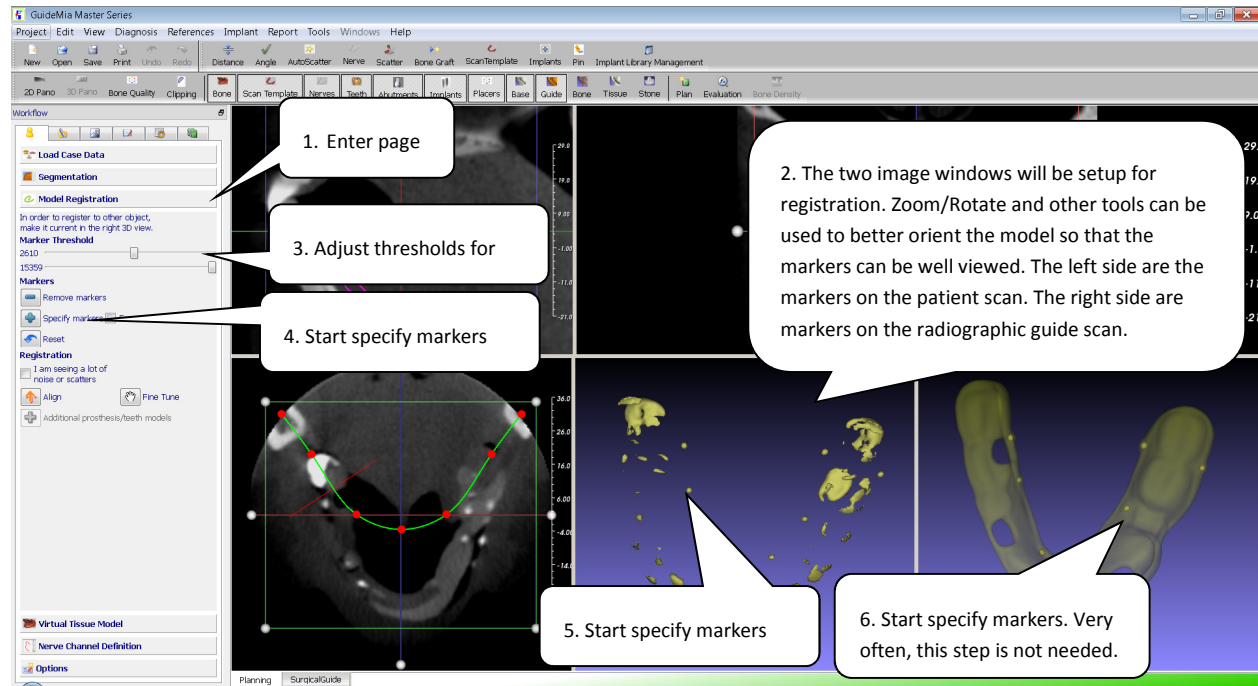
Figure 4.31. Tooth removal

5.6.3 MODEL REGISTRATION

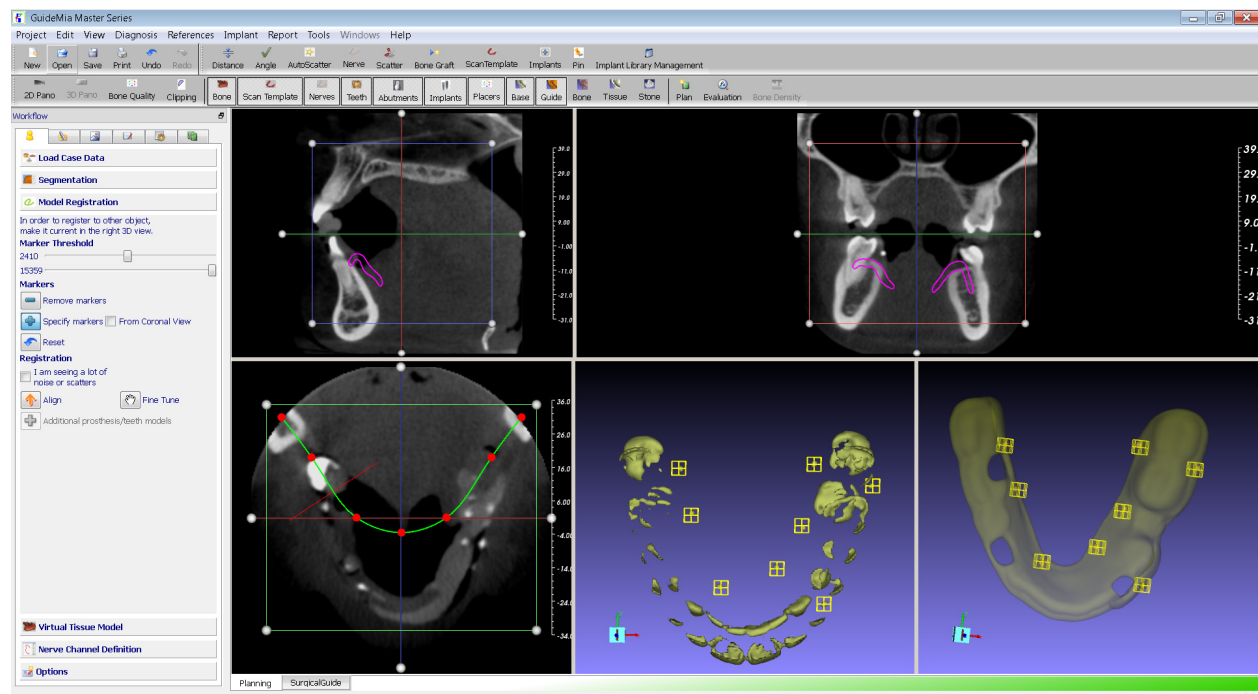
UI	Description
	Upon entering this tool page, the 3D views will be initialized for registration.
	<div>2000</div> <div><div></div></div> Adjust and display the high threshold for markers.
	<div>15359</div> <div><div></div></div> Adjust and display the low threshold for markers.
	<div><div></div>Remove non-marker</div> Specify an area that is not a marker but is considered as marker for some reason.

	<div> <p>Specify markers Specify markers if not recognized. Points on a STL model can also be specified as markers. This function has a new option “From Coronal View”. System can now specify markers from Coronal View. The helps the situation where users can hardly find a good point on the 3D rendering due to massive scatters.</p> </div> <div> <p>Reset Clear the markers and revert the registration results.</p> </div> <div> <p>I am seeing a lot of noise or scatters This turns off/on the function to perform registration more intelligently based on the input points. When the scatter level is high, the makers need to be more accurate and the smart mode is off.</p> </div> <div> <p>Align Perform registration and update all views.</p> </div> <div> <p>Fine Tune Fine tune the registration results.</p> </div> <div> <p>Additional prosthesis/teeth models This button let users to load additional models, which will be placed into the views with the transformation inherited from the registered radiographic guide or stone model.</p> </div>
--	--

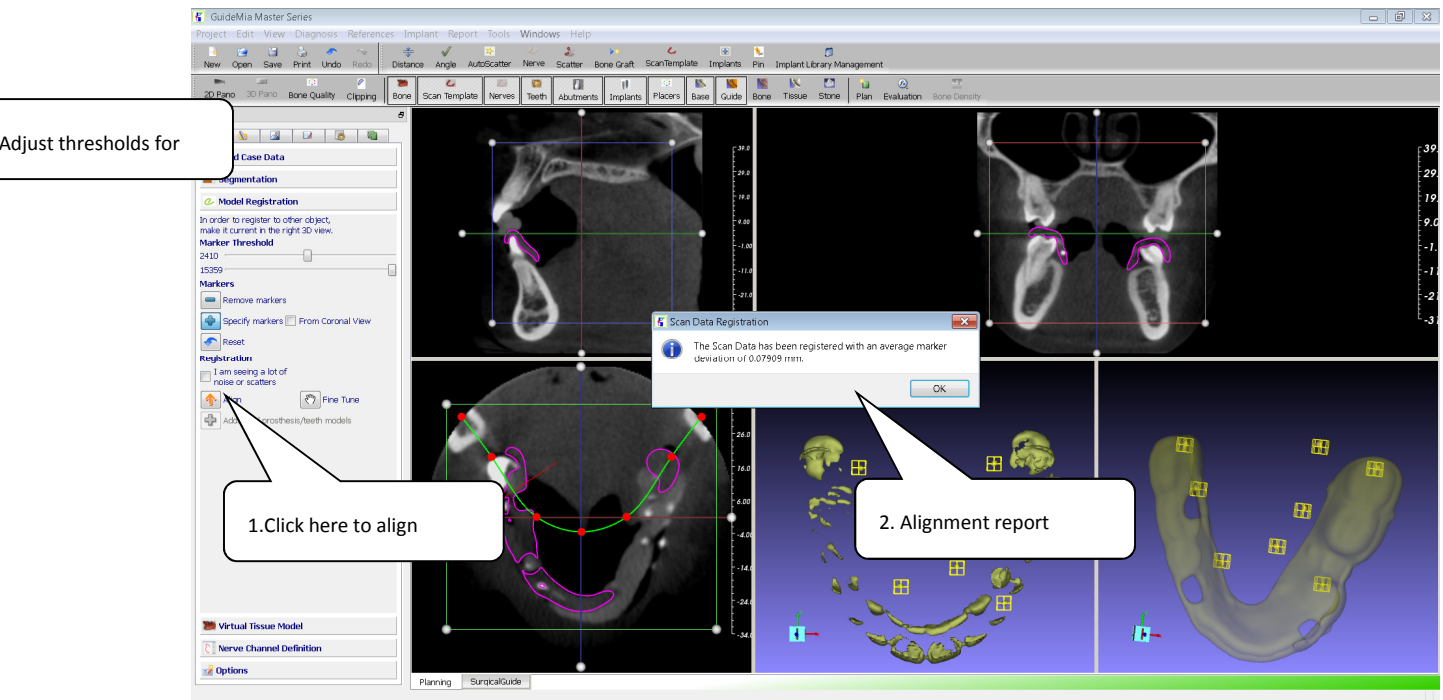
Figure 5.31 and 5.32 illustrate the procedure of model registration. See chapter 6 and 8 for more details.



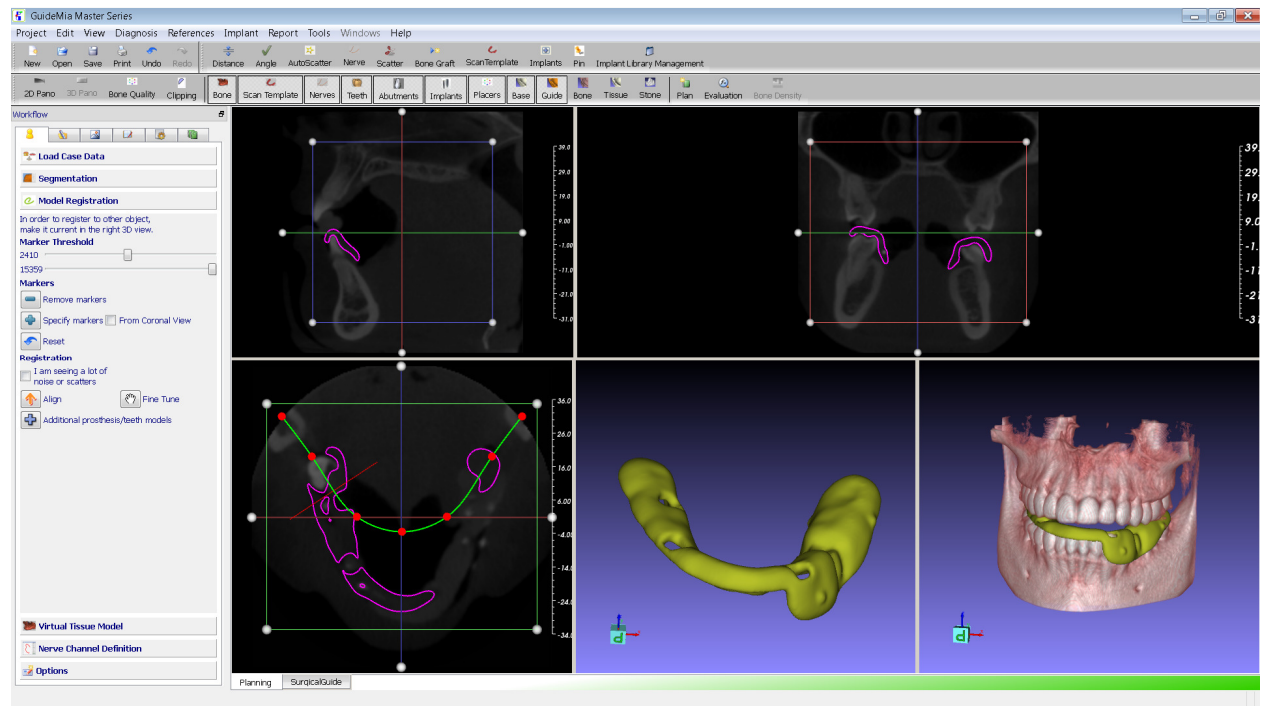
(a)



(b)

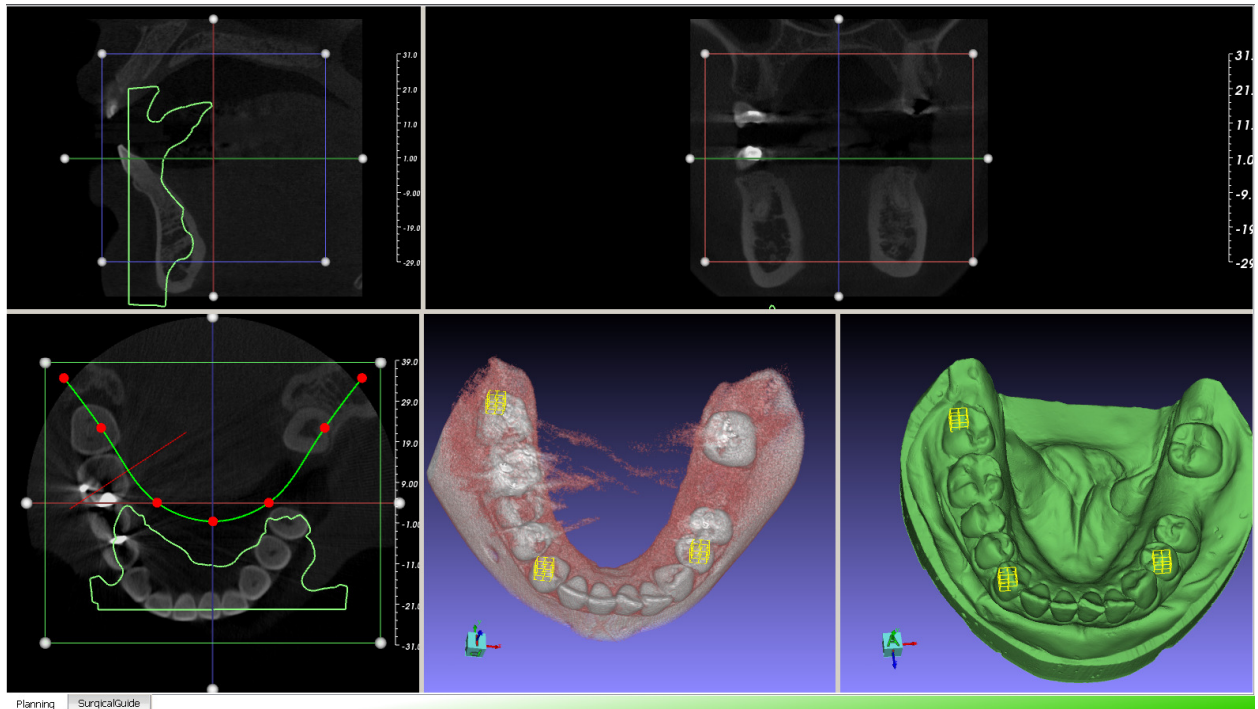


(c)

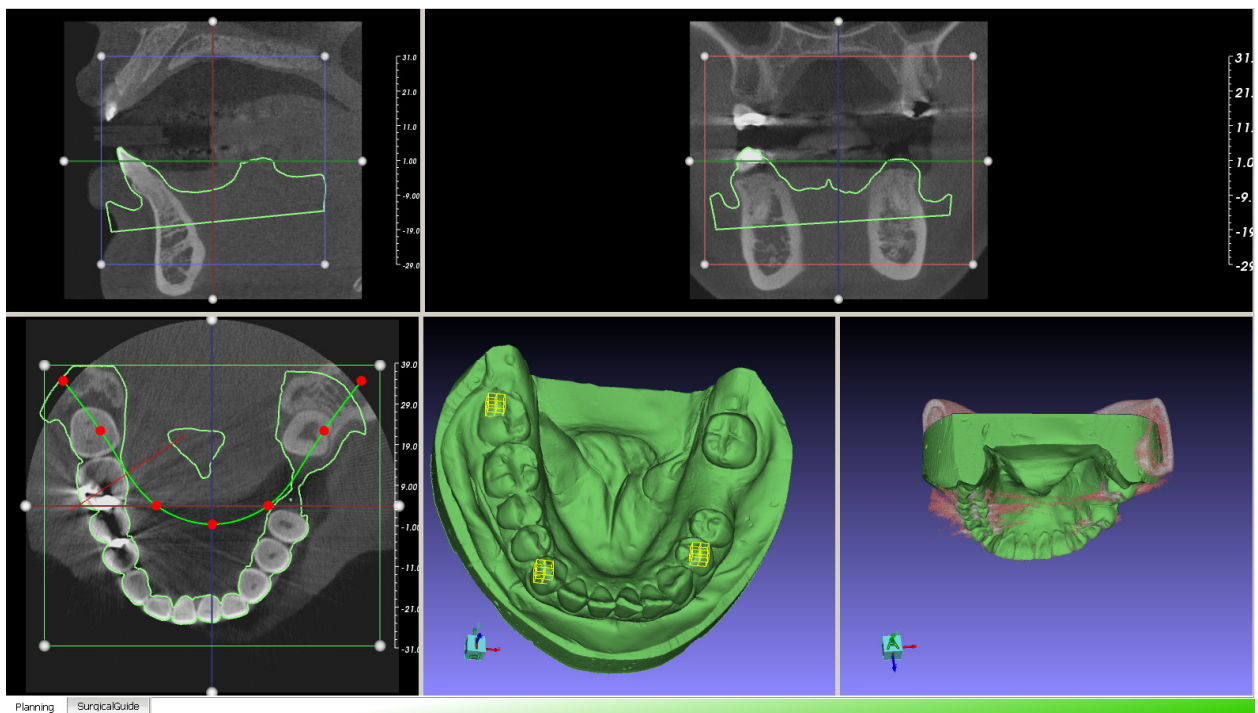


(d)

Figure 5.31. Radiographic Guide registration



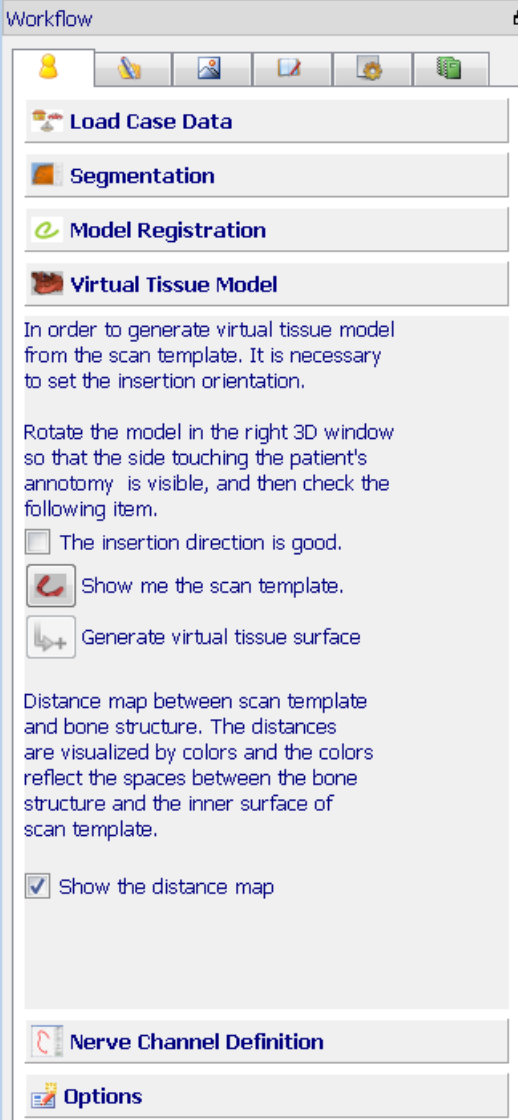



(1) Specify markers for registration. The markers represent areas for registration other than just points. There is no need to specify same amount of markers or have corresponding orders.



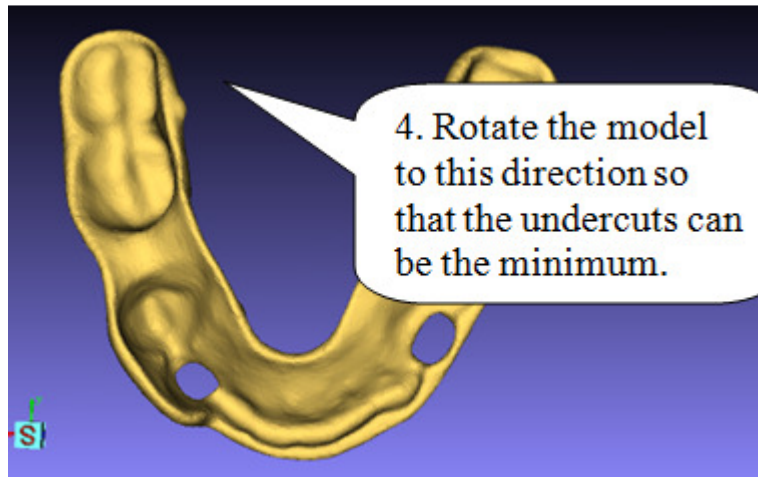
(2) After registration

Figure 5.32. STL model registration to bone/teeth

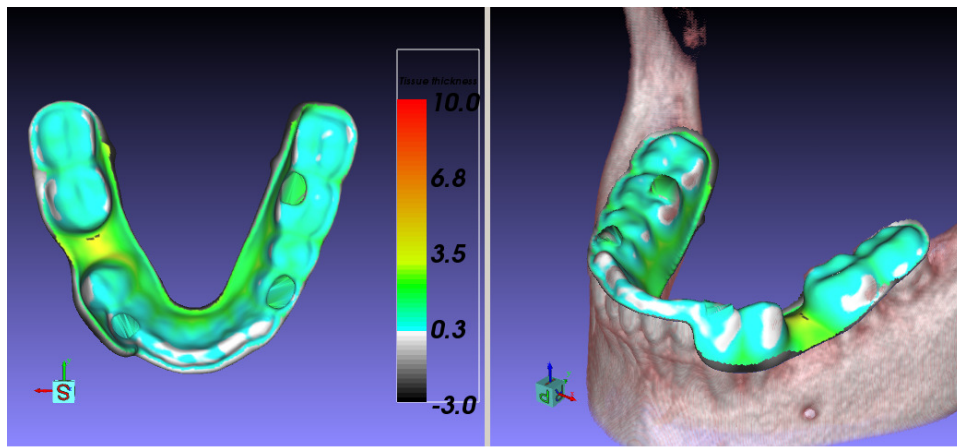
5.6.4 VIRTUAL TISSUE MODEL

UI	Description
 <p>Workflow</p> <p>Load Case Data</p> <p>Segmentation</p> <p>Model Registration</p> <p>Virtual Tissue Model</p> <p>In order to generate virtual tissue model from the scan template. It is necessary to set the insertion orientation.</p> <p>Rotate the model in the right 3D window so that the side touching the patient's anatomy is visible, and then check the following item.</p> <p><input type="checkbox"/> The insertion direction is good.</p> <p><input type="checkbox"/> Show me the scan template.</p> <p><input type="checkbox"/> Generate virtual tissue surface</p> <p>Distance map between scan template and bone structure. The distances are visualized by colors and the colors reflect the spaces between the bone structure and the inner surface of scan template.</p> <p><input checked="" type="checkbox"/> Show the distance map</p> <p>Nerve Channel Definition</p> <p>Options</p>	<p> The insertion direction is good. Confirm that a virtual insertion direction is defined.</p> <p> Show me the scan template. Show the radiographic guide or stone model scan or intra-oral scan.</p> <p> Generate virtual tissue surface Generate virtual tissue surface model.</p>
	<p><input checked="" type="checkbox"/> Show the distance map Show the tissue model with color map indicating the distances between the tissue model and the bone/tooth structures.</p>

The concept and result of virtual tissue model is shown in the following pictures. The model is the extraction of the adaption surface of a radiographic guide. In this case, since two teeth are removed the area corresponding to the teeth has a reddish color, which means the area is far from patient anatomy. The white/gray color indicates a tight fit of the radiographic guide and the patient anatomy.



(a)



(b)

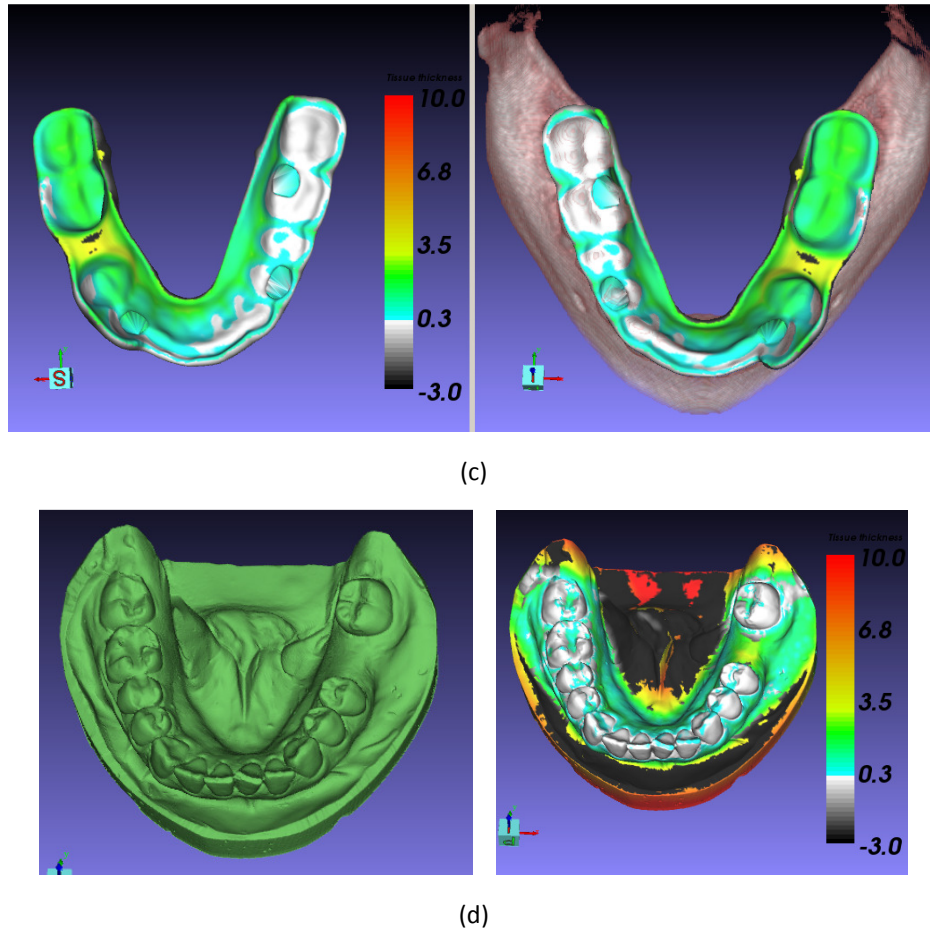


Figure 5.33. Virtual tissue model. (a) Preparing model. (b) Generated result. The model is invisible by default in the assembly view. Use the model navigator to show it. (c) The uneven color distribution indicates the radiographic guide is either not properly placed when the patient was scanned, or the registration failed. (d) Virtual tissue model from optical scan. View direction shown in the left side. Result in the right side.

5.6.5 NERVE CHANNEL DEFINITION

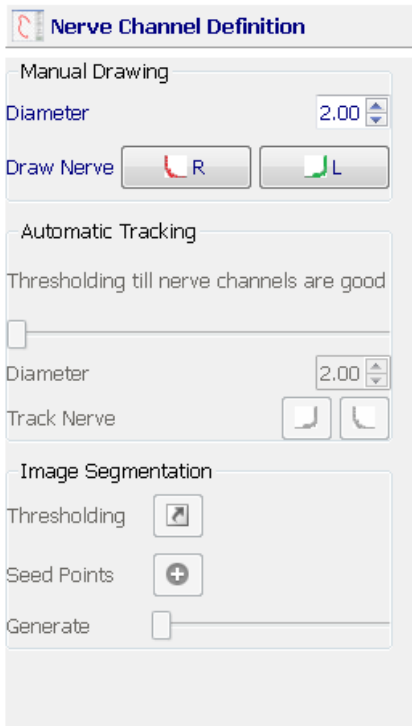



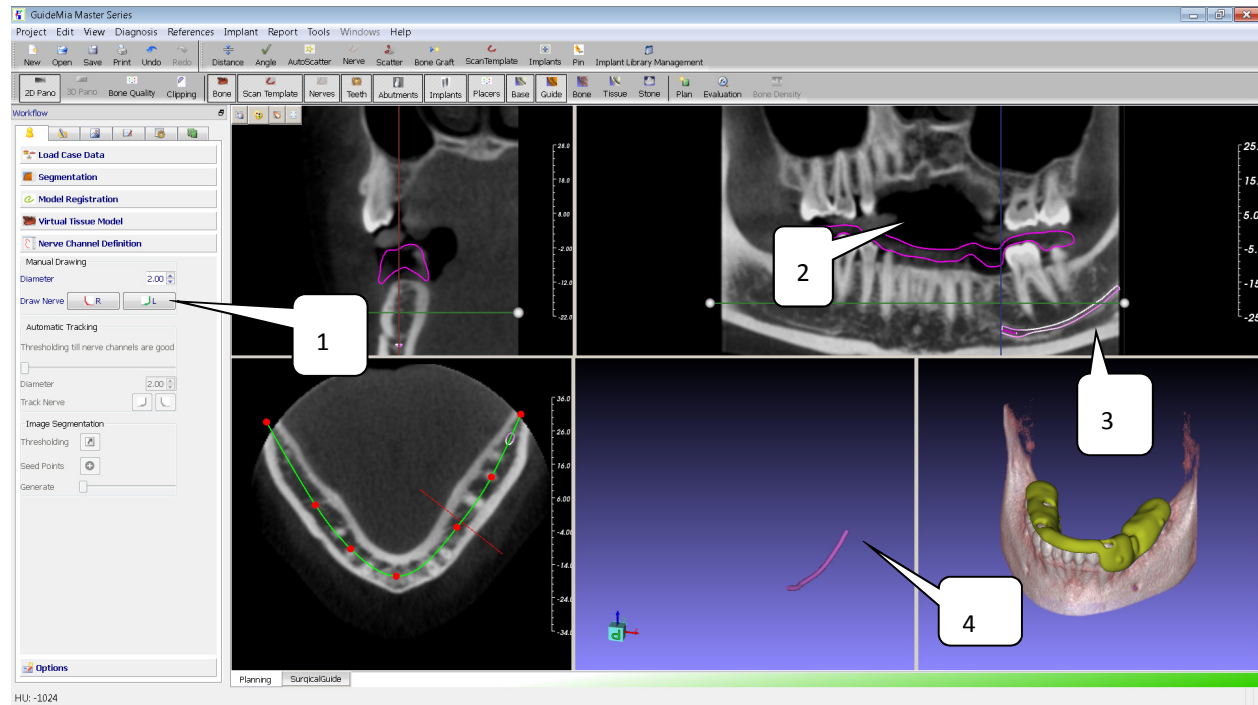
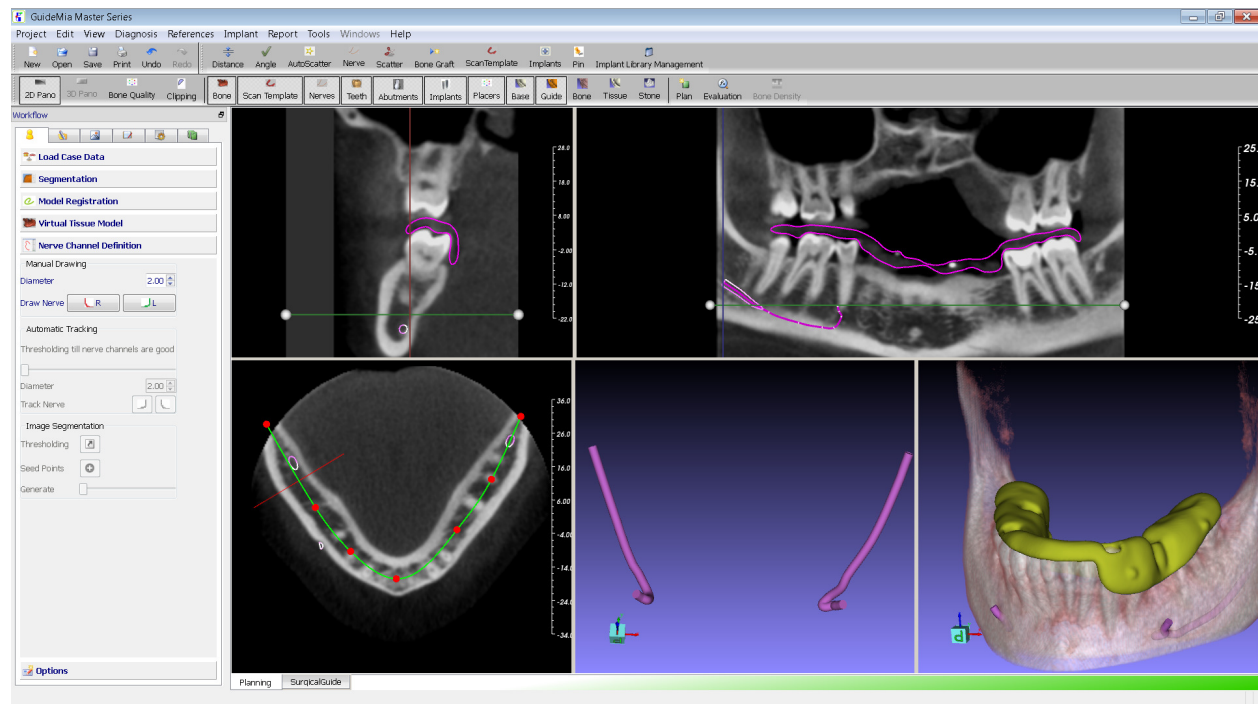
UI	Description
	 Specify the diameter of nerve model in “mm”, which will be manually drawn in 2D views.
	 Draw left nerve channel.
	 Draw right nerve channel.
	The rest part in this toolbox is for future releases.

Figure 5.34 shows an example of nerve creation. The arch curve needs to be adjusted before entering the nerve modeling tool.



(a)



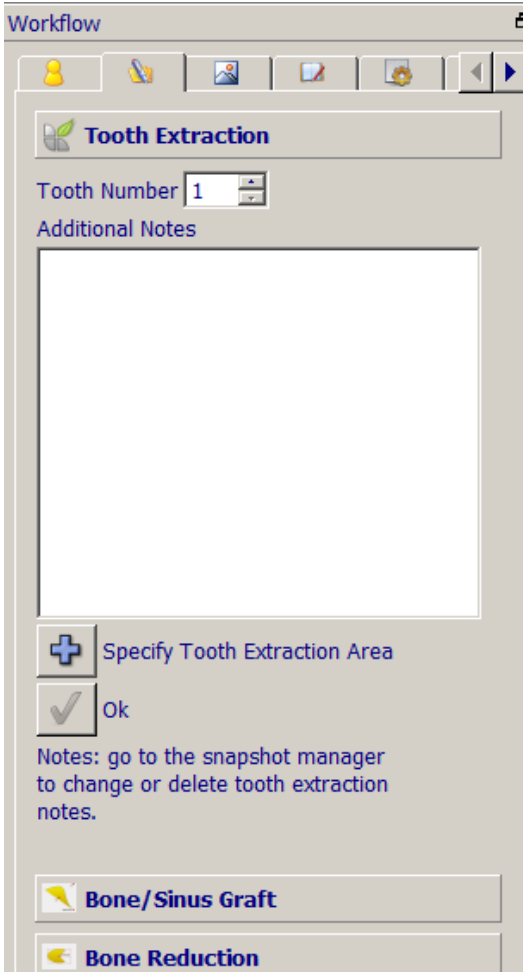
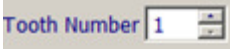
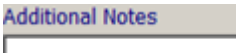

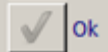
(b)

Figure 5.34. Nerve channel drawing. (a) Process. (b) Results

Nerve channel drawing steps are listed below. Upon entering this step, the system will automatically changes to panoramic mode. Therefore, make sure the arch curve has been well defined before.

- 1) Choose to define left channel
- 2) Identify the entrance point by wheel to change slice, MB1 to change thresholds, etc.
- 3) Place handles by MB1, change slice by mouse wheel. Keep doing this when the nerve is tracked. MB3 to finish the tracking
- 4) 3D nerve model shows up and changes following the 2D
- 5) Repeat for another side.

5.6.6 TOOTH EXTRACTION

UI	Description
	 Tooth to extract
	 Add treatment notes
	
	 Finish definition of an extraction area.

The steps to specify tooth extraction are listed below. The tooth area can be removed first by the extraction tool found in the segmentation toolbox of the case definition panel.

- 1) Enter planning page See Figure 4.36
- 2) Enter first tooth number
- 3) Add treatment notes
- 4) Orient and zoom either 3D window so that the tooth area is well displayed
- 5) Start specify tooth extraction area
- 6) Draw an area by click on the window. When profile is closed, the area is defined
- 7) Okay to finish specifying an area
- 8) Go to Snapshot navigator to review the created notes. See Figure 4.37.

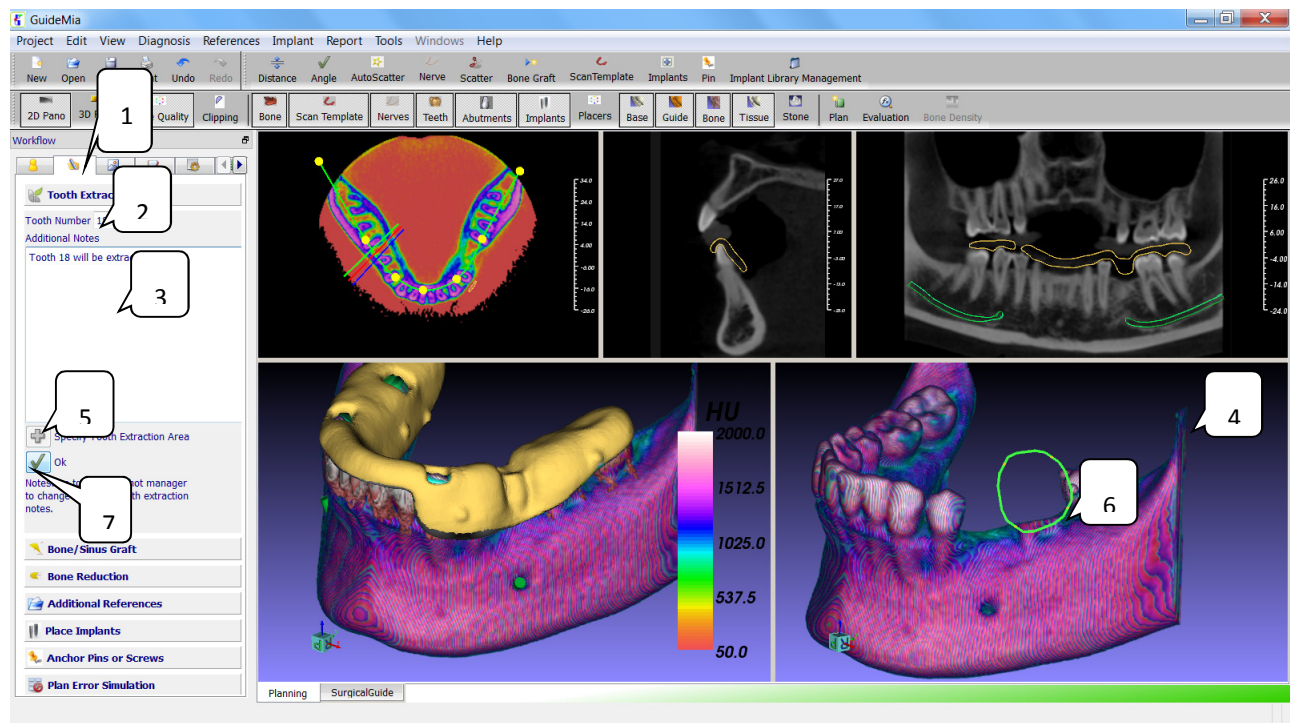


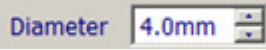


Figure 5.35. Define tooth extraction notes



Figure 5.36. Review the notes

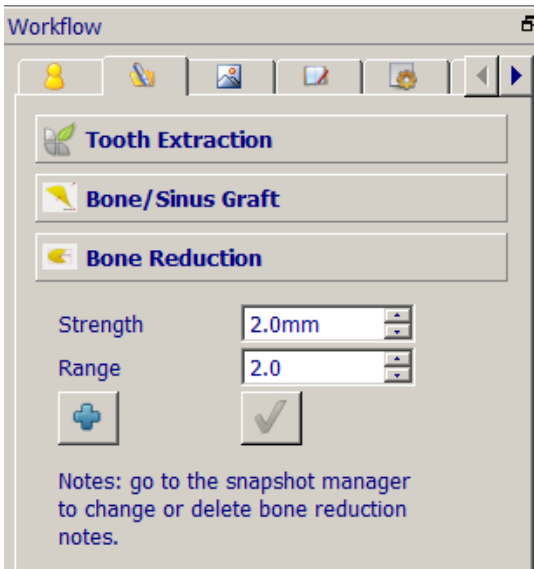
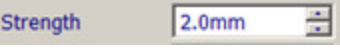
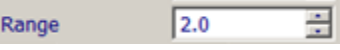


5.6.7 BONE AND SINUS GRAFTING

UI	Description
	Define bone grafting height
	Define bone grafting range
	Add bone grafting area. F1.43
	Finish definition of a bone grafting area.
	Define sinus grafting height

	 Define bone grafting range.
	 Add bone grafting area.
	 Finish definition of a sinus grafting area.

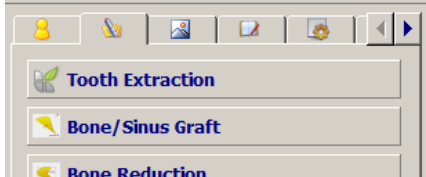

The user interactions are similar to "Tooth Extraction".

5.6.8 BONE REDUCTION

UI	Description
	 Define bone reduction height
	 Define bone reduction range
	 Add bone reduction area.
	 Finish definition of a bone reduction area.

The user interactions are similar to "Tooth Extraction".

5.6.9 ADDITIONAL REFERENCES

UI	Description
	 <p>Add virtual tooth models.</p>

	<div data-bbox="703 226 1081 296"> Additional Optical Sca Add </div> <p>Add additional optical scans or STL files.</p>
--	--

These tools will just prompt the user for a STL file. The specified STL file will be imported into the graphics windows, and the user can further move and rotate the STL model with placement widgets. See Figure 4.38 for a screenshot.

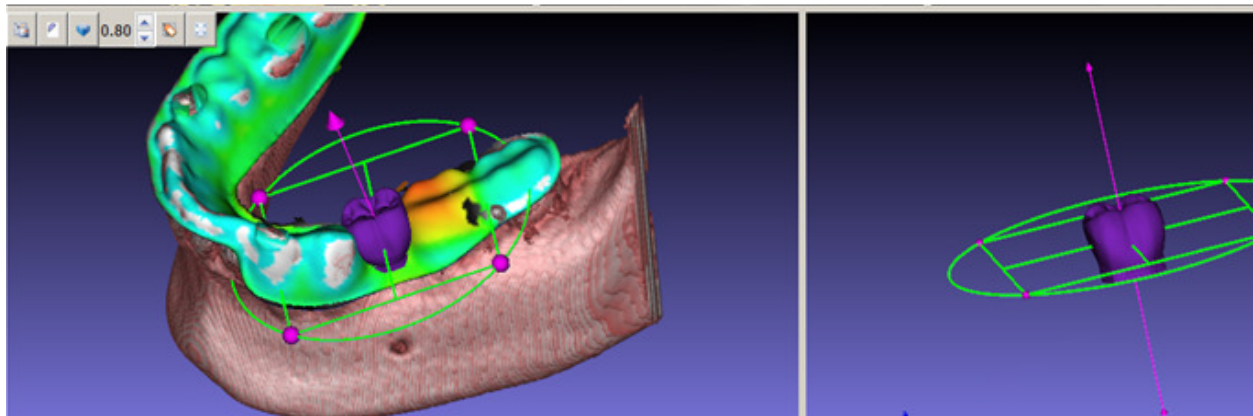











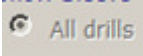

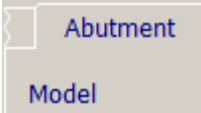


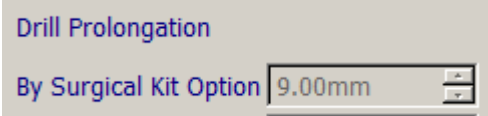

Figure 5.37. A virtual tooth model placed into the scene.

TIP: It is very important to have additional models like antagonist, diagnostic models, virtual teeth, etc. in order to preview the implant outcome. This is especially important for fully edentulous cases if the radiographic guides do not have enough features to help plan the cases.

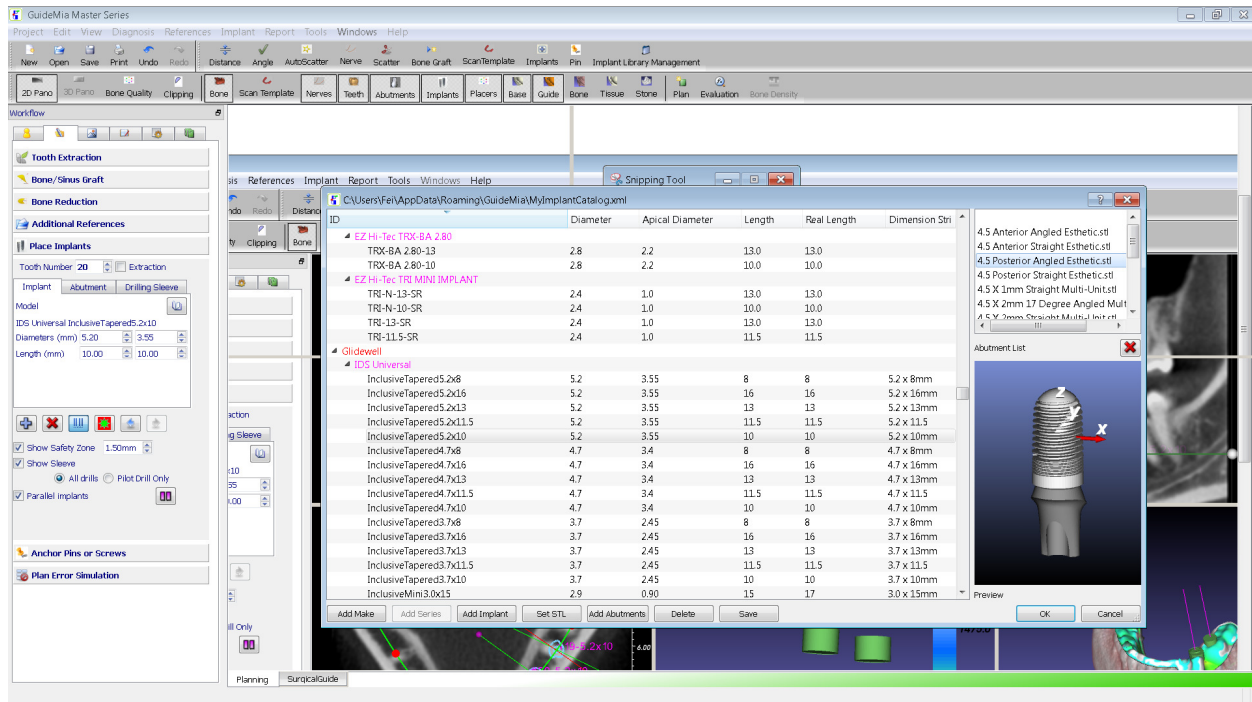
5.6.10 PLACE IMPLANTS

UI	Description
<div data-bbox="190 1507 672 1858"> <div>Place Implants</div> <div> Tooth Number 1 Extraction </div> <div> Implant Abutment Drilling Sleeve </div> <div> Model Undefined Diameters (mm) 3.00 3.00 Length (mm) 8.00 8.00 </div> </div>	<div data-bbox="721 1507 1406 1583"> Tooth Number 1 Set tooth number </div> <div data-bbox="721 1604 1406 1751"> <input type="checkbox"/> Extraction Specify if there will be immediate tooth extraction at the implant site. The surgical guide design module will use this flag to design guides accordingly. </div> <div data-bbox="721 1772 1040 1858">  Go to implant library. </div>

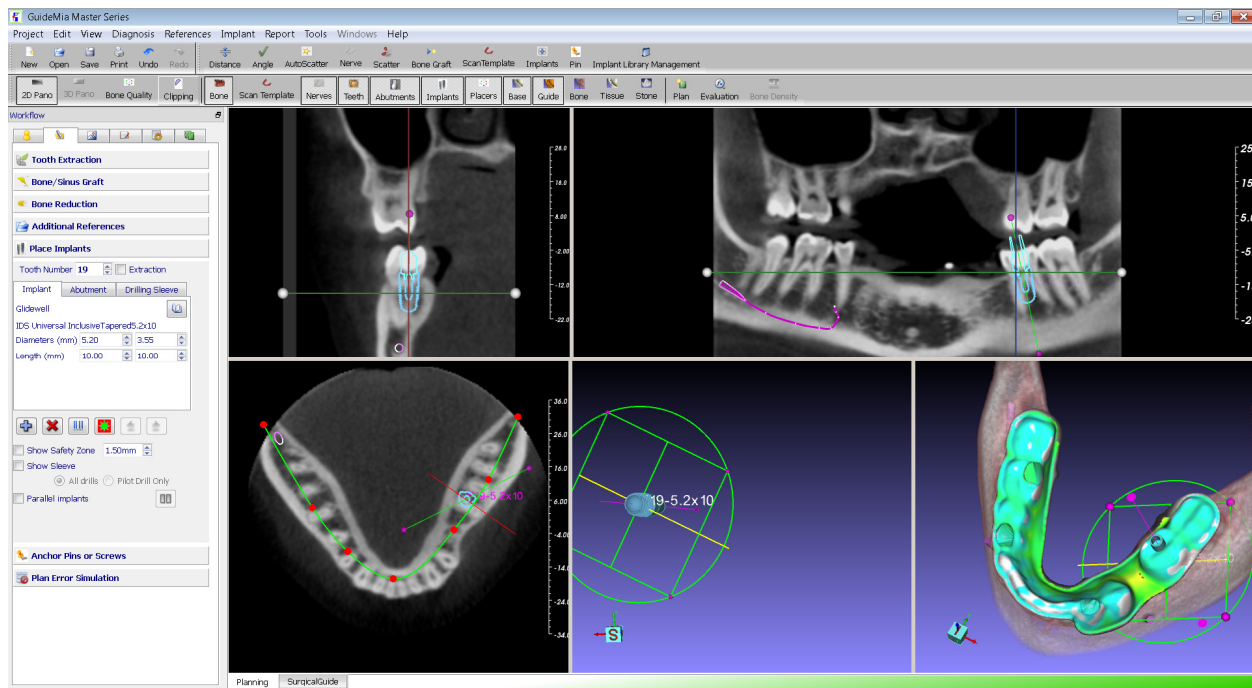
 <input type="checkbox"/> Show Safety Zone 1.50mm <input type="checkbox"/> Show Sleeve <input checked="" type="radio"/> All drills <input type="radio"/> Pilot Drill Only <input type="checkbox"/> Parallel implants	Model Undefined Shows the selected implant model information.
Place Implants Tooth Number 1 <input type="checkbox"/> Extraction Implant Abutment Drilling Sleeve Diameter <input type="text"/> mm ColarDiameter <input type="text"/> mm Height <input type="text"/> mm Colar Height <input type="text"/> mm Slanted Angle <input type="text"/> deg	Diameters (mm) 3.00 3.00 Implant Diameters (top and bottom) Length (mm) 8.00 8.00 Define implant catalog length and actual length.
Place Implants Tooth Number 1 <input type="checkbox"/> Extraction Implant Abutment Drilling Sleeve Sleeve Height By Surgical Kit Option 3.50mm Customized 3.50mm Drill Prolongation By Surgical Kit Option 9.00mm Customized 9.00mm	 Add/Update Implant  View/inspect implant neighborhood  Check implant interference
	<input type="checkbox"/> Parallel implants Turn on/off implant parallel option so that the new implants will follow the direction of the previous one
	 Make all implants parallel to the first one
	 Delete implant
	 Go to previous implant (Set current)
	 Go to next implant (set current)
	<input type="checkbox"/> Show Safety Zone 1.50mm Show/Hide safety zone of implants, and define the size of the safety zone
	<input type="checkbox"/> Show Sleeve Show/Hide the drilling sleeves

	 <p>Drilling sleeves for all drill sequences.</p>
	 <p>Drilling sleeves for pilot drills only.</p>
	 <p>Abutment functions</p>
	 <p>Use drilling sleeve height defined by surgical kit.</p>
	 <p>Customize the height of drilling sleeves</p>
	 <p>Drill prolongation determined by surgical kit.</p>
	 <p>Customize drill prolongation.</p>

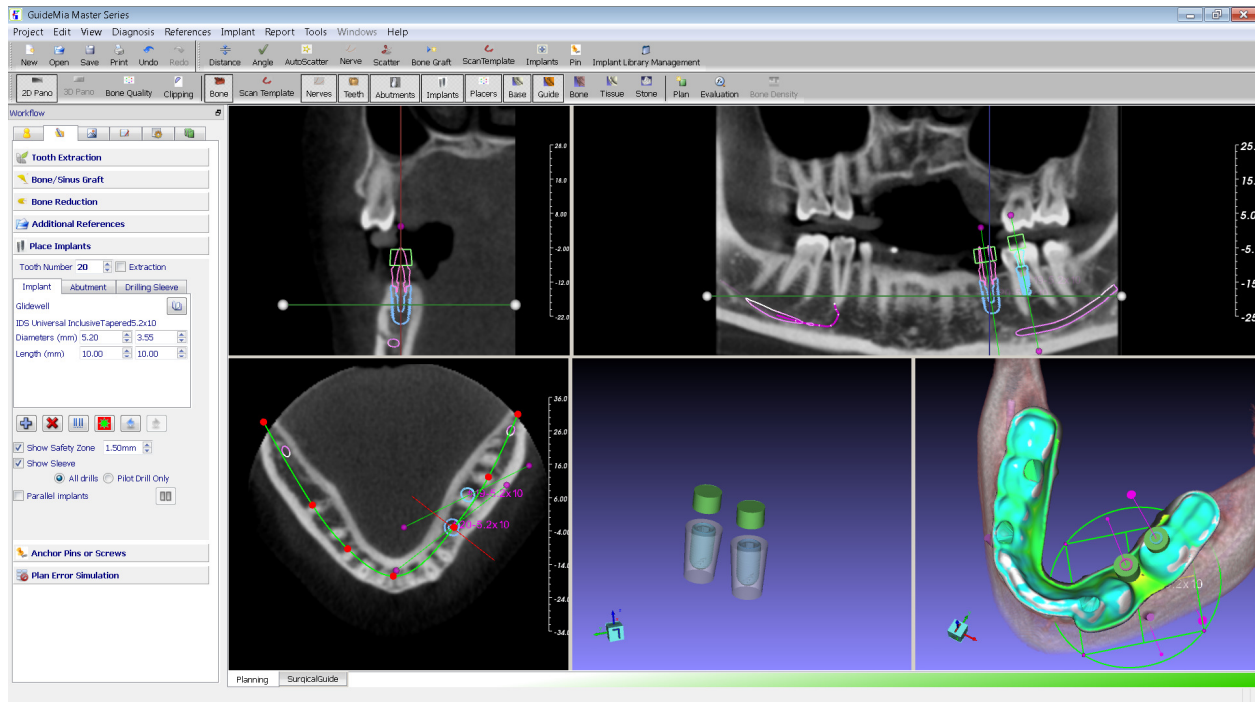
The procedures to place implants and adjust implant locations are shown in the following pictures. Auxiliary functions are also included in this workflow.



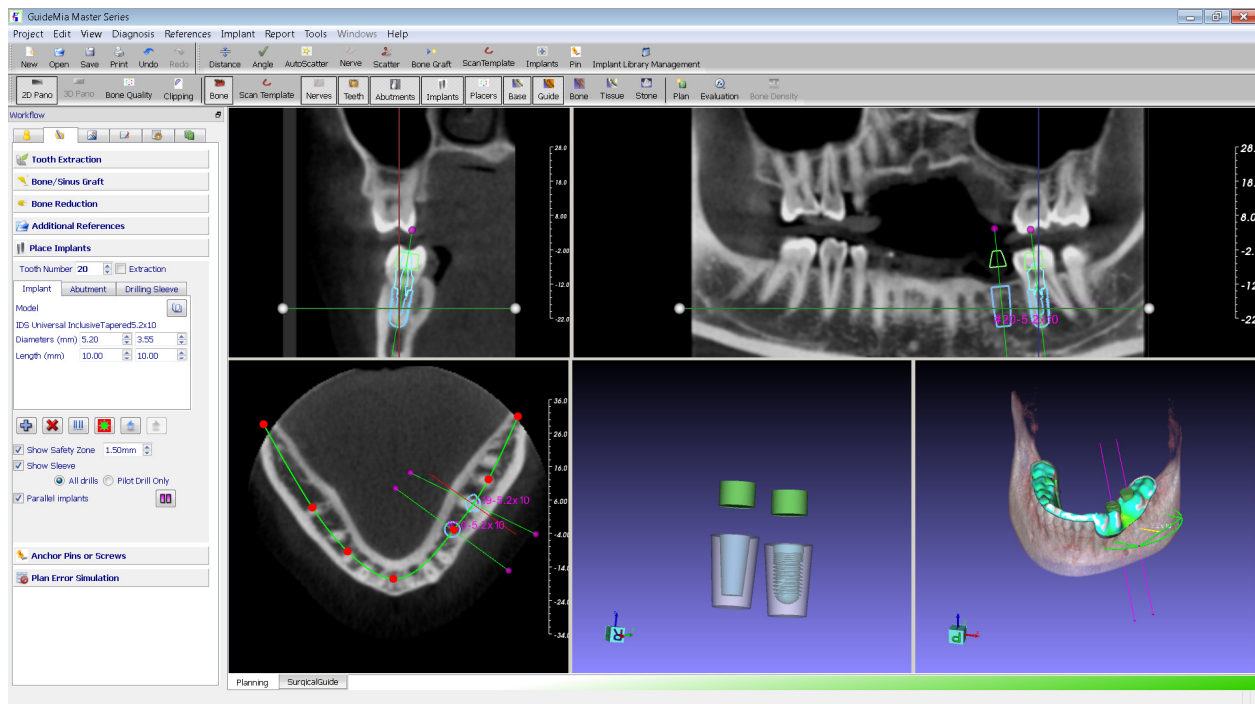
(a) Select Implant



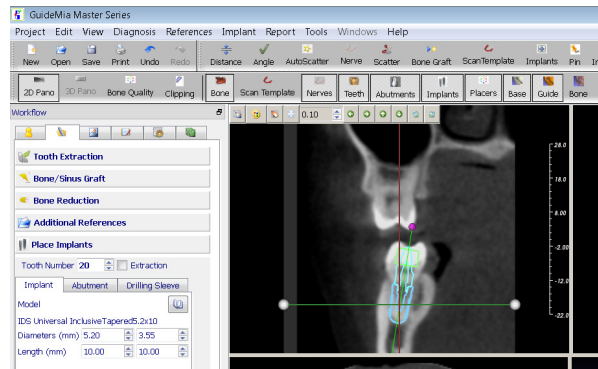
(b) Add implant



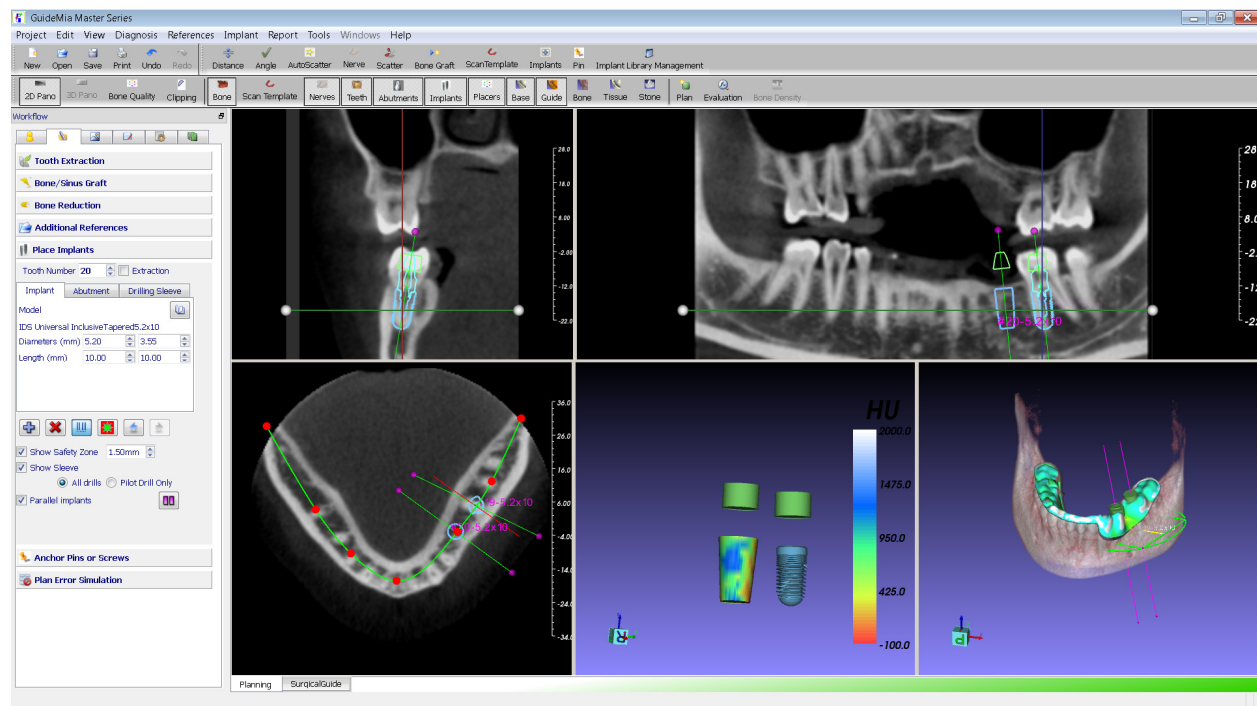
(c) Additional functions



(d) Make implants parallel



(e) Fine tuning the implant placement



(f) Implant neighborhood bone density inspection

Figure 5.38. Insert and place implants

With dual scan cases, radiographic guides are made to fit onto the plaster/stone models. The major consideration at manufacturing time is the aesthetics other than treatment planning or surgical guide design. Often times, there isn't enough materials for placing drilling sleeves. This is shown in the Figure 4.40. In the left, the green cylinder shows the space the drilling sleeve will take. The middle one shows the cross section that green sleeve extends out of the radiographic guide. The right one is the surgical guide created for the scenario. The green and red areas interfere with patients' soft tissue, which is not right for the tissue-based surgical guide. The material in such an area can be removed by software or a technician after manufacturing. However, this can lead to problems; for example, the sleeve can be too short for guiding the drills after been trimmed.

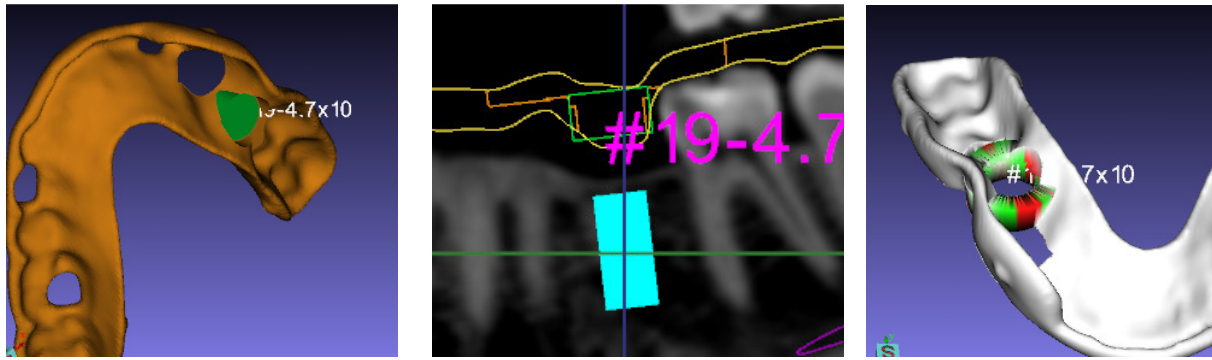


Figure 5.39. Adjust drilling sleeves

The tool in this section is to solve this problem by either changing the sleeve length, or changing the prolongation of the drilling operation.

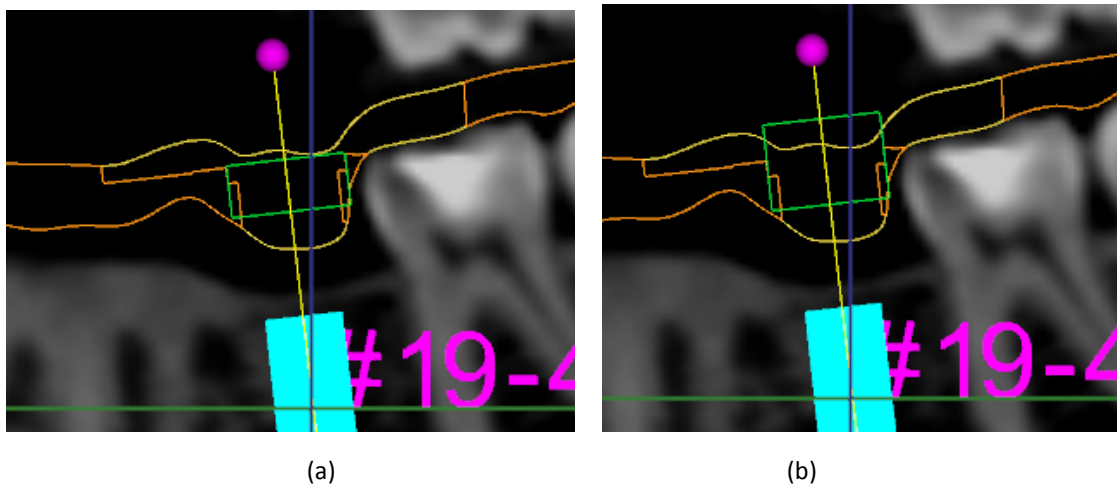


Figure 5.40. Customize sleeve length and drilling prolongation. (a) Shorter sleeve.

(b) Bigger prolongation with original sleeve.

5.6.11 IMPLANT LIBRARY MANAGEMENT

The dialog design is as below. It has an implant tree with header, and a couple of buttons.

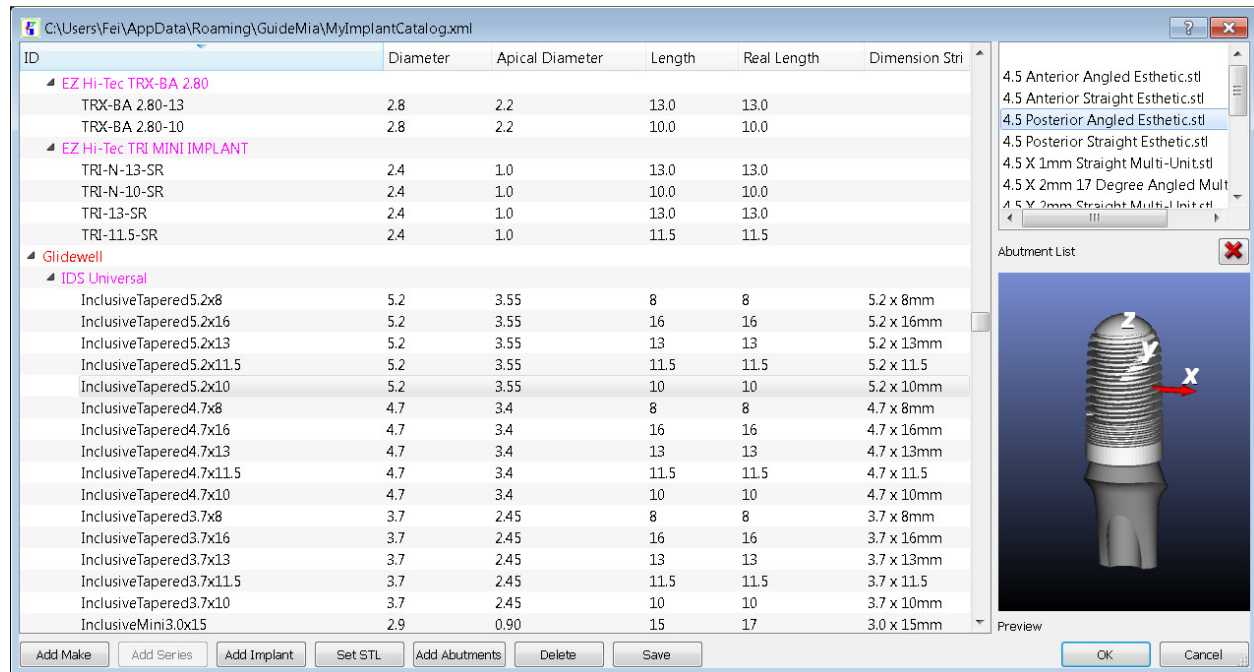



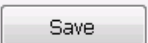
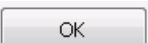
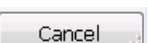
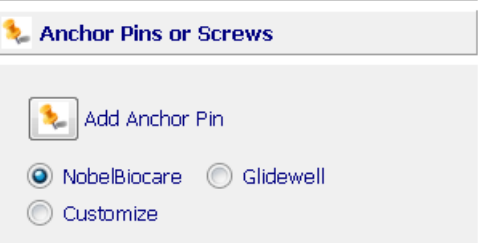





Figure 5.41. Implant library dialog

UI	Description
See the full picture above this table.	<input type="text" value="ID"/> Sort implant lib by ID
	<input type="text" value="Diameter"/> Sort by diameter
	<input type="text" value="Apical Diameter"/> Sort by apical diameter
	<input type="text" value="Length"/> Sort by length
	<input type="button" value="Add Make"/> And a new implant make
	<input type="button" value="Add Series"/> Add a new implant series
	<input type="button" value="Add Implant"/> Add a new implant model

	 Add implant's STL file. The implant STL models have to be placed in a predefined coordinate system properly. Contact technical support for more details.
	 Add the STL files of an implant's compatible abutments. The STL models have to be placed in a predefined coordinate system properly. Contact technical support for more details.
	 Delete selected implant or category
	 Save implant lib
	 Ok and close dialog
	 Cancel operation

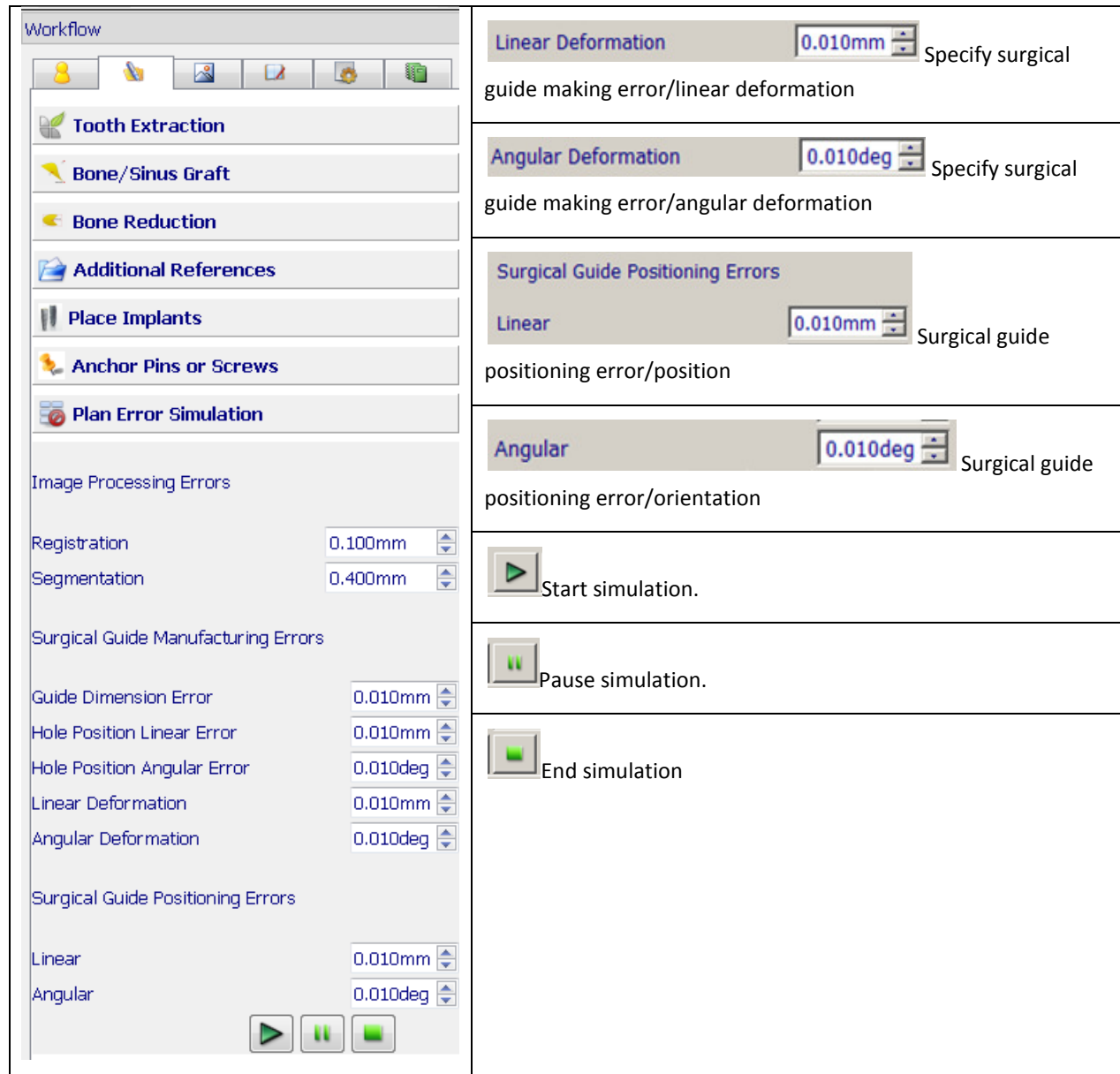
5.6.12 DESIGN ANCHOR PINS AND SCREW HOLES

UI	Description
 <p>The dialog box titled "Anchor Pins or Screws" contains a section with the title "Add Anchor Pin". Below this title are three radio button options: "NobelBiocare" (selected), "Glidewell", and "Customize".</p>	 <p>The user click on this button, and then the location on the radiographic guide or stone model, a preview cylinder for the anchor pin will be created with placement attached. The user can further adjust the location and orientation.</p>

<div>  Add Anchor Pin </div> <div> <input type="radio"/> NobelBiocare <input type="radio"/> Glidewell <input checked="" type="radio"/> Customize </div> <div> Anchor Pin STL file <input type="text"/>  </div> <div> Anchor Pin Diameter: <input type="text" value="1.50mm"/> Anchor Pin Length: <input type="text" value="25.00mm"/> Anchor Pin Full Length: <input type="text" value="36.00mm"/> Sleeve Thickness: <input type="text" value="0.75mm"/> Sleeve Length: <input type="text" value="11.00mm"/> Sleeve Flange Thickness: <input type="text" value="1.00mm"/> </div>	<div> <input checked="" type="radio"/> NobelBiocare <input type="radio"/> Glidewell </div> <p>Choose the anchor pin design of either NobelBiocare or Glidewell compatible.</p> <div> <input checked="" type="radio"/> Customize </div> <p>For customized, system will prompt for STL model specification and key dimensions. STL models will need to be placed in predefined coordinate system properly. Contact technical support for more details.</p> <p>The anchor pin placement and adjustment operations are similar to implants.</p>
--	---

5.6.13 ERROR SIMULATION

UI	Description
	<div>Registration <input type="text" value="0.065mm"/></div> <p>Show registration algorithm error and allow adjustment for simulation purpose.</p>
	<div>Segmentation <input type="text" value="0.523mm"/></div> <p>Show and allow to adjust segmentation errors</p>
	<div>Guide Dimension Error <input type="text" value="0.010mm"/></div> <p>Specify surgical guide making error/dimension</p>
	<div>Hole Position Linear Error <input type="text" value="0.010mm"/></div> <p>Specify surgical guide making error/hole position</p>
	<div>Hole Position Angular Error <input type="text" value="0.010deg"/></div> <p>Specify surgical guide making error/hole orientation</p>



This function will generate a series of locations for an implant, and update all the image views moving the implant from one location to another. By doing this the system simulates the possible errors of the treatment plan and procedure. The user can thus preview the extreme situations and assess the treatment plan. Figure 4.44 shows a series of implant locations in the panoramic view.

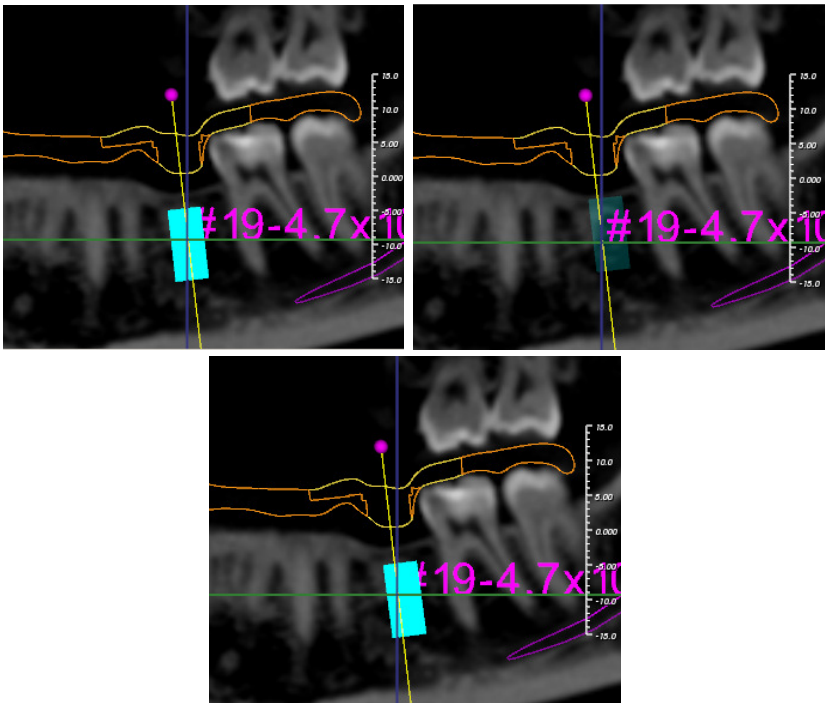




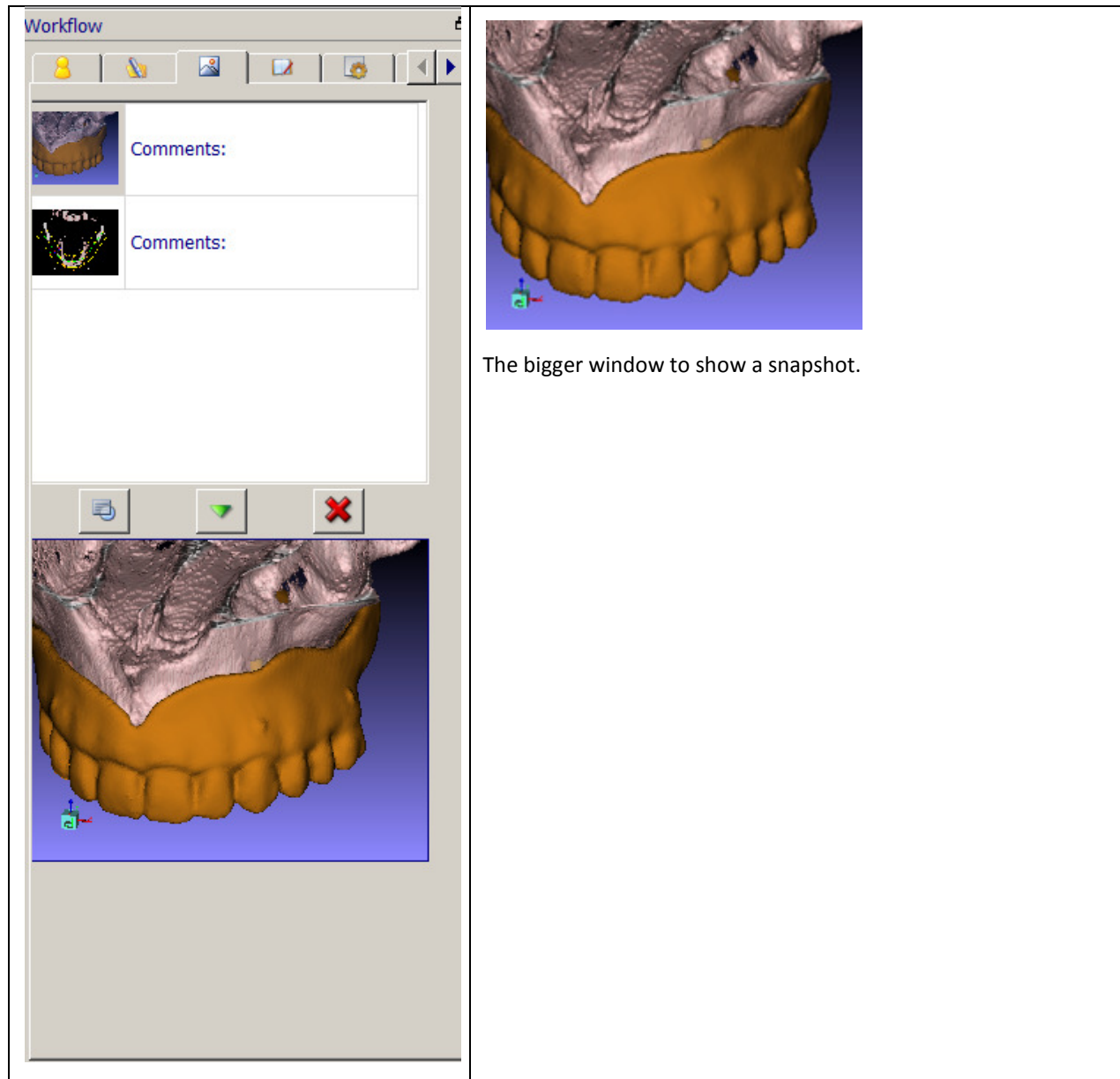


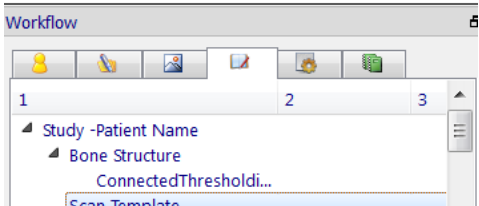
Figure 5.42. A series implant locations













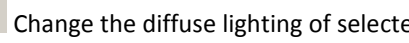
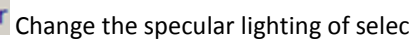
5.6.14 SNAPSHOT (DIAGNOSIS FINDING) MANAGEMENT

UI	Description
	List the snapshots, allow selection.
	 The thumbnail of a snapshot.
	<div>Comments:</div> <div>Show and double click to edit notes/comments.</div>
	 Set the snapshot to be current, meaning, restore one of the image views to the status when the snapshot was captured.
	 Show bigger picture of the selected snapshot
	 Delete selected snapshots



5.6.15 PLANNING AND DESIGN OBJECT NAVIGATOR

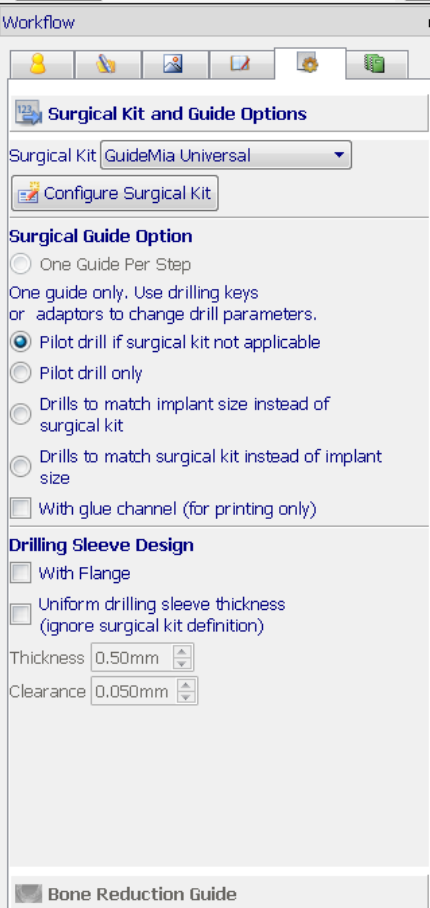
UI	Description
	Use tree list to navigate through the objects created during planning and design.
	The selected object – if applicable – will have their properties shown in the table and allow editing.

	 Update objects by the edited properties.
	 Make current the selected object.
	 Make selected implants parallel to the first selected.
	 Use selected model as the base for surgical guide design
	 Show/Hide selected object in 2D views
	 Show/Hide the selected object in assembly view.
	 Delete the selected object.
	 Cancel object editing
	Color map  Change the color scheme for bone model.
	Color  Change the color of selected object to one of the colors in the pull down menu, or by color selection dialog. The dialog can be brought up by the last item in this combo box.
	Opacity  Change the opacity of selected object.
	Ambient  Change the ambient lighting of selected object.
	Diffuse  Change the diffuse lighting of selected object.
	Specular  Change the specular lighting of selected object.

	Saturation Change the color saturation of selected object.
	Luminance Change the color luminance of selected object.

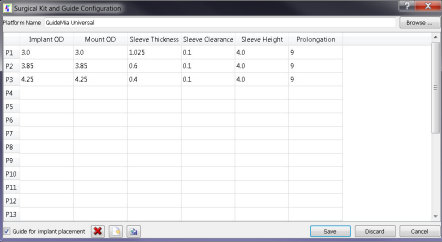
5.6.16 SURGICAL KIT AND GUIDE OPTIONS

Surgical guide options.

UI	Description
	<p>Surgical Kit GuideMia Universal</p> <p>Select surgical kit.</p> <p>Configure Surgical Kit</p> <p>Configure surgical kit.</p> <p>Surgical Guide Option</p> <p>Choose different surgical guide option</p> <p>One guide per step (Not available now)</p> <p>Pilot drill if surgical kit not applicable</p> <p>Pilot drill only</p> <p>Drills to match implant sizes instead of surgical kit</p> <p>Drills to match surgical kit instead of implant size</p> <p>With glue channel</p>

Surgical kit configuration.

UI	Description
----	-------------



Platform Name

Surgical kit name.

Browse definition files.

	Implant OD	Mount OD
P1	3.4	4
P2	4.3	4.9
P2	5	6.1
P4	6	6.1

Kit parameter display

☒ Guide for implant placement

The kit will have implant mounts. The surgical guides will be designed for implant placements. In other words the drilling sleeves are based on the diameters of the implant mounts.

If the option is off, the guides will be designed for osteotomy, which means the inner diameters of the drilling sleeves will be those of the implants.

☒ Delete implant platform

☐ New implant platform

☐ Save configuration as a new file

Save, discard or cancel editing

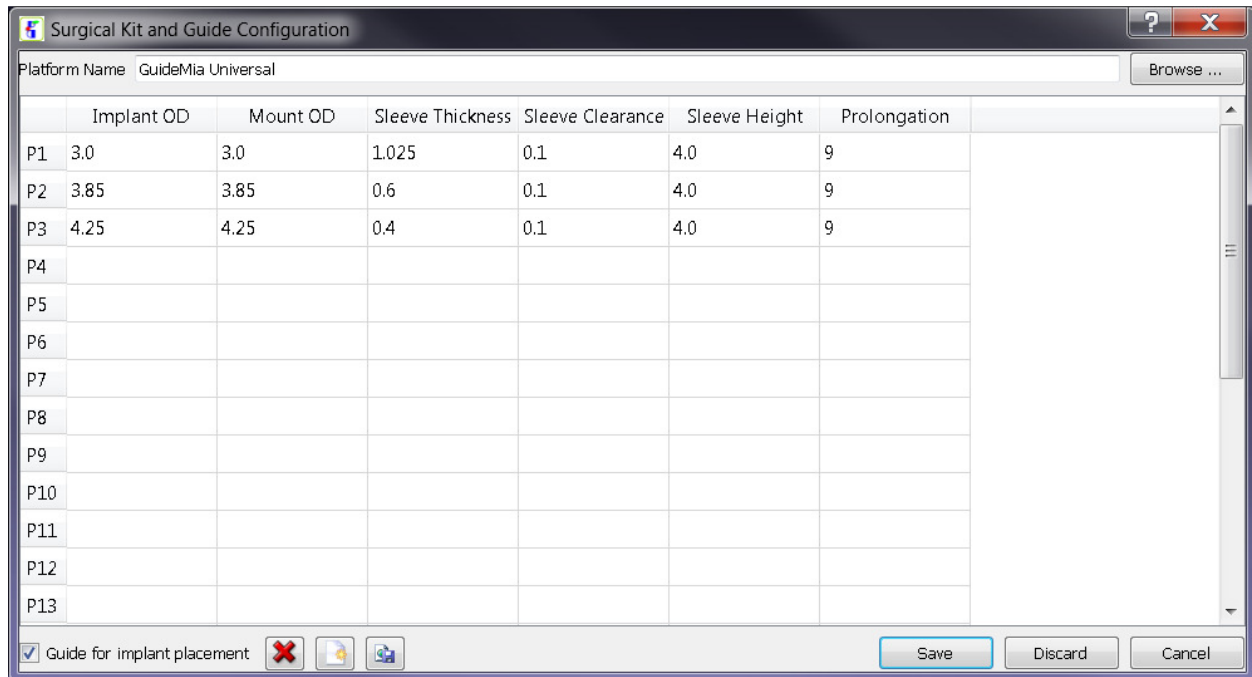












Figure 4.45. Surgical kit configuration dialog

5.6.17 DESIGN SURGICAL GUIDES

UI	Description
	<p>1. Choose style (Cut on guide top)</p> <p><input type="radio"/> Rectangular <input checked="" type="radio"/> Cylindrical</p> <p>Choose surgical guide style. The opening on the top of the surgical guides can be rectangular or cylindrical.</p>
	<p>Drilling preferred: the guide can be drilled, milled or printed. Essentially, no material can be added to the radiographic guide.</p>
	<p>No drilling: the guide can not be a drilled guide from radiographic guide. Materials can be added to the guide as needed.</p>
	<p>2. Define guide type Tissue/tooth-borne Define surgical guide type</p> <p>1. Set guide type to tissue-based</p> <p>2. Set guide type to bone-based guide</p>

 <p>Workflow</p> <p>Surgical Kit and Guide Options</p> <p>Bone Reduction Guide</p> <p>Surgical Guide</p> <p>1. Choose style (Cut on guide top) <input type="radio"/> Rectangular <input checked="" type="radio"/> Cylindrical</p> <p>2. Define guide type Tissue/tooth-borne</p> <p>3. Define guide insertion and thickness <input checked="" type="checkbox"/> Update direction <input checked="" type="checkbox"/> Undercuts 15deg</p> <p>Guide Thickness 3.00mm</p> <p>4. Define the guide base <input checked="" type="radio"/> Track <input type="radio"/> Circle <input type="radio"/> Cut <input type="radio"/> Alternative <input type="radio"/> Reverse <input type="radio"/> Calibrate <input type="radio"/> Reset</p> <p>5. Create guide and features <input type="button" value="Generate/Update Surgical Guide"/> <input type="button" value="Circle"/> <input type="button" value="Trim"/> <input type="button" value="Reset"/></p> <p><input type="button" value="Access opening"/> <input type="button" value="Inspection Window"/> <input type="button" value="Irrigation Window"/> <input type="button" value="Anchor Pin"/> <input type="button" value="CaseTag"/> <input type="button" value="Export STL File"/></p> <p>Master Model</p>	<div> <input checked="" type="checkbox"/> Undercuts 15deg </div> <p>Set the option on/off to remove undercuts in surgical guide. Default is on.</p> <p>Change the undercut angle if the option is on.</p> <div> <input checked="" type="checkbox"/> Update direction <div>Update the guide insertion direction (in order to remove undercuts)</div> </div> <div> <div>Guide Thickness 3.00mm</div> <div>Set guide thickness</div> </div> <div> <p>4. Define the guide base</p> <div> <input checked="" type="radio"/> Track <input type="radio"/> Circle <input type="radio"/> Cut <input type="radio"/> Alternative <input type="radio"/> Reverse <input type="radio"/> Calibrate <input type="radio"/> Reset </div> </div> <p>Prepare data for surgical guides</p> <p>Track: click points on the base model, the system will connect them by tracking the model until the profile is closed.</p> <p>Circle: draw a profile in the design window to cut the base model (bone model or scan of plaster model) to create surgical guide. This is an alternative to the "Track" tool.</p> <p>Cut: Use the profile to cut the base mode.</p> <p>Alternative: there are cases the system actually returns the area outside of the tracking profile. When this happens, this button will switch the result to the inside part.</p> <p>Reset: Undo the cutting</p> <p>Reverse: reverse the normal of the trimmed surface model in order to ensure the direction is good for making guide</p> <p>Calibrate: adjust the plaster model so that it matches the tooth shapes of the CT scan.</p> <p>5. Create guide and features</p> <p>Design surgical guides</p>
--	--

	 Generate/Update Surgical Guide Generate the guide model. This single button will include all the combinations of surgical kits, guide type, manufacturing method, etc.
	 Circle Circle an area on the surgical guide
	 Trim Trim the guide to keep the circled area
	 Reset Reset the model trimming
	 Access opening Add access opening to a surgical guide
	 Inspection Window Add inspection window by the profile specified by the circle tool
	 Irrigation Window Add irrigation window
	 Anchor Pin Add anchor pin
	 CaseTag Add case tag
	 Export STL File Export surgical guide as STL file

The tracking tool is to select a region on the base model, from which a surgical guide will be created. The operation is illustrated in the following. The stone model is used as a base, a profile/boundary is created, a surgical guide base is created by selecting area within the profile, and then the surgical guide is created for the planned implant. The surgical guide is added into the object navigator, and can then be viewed by all the 2D and 3D views.

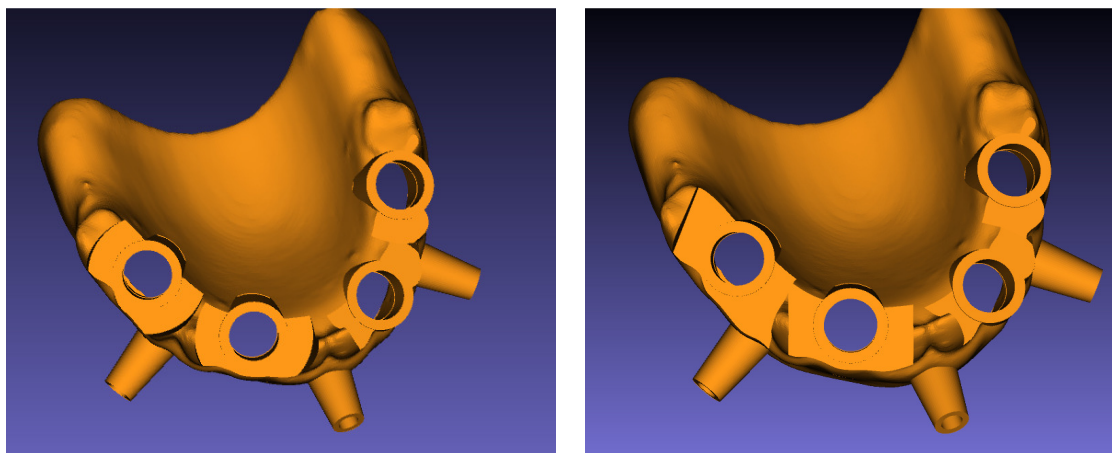
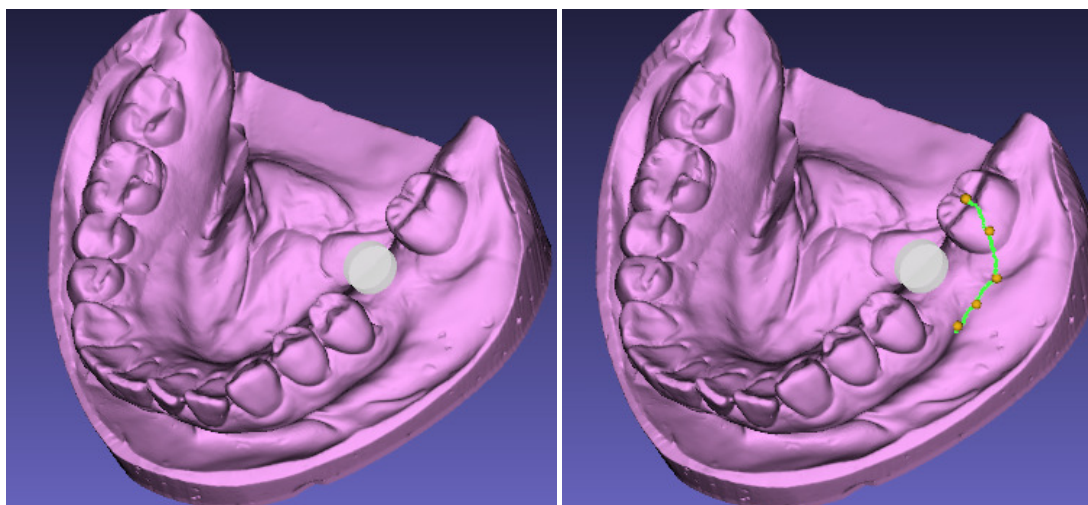
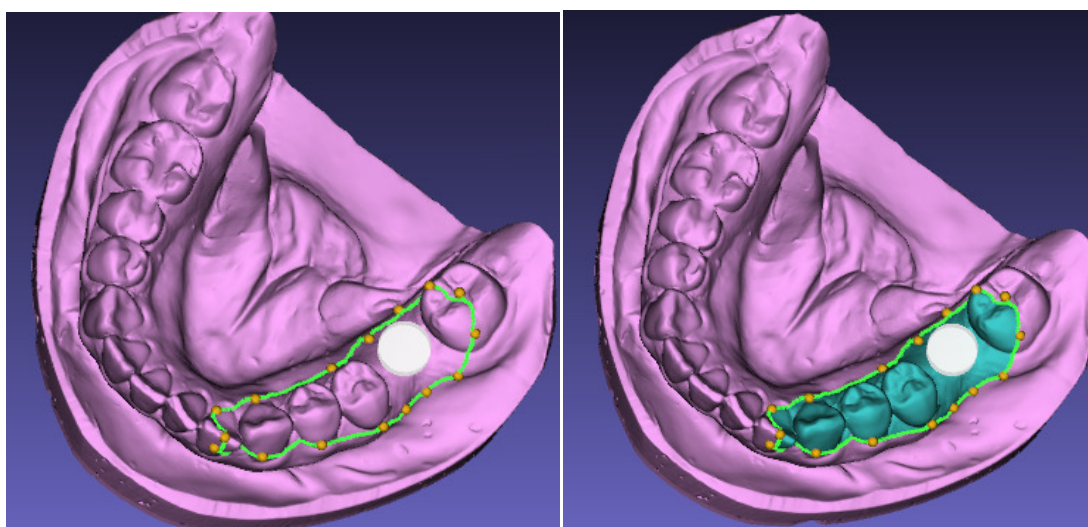


Figure 5.43. Surgical guide styles with cylindrical cuts or rectangular.



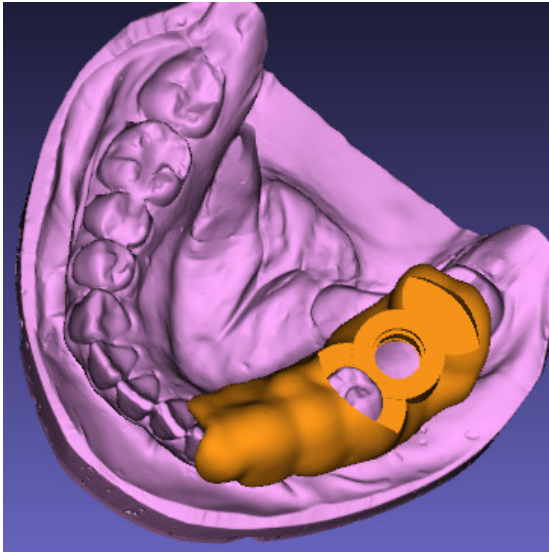
(a) Initial base model

(b) Tracking a boundary

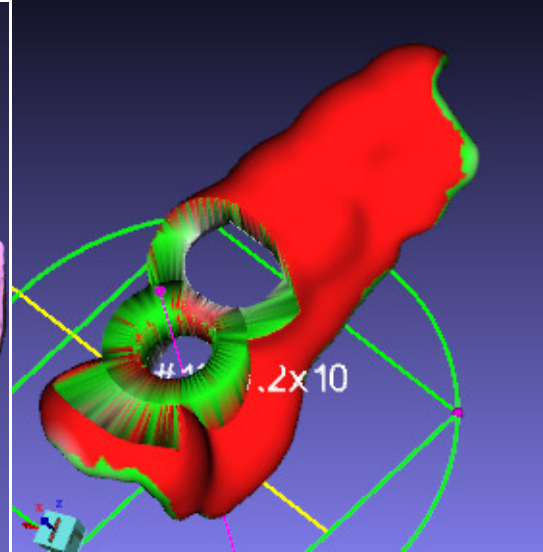


(c) Finish defining the boundary

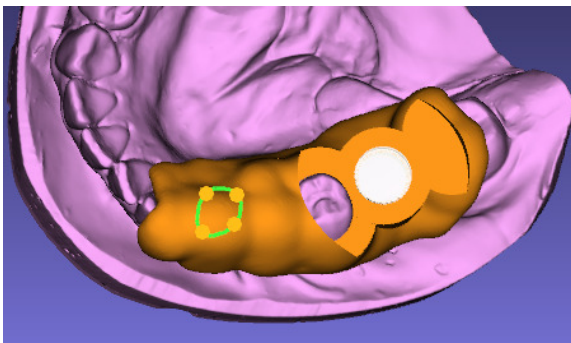
(d) Cut the base model for guide design



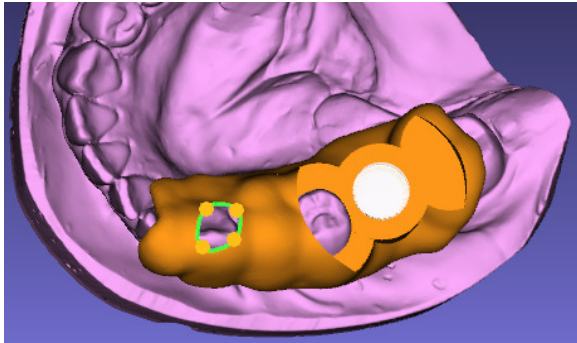
(e) Surgical guide designed.



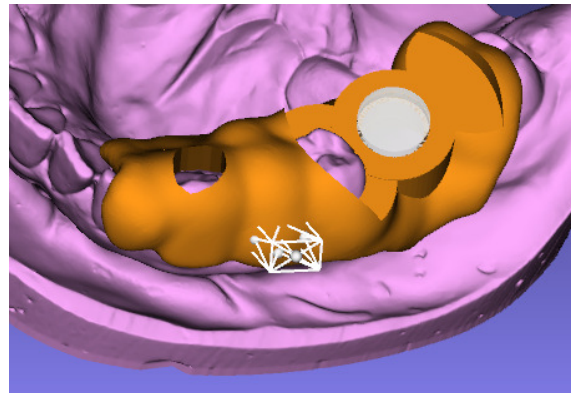
(f) Surgical guide is planning view with distance map



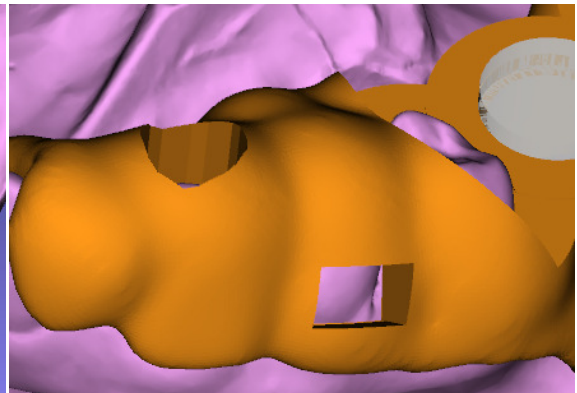
(g) Define a profile for inspection window



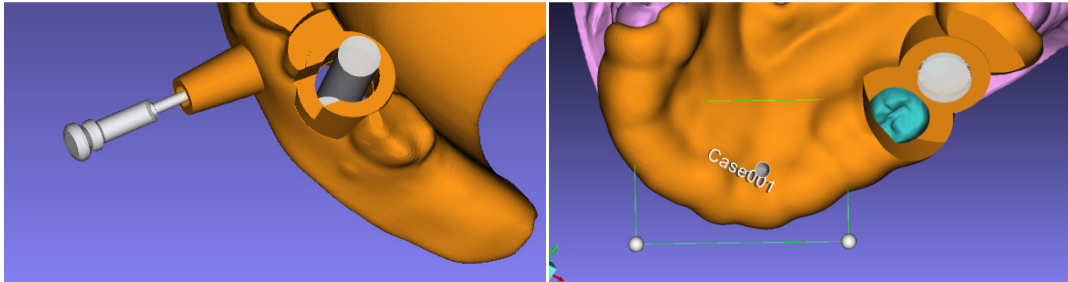
(h) Cut the inspection window



(i) Define an irrigation window

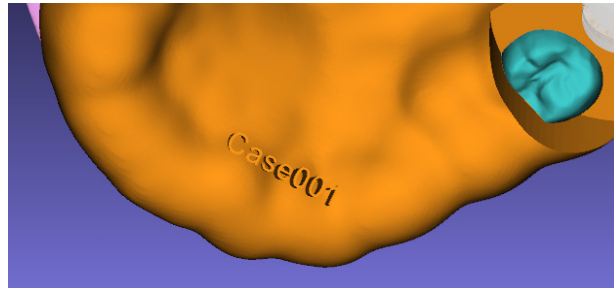


(j) Finished irrigation window



(k) Access opening

(l) Defining case tag



(m) Finished case tag

Figure 5.44. Surgical guide design process. This process is for tissue-level guides based on stone model or bone level guides

5.6.18 DESIGN MASTER MODELS

UI	Description
	<div> Master Anatomy Model Generate or Update </div> <p>Generate or update anatomy model (a component of the master mode)</p>
	<div> Export STL File </div> <p>Export STL file</p>
	<div> Master Stone Model Generate or Update </div> <p>Create or update master stone model</p>

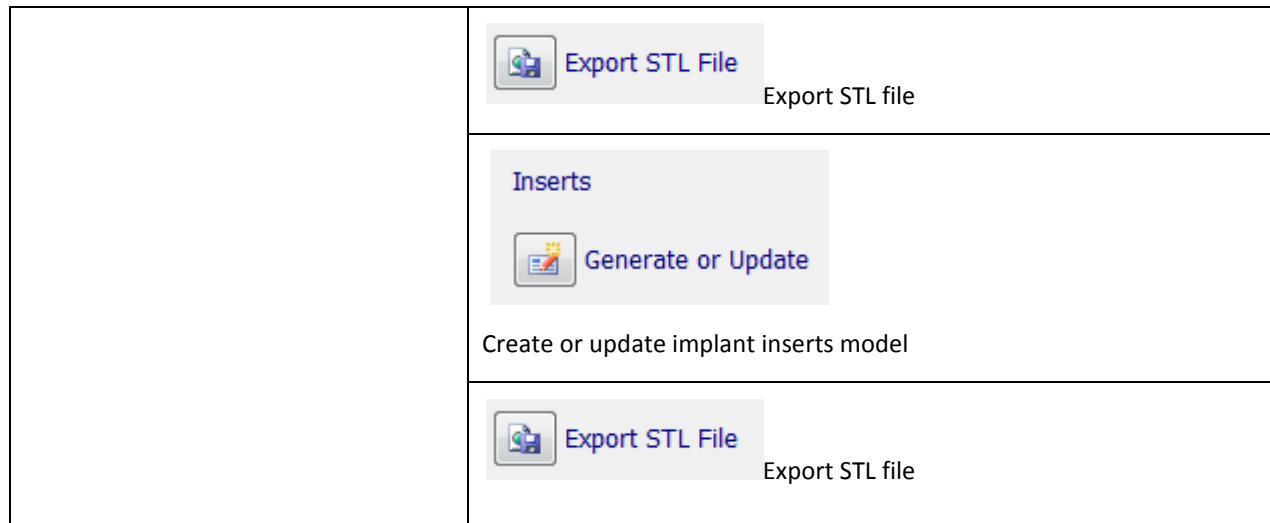


Figure 4.47 gives an illustration of the master model created from radiographic guide and bone structure. Figure 4.48 is one created from optical scan of the stone model.

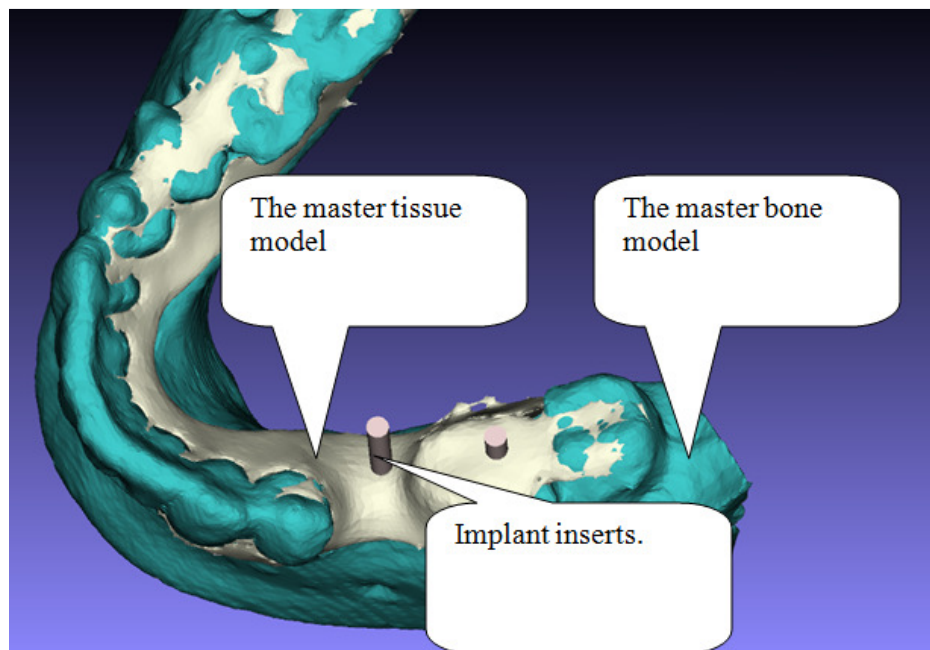


Figure 5.45. Master model and implant inserts for a dual scan case with radiographic guide.

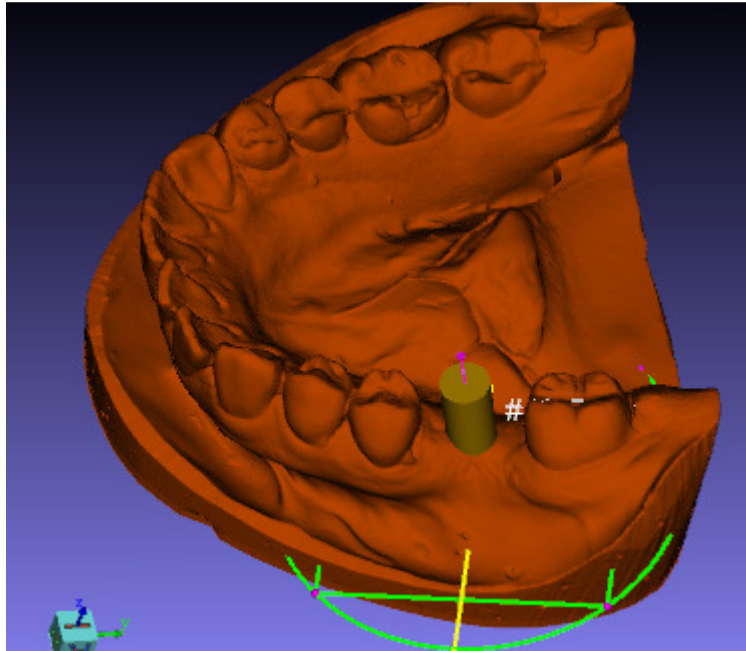





Figure 5.46. Master model and implant inserts for a dual scan case with optical scan of a stone model.

5.6.19 GENERATE TREATMENT PLANS

UI	Description
<div data-bbox="191 1142 597 1583"> <p>Workflow</p>  <p>Planner/Doctor: John Smith</p> <p>Business Name: ABD Dental Clinic</p> <p>Telephone: 123-456-7890</p> <p>Email: abc@abcdental.com</p> <p>Additional Comments</p> <p>Additional comments: None.</p> <p><input type="checkbox"/> Volume Rendering</p> <p><input type="checkbox"/> Bone Quality</p> <p><input checked="" type="checkbox"/> Generate Report</p> </div>	<div data-bbox="646 1142 1159 1310"> <p>Planner/Doctor: John Smith</p> <p>Business Name: ABD Dental Clinic</p> <p>Telephone: 123-456-7890</p> <p>Email: abc@abcdental.com</p> </div> <p>Input operator/planner's name and contact information that will be shown in the reports.</p> <div data-bbox="646 1436 1110 1528"> <p>Additional Comments</p> <p>Additional comments: None.</p> </div> <p>Add additional comments</p> <div data-bbox="646 1625 883 1675"> <p><input type="checkbox"/> Volume Rendering</p> </div> <p>Set to generate images for the plan using volume rendering</p>

	 Bone Quality Set to generate images mapping bone density into colors.
	 Generate Report Generate report and browse it in web browser

A treatment plan has the following sections:

- 1. Customer (dental office, lab, etc) log and GuideMia logo.**
- 2. Title with customer address and contact**
- 3. Patient basic information**
- 4. Plan overview, including**
 - a. Implant list**
 - b. Anchor pins**
 - c. Drilling instructions**
 - d. Surgical guide**
 - e. Plan overview pictures (slices, cross sections, bone model, surgical guide, etc)**
- 5. Tooth Extraction: list screen shots and notes**
- 6. Bone Reduction : list screen shots and notes**
- 7. Bone Grafting : list screen shots and notes**
- 8. Sinus Grafting : list screen shots and notes**
- 9. Diagnosis And Planning Notes : list screen shots and notes**
- 10. Implants: List 16 cross section views for each implant**

5.7 MOUSE EVENTS

5.7.1 2D VIEWS

The following are the basic operations in all the 2D views.

1. **MB1: selection or input tool.** For example, if an implant is showing, clicking on it will show its placement widget. If defining a distance, MB1 will specify one of the two points.
2. **MB1 press, move and release:** If an object (such as a handle) is selected, this will move the object, otherwise, adjust the window/level values for thresholding. The threshold values will be shown in the status bar at the bottom of the system window.
3. **MB2 press, move and release:** pan the viewport of the rendering.
4. **MB3 press, move and release:** zoom in and out.
5. **MB3: stop the underlying operation, or exit from a repeatable operations.** For example, if the user is defining a nerve channel by adding nodes, MB3 will finish the channel definition.
6. **MW: scroll through the image slices.**
7. **CTRL_MB1: fast scroll through the slices**
8. **MB1 Double click:** if mouse is over an implant, the implant library dialog will popup. Otherwise, change 2D view slice lines to the clicked point and show slices accordingly.
9. **Mouse move over pixels: show pixel Hounsfield unit values**

5.7.2 3D VIEWS

The following are the basic operations in 3D windows:

1. **MB1: selection or input tool.** For example, if an implant is showing, clicking on it will show its placement widget. If defining a distance, MB1 will specify one of the two points.
2. **MB1 press, move and release:** rotate the image, in other words, rotate the viewing 'camera'.
3. **MB2 press, move and release:** pan the viewport. As a result, all the rendered objects are moved.
4. **MB3 press, move and release:** zoom in and out.
5. **MB3: stop the underlying operation, or exit from a repeatable operations.** For example, if the user is defining a nerve channel by adding nodes, MB3 will finish the channel definition.
6. **MW: MW is only used in certain operations,** for example, move the cross section plane along the arch curve if in this clipping mode, update the implant neighborhood size when inspecting the neighborhoods, etc.

5.7.3 ARCH CURVE INTERACTIONS

1. Initialize arch curve by axial view

2. Move arch curve by drag and drop
3. Adjust arch curve by handles
4. Update panoramic view following the arch curve

5.7.4 SLICE LINES AND REGION OF INTEREST

1. Show (Initialize) slice lines and region of interest in all 2D views
2. With Panoramic view, show slice lines in sagittal and coronal views, arch curve and cross section line in axial views.
3. With cross section mode in 3D views, show a cross section line in axial window accordingly.
4. All slice lines in all views are associated and move together.
5. All 2D views will have scales/rulers
6. The changes of and region of interest boxes will trigger the update of bone segmentation

5.7.5 PLACEMENT WIDGET INTERACTIONS

In 2D views, the following interactions will be implemented:

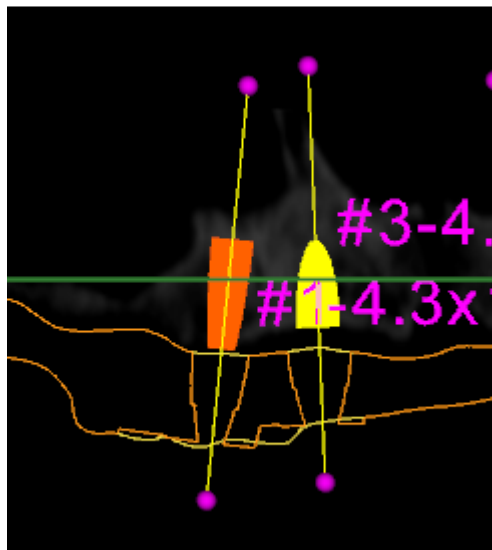


Figure 5.47. 2D placement widget

1. **MB1 drag and drop placement handles: rotate model and widget about tip or top point of an implant, or center of any other object**
2. **MB1 drag and drop the center line of a placement widget: : rotate model and widget about center of the underlying object**
3. **MB2 on handles: shift the shown slice to the center of the underlying object**
4. **MB1 drag and drop on the model: move the widget and model**
5. **MB2 drag and drop on the two triangles like handles for objects other than implants: reposition the placement widget to another location of the model.**
6. **All changes of will be propagated to all image windows**

In 3D views, the following interaction will be implemented:

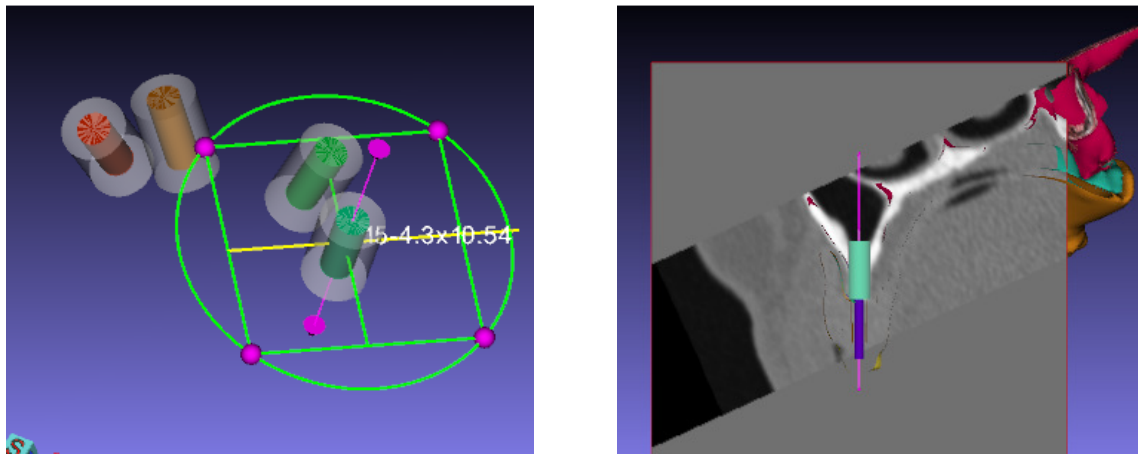


Figure 5.48. 3D placement widget

7. Full 3D widget mode:

- MB1 drag and drop spherical handles: rotate implant about its center line
- MB1 drag and drop on arrow head: rotate implant around its center
- MB2 drag and drop on arrow head: move implant along center line
- MB1 drag and drop the implant model: move the implant to new location
- MB1 drag and drop the four square sides: rotate the model about X or Y axis of the placement widget

8. Cross section mode:

- MB1 drag and drop on arrow head: rotate implant around the axis defined by center line and view normal.

- MB1 drag and drop the implant model: move the implant to new location on the cross section plane.
 - MB2: change the orientation of the cross section plane, and update the cross section line in 2D axial view.
 - MB1 to change the thresholding
9. All changes of will be propagated to all image windows

5.8 CONFIGURATION AND CUSTOMIZATION

System will work out of box without user customization. Limited user configuration can be done through an external file config.dat. This file also serves as a place to save system settings or status. It has the following data items.

This file config.dat is in C:\Users\[AccountName]\AppData\Roaming\GuideMia. In this path "AccountName" represents your windows login.

ImageDirectory	where the image data are stored. System will start from here in the project/new dialog.
view2DColor	view color mode or black/white mode in 2D views
view2DColorMapMode	view bone quality mode in 2D views
view2DWindow	the "window" value for 2D views
view2DLevel	the "level" value for 2D views
scanTemplateWindow	the "window" value for radiographic guide segmentation or visualization
scanTemplateLevel	the "level" value for radiographic guide segmentation or visualization

6 . TREATMENT PLANNING WORKFLOW

6.1 WORKFLOW

This chapter will guide you through a comprehensive treatment planning workflow. The following is the quick index for the treatment planning steps. Each of them corresponds to one or two pages of screenshots along with annotations in section 6.5.

1. New project
2. Image window interactions
3. Threshold adjustment
4. Load radiographic guide
5. Automatic registration of radiographic guide
6. Use object navigator to browse objects
7. Bone segmentation
8. Undo/redo. Save project
9. Browse project file
10. Thresholding of radiographic guide
11. Create tooth model
12. Adjust tooth model by cutting
13. Surface rendering
14. Bone model from surface peeling simulation
15. Simulate tooth extraction
16. 2D views: panoramic view, arch curve manipulation, slice changes
17. 2D views: color mode
18. Manual registration of radiographic guide
19. Specify markers
20. Registration report
21. Finish registration
22. Create virtual tissue model
23. Generated virtual tissue model
24. Nerve drawing
25. Finished nerves
26. View nerve with bone structure
27. Model navigator and model display editing
28. More about model navigator
29. Plan tooth extraction
30. Review tooth extraction in snapshot navigator
31. Plan bone grafting and sinus grafting
32. Capture snapshots
33. Add additional references and virtual teeth

34. Virtual tooth manipulation with placement widgets
35. Implant planning - select implant from library
36. Implant planning - add implant
37. Implant planning - adjust implant parameters and advanced operations
38. Implant planning - more placement operations
39. Implant planning - make implants parallel
40. Implant planning - implant position adjustment
41. Treatment plan error simulation

Implant treatment planning workflows in GuideMia are classified by the patient situations and the choices of treatment planning approaches.

6.2 CLINICAL CASES

The clinical cases can be classified as:

1. Lower jaw fully edentulous cases
2. Upper jaw fully edentulous cases
3. Lower jaw partially edentulous cases
4. Upper jaw partially edentulous cases

All the cases can come with variations in the following areas:

1. With variations of bone modification (either grating or reduction), tooth extraction, sinus grafting, etc
2. Without any of such treatments

6.3 TREATMENT PLANNING APPROACHES

Treatment planning approaches are concerned about both the inputs and the outputs. The main input data includes the following.

1. For all the cases, the patient CT scan is a necessary input.
2. Radiographic guides are used to classify clinical cases.
 - a. Cases based on CT scan of radiographic guides
 - b. Cases not based on CT scan of radiographic guides.
3. Additional data
 - a. Cases using other data sources such as digital models of patients' oral-dental structures or plaster models.
 - b. Cases not using other data sources, meaning, cases based on CT scan only.

Treatment planning can be also categorized by the outputs.

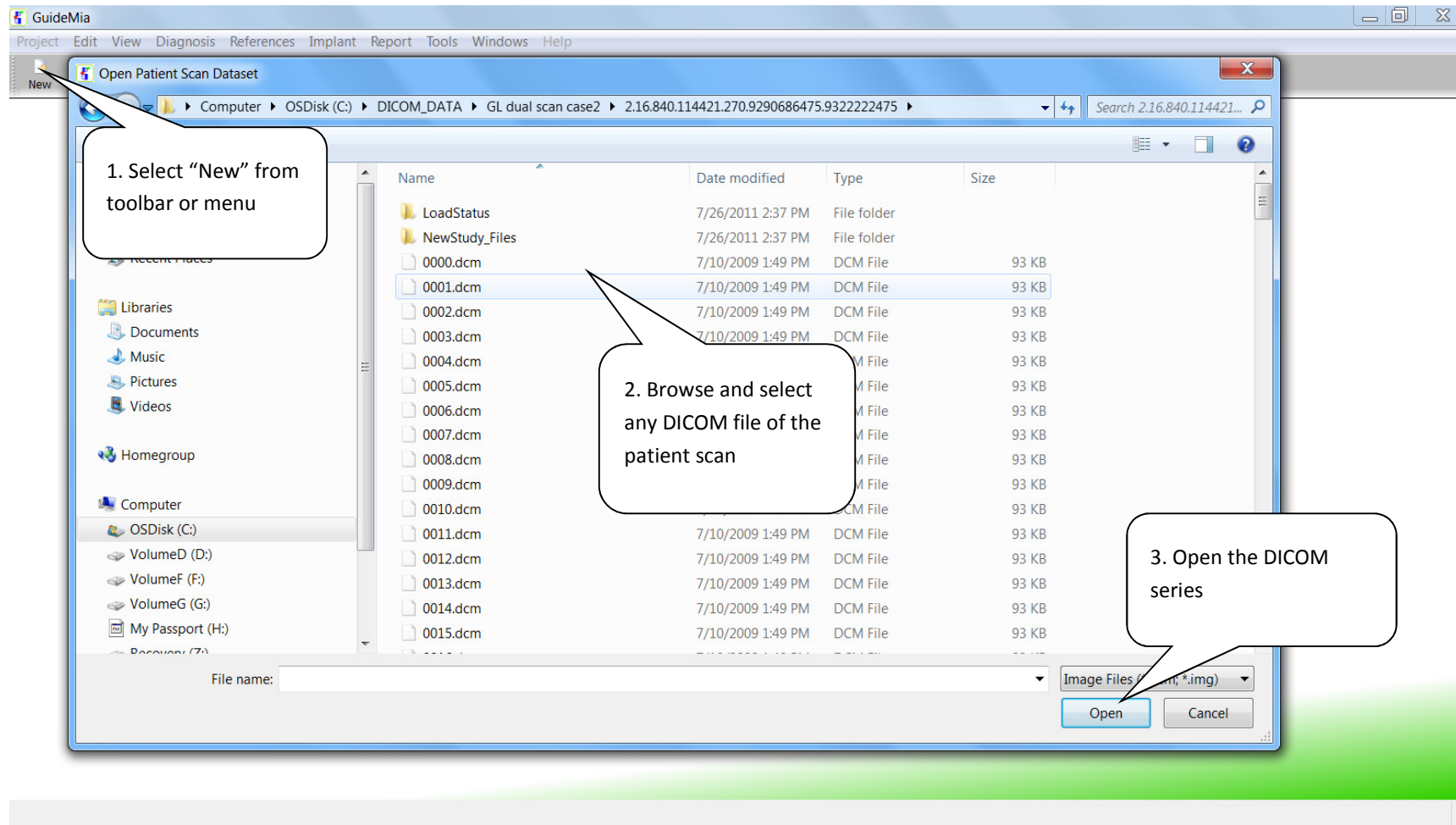
1. Cases generating surgical guides.
2. Cases generating digital models of patients' anatomy embodied with implant information, from which surgeons can further plan a treatment plan, and make surgical guides using any approved lab procedures.

6.4 VARIATIONS OF THE WORKFLOWS

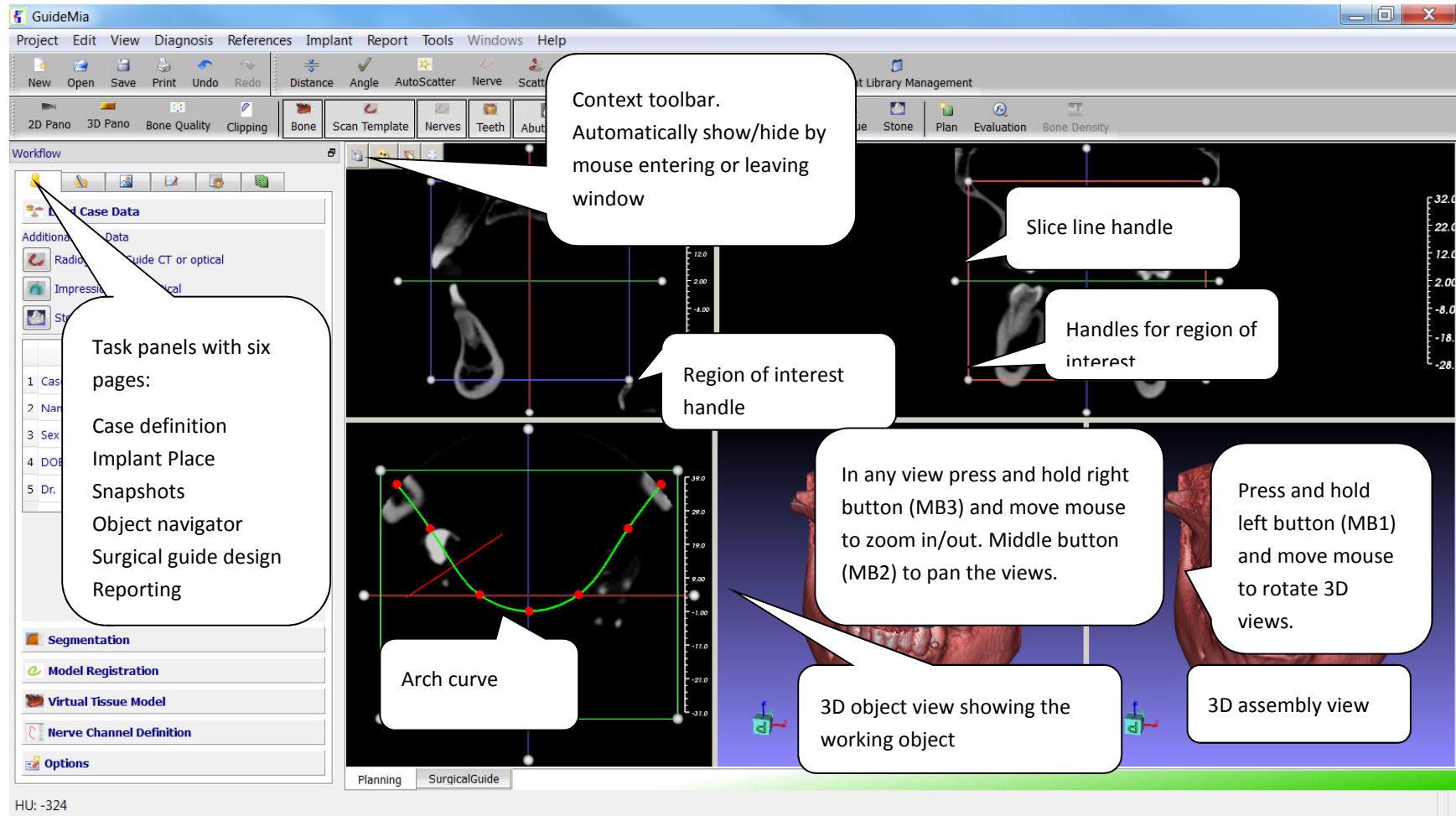
In general treatment planning has four categories of clinical cases as far as the involved steps in a workflow are concerned:

- Treatment planning with patient CT scan only. No surgical guide will be required or generated.
- Treatment planning with patient CT scan, and additional models (either CT scan or optical scan) that can provide references for planning. No surgical guide will be required or generated.
- Treatment planning with patient CT scan only. Surgical guide will be generated based on patient scan only.
- Treatment planning with patient CT scan, and additional models (either CT scan or optical scan) that can not only provide references for planning, but also serve as base models for surgical guide design. Surgical guide will be designed and output.

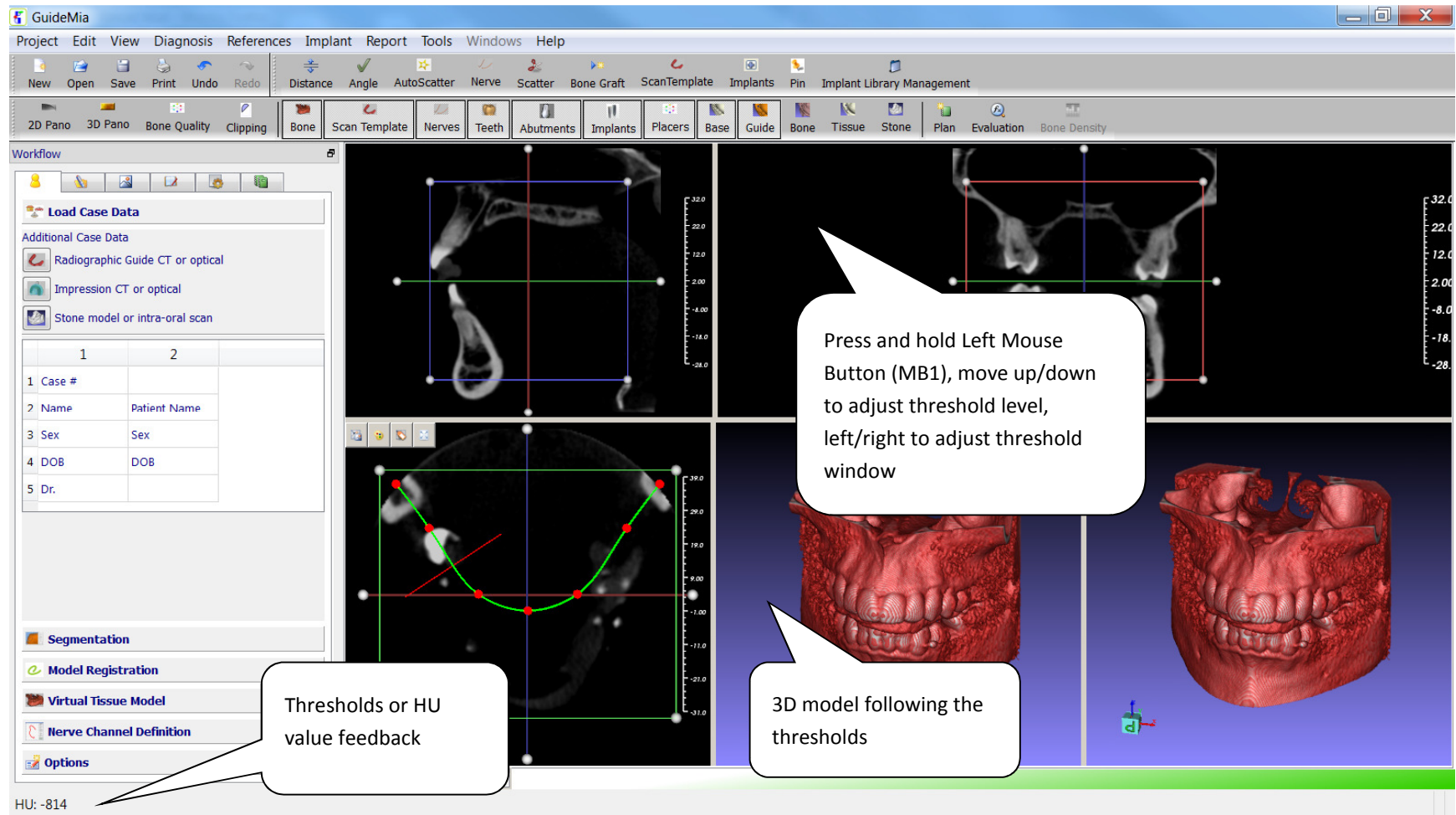
6.5 WORKFLOW STEPS



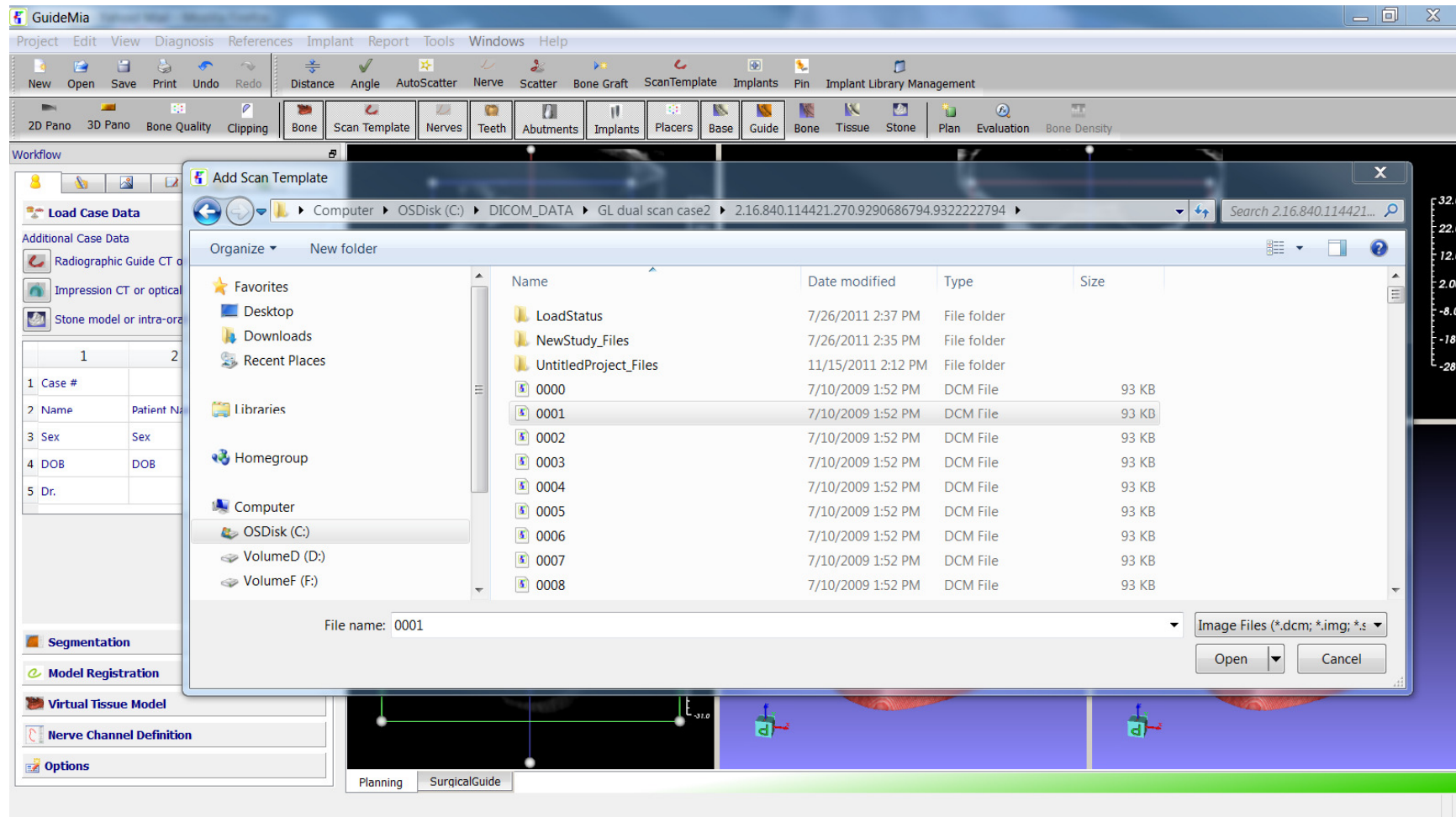
Step 1. New project.



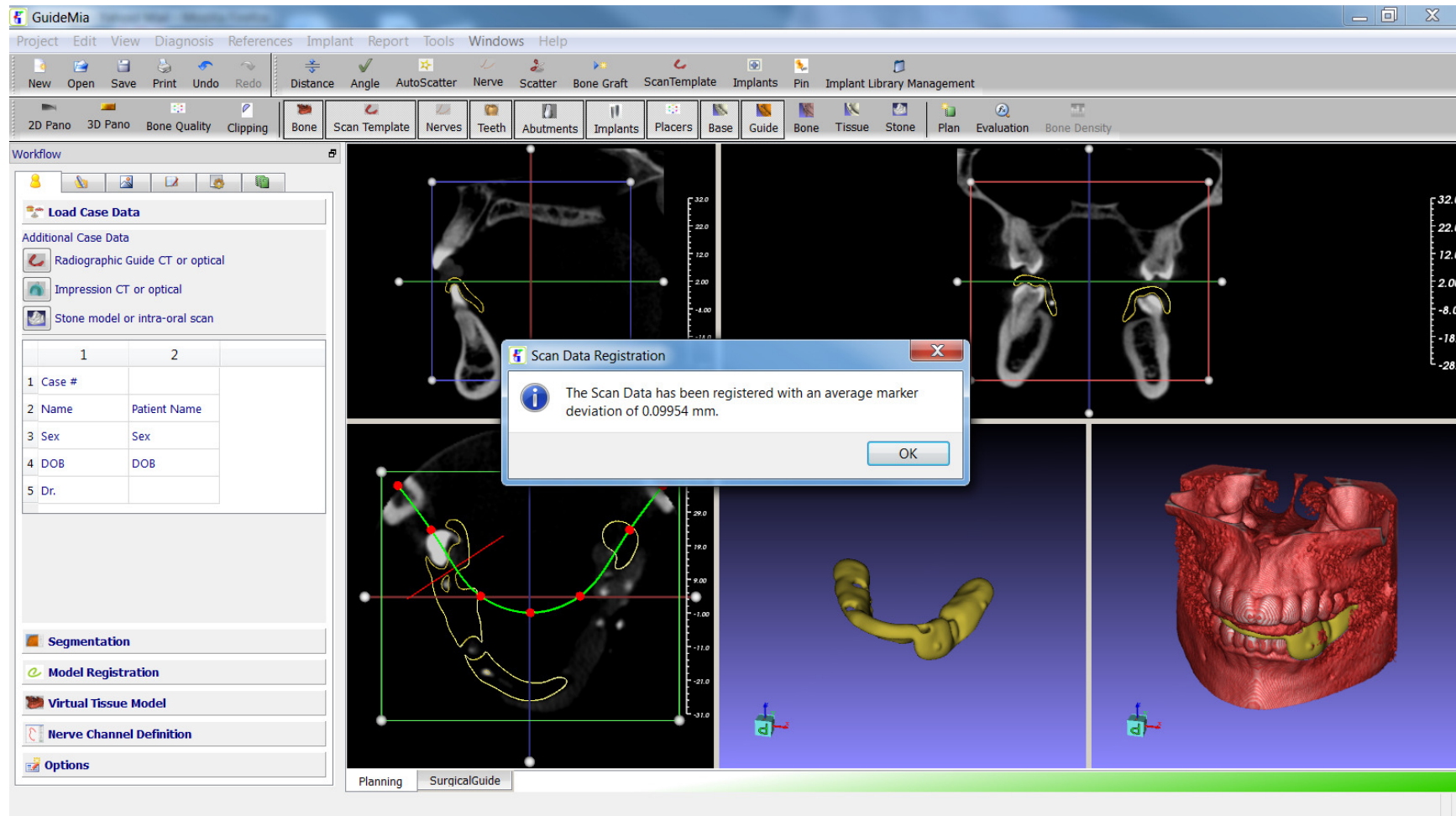
Step 2. Window upon case opening. There are three 2D slice windows and two 3D views. Please see the picture for some basic operations



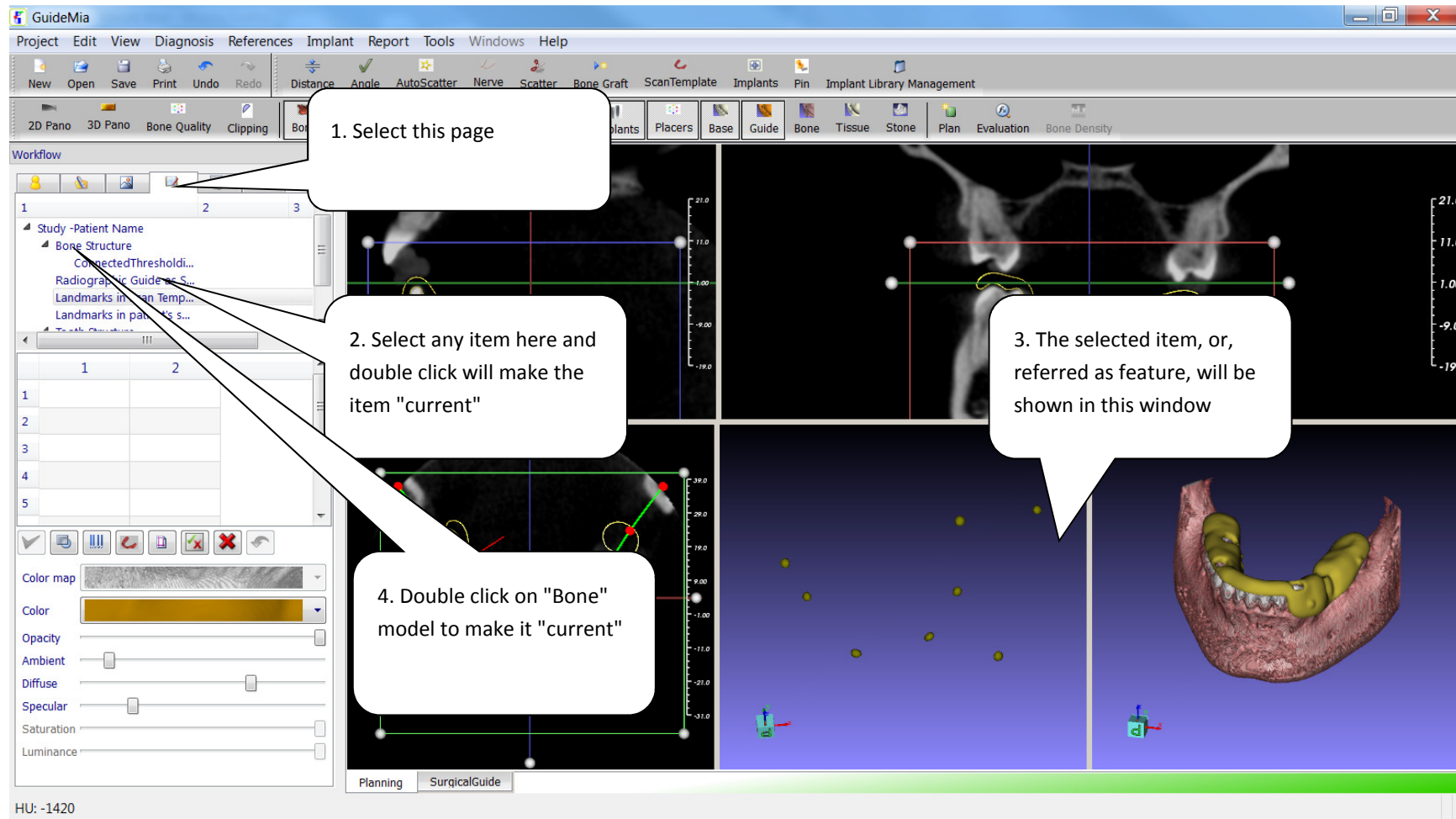
Step 3. Bone threshold adjustment.



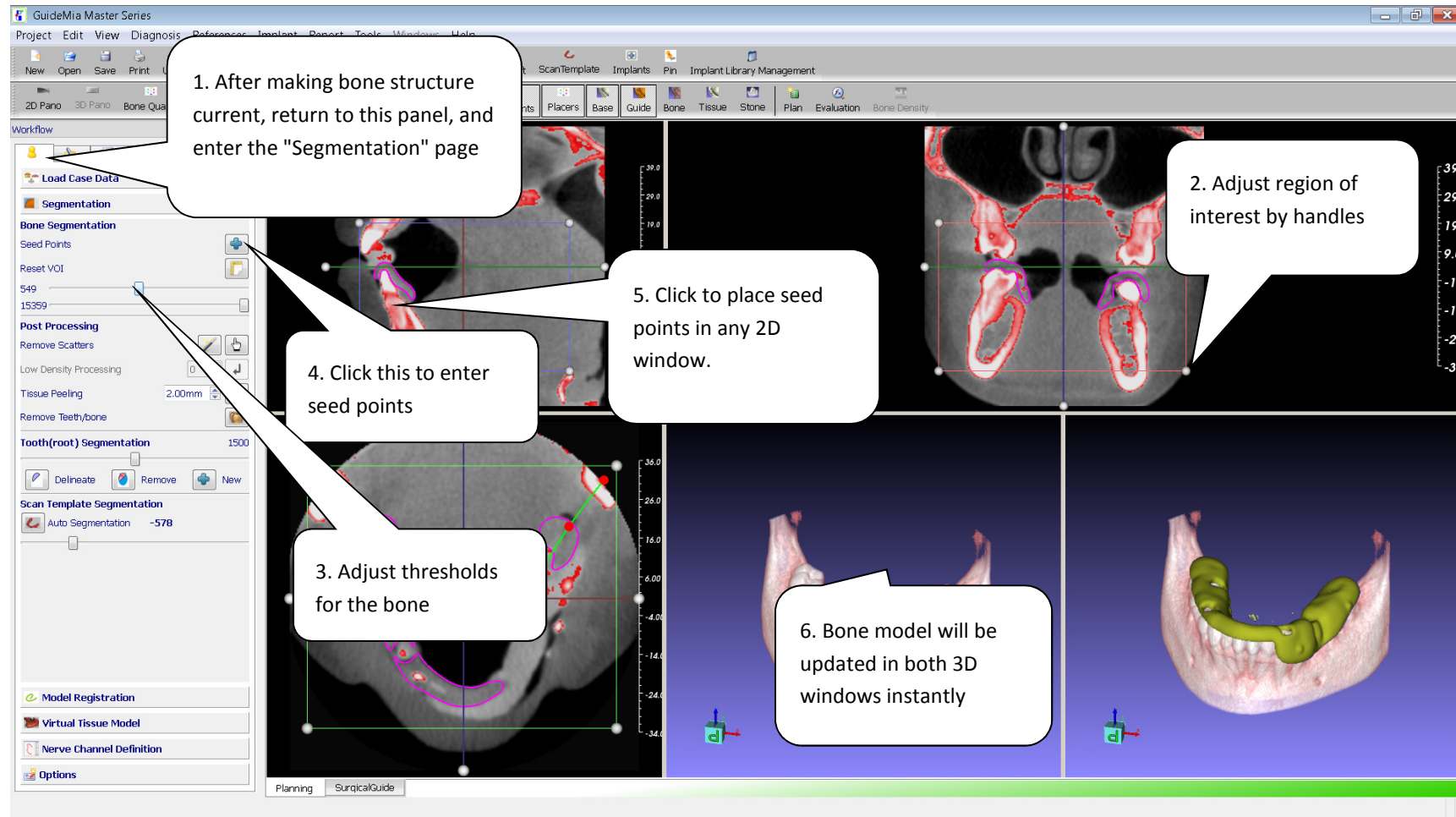
Step 4. Load scan of radiographic guide, or, scan template. Same as loading patient scan, one DICOM file needs to be specified.



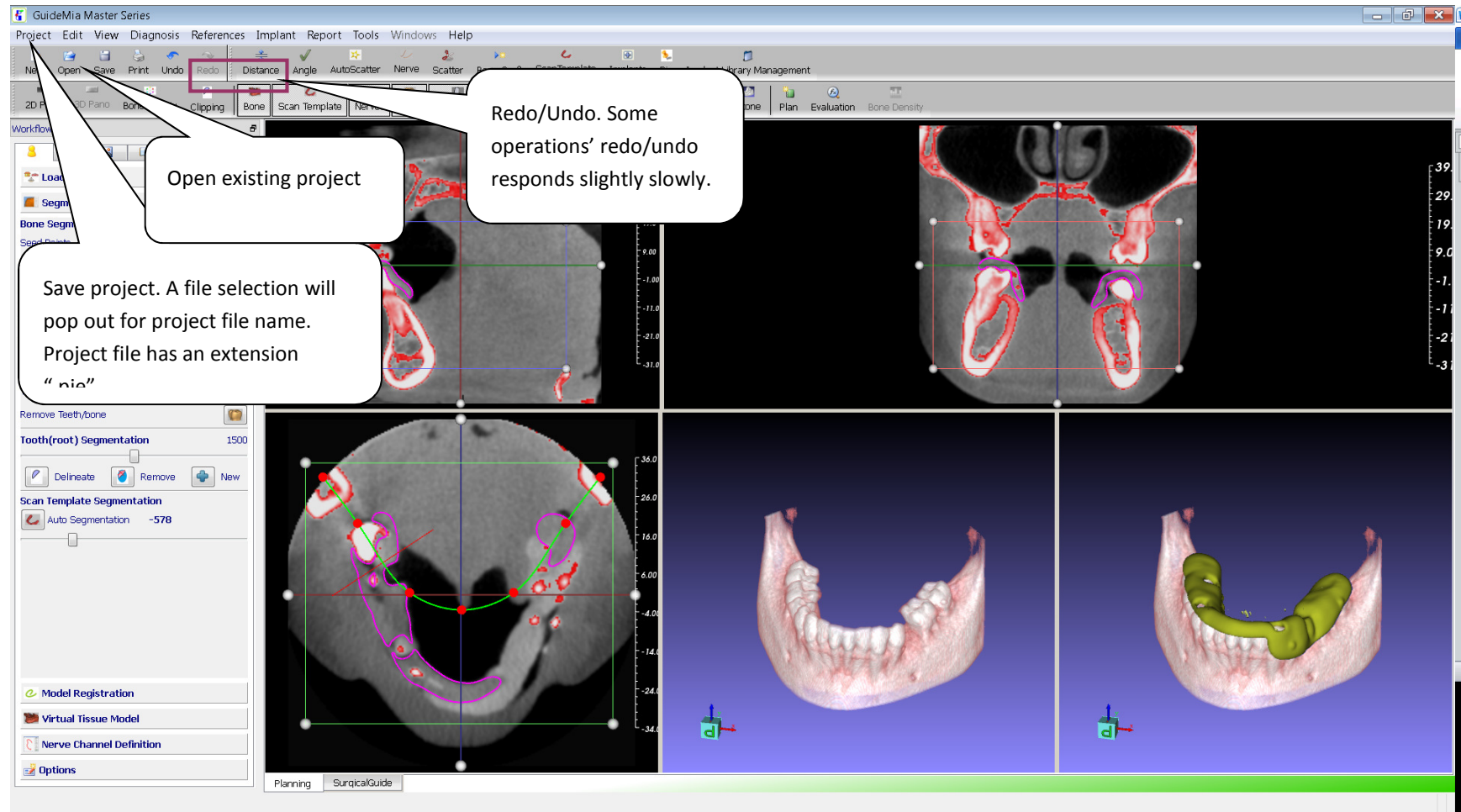
Step 5. After loading radiographic guide, or scan template, registration of the guide and the patient scans are automatically performed. The message window shows the approximate marker deviations between the two scan. The registration can also be manually done as illustrated later. The initial thresholds of the radiographic guide depend on the last session, and can be adjusted later.



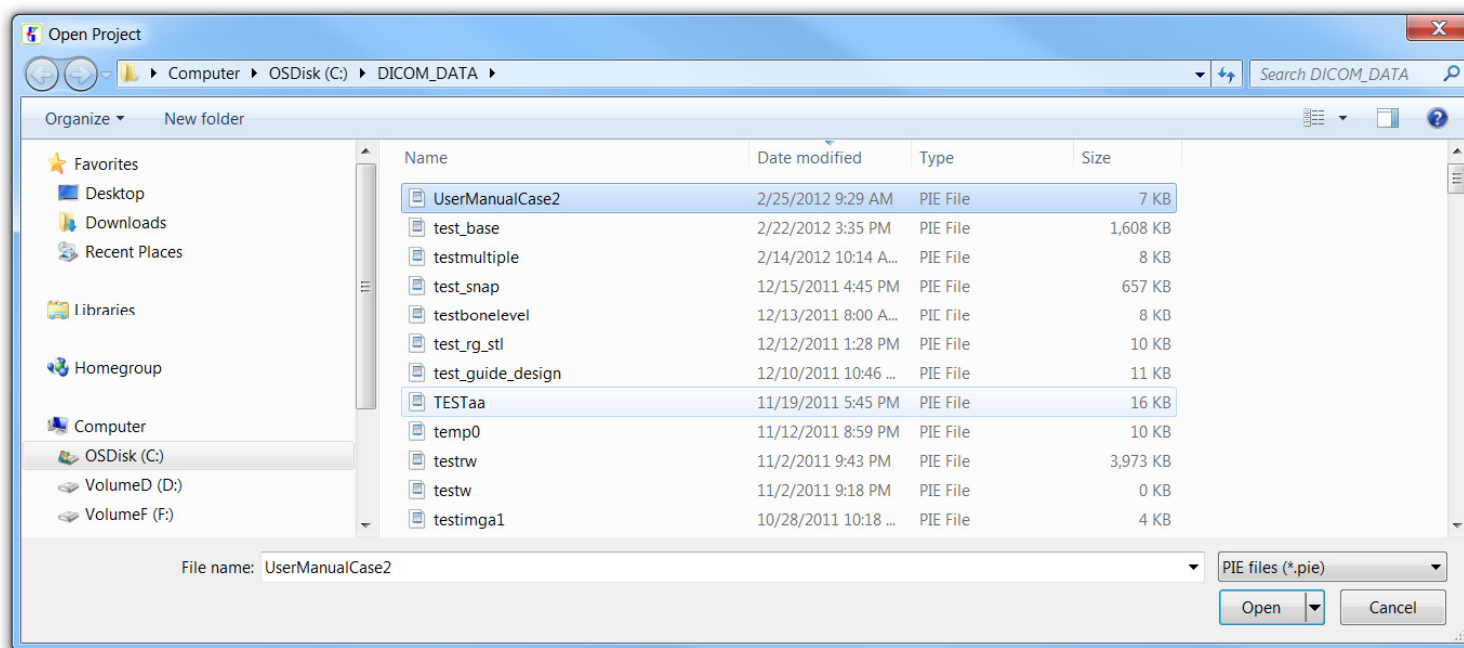
Step 6. Using object navigator to view the radiographic markers. More operations with the navigator will be introduced later.



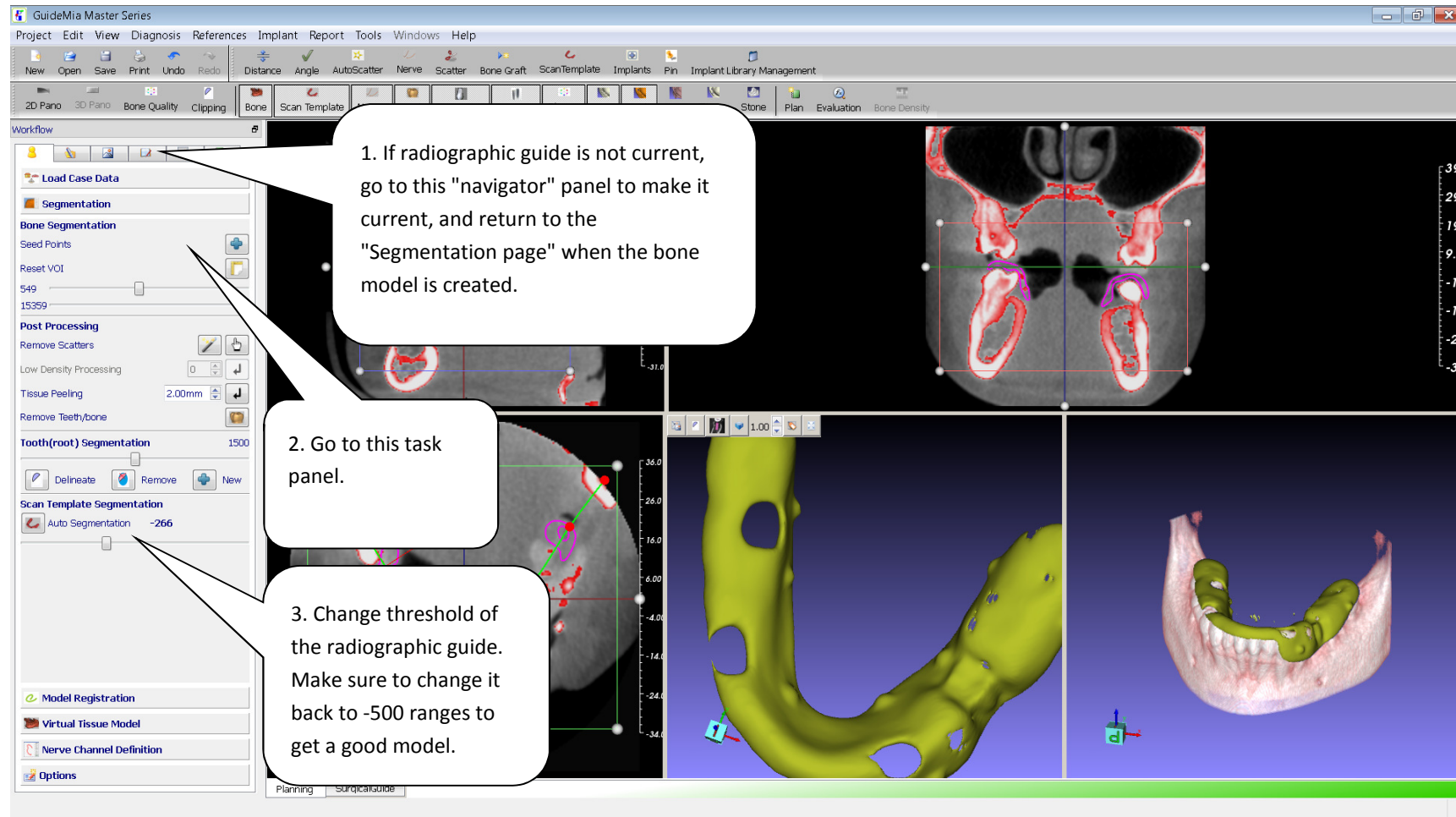
Step 7. Bone segmentation. It has three basic inputs: region of interest, seed points, and thresholds.



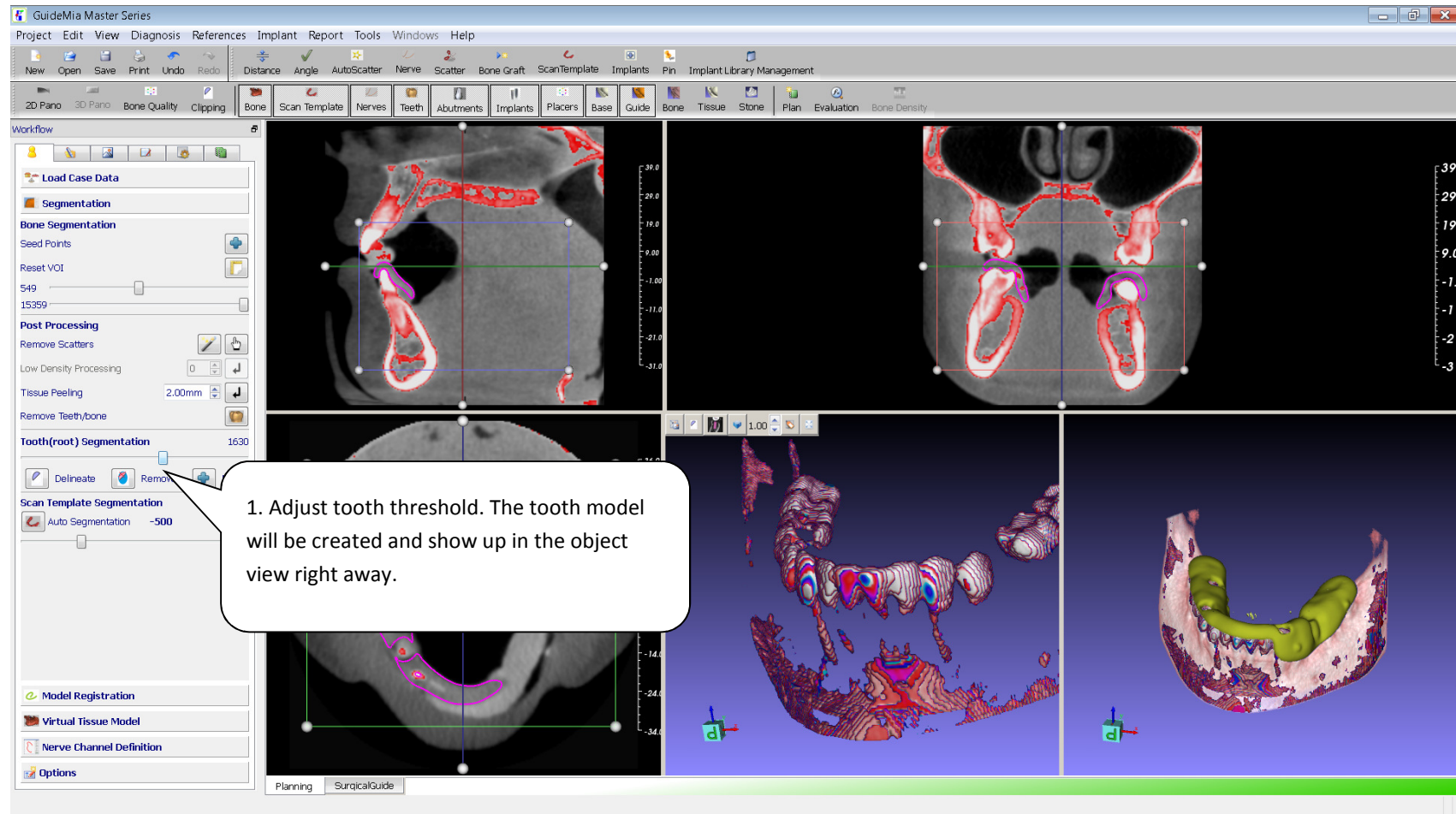
Step 8. Save Project, and some other operations.



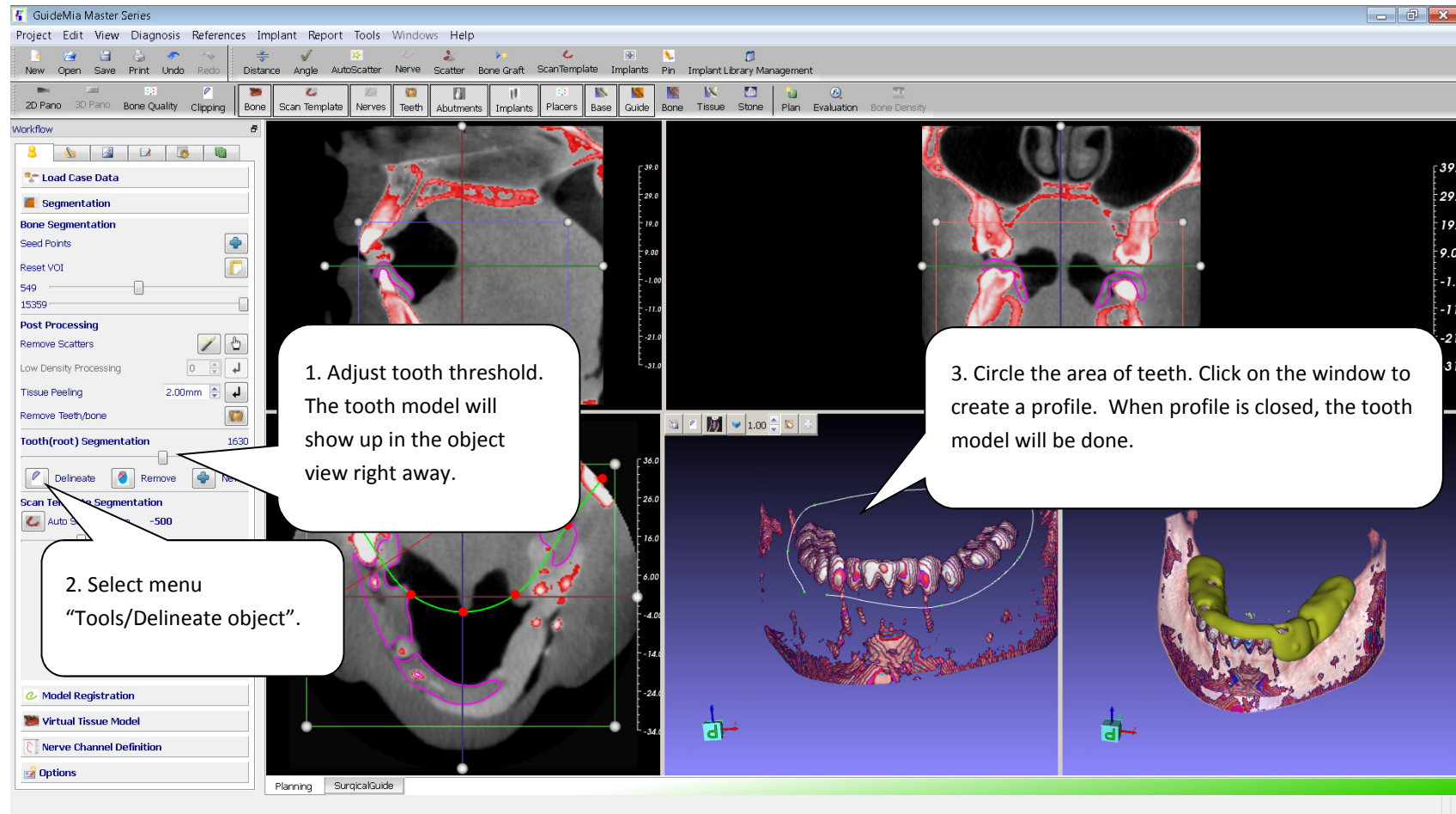
Step 9. Go to menu "Project", select "Close" to close project, "Exit" to end the session, and then restart GuideMia, open project, and go to the "Segmentation" page to continue this case.



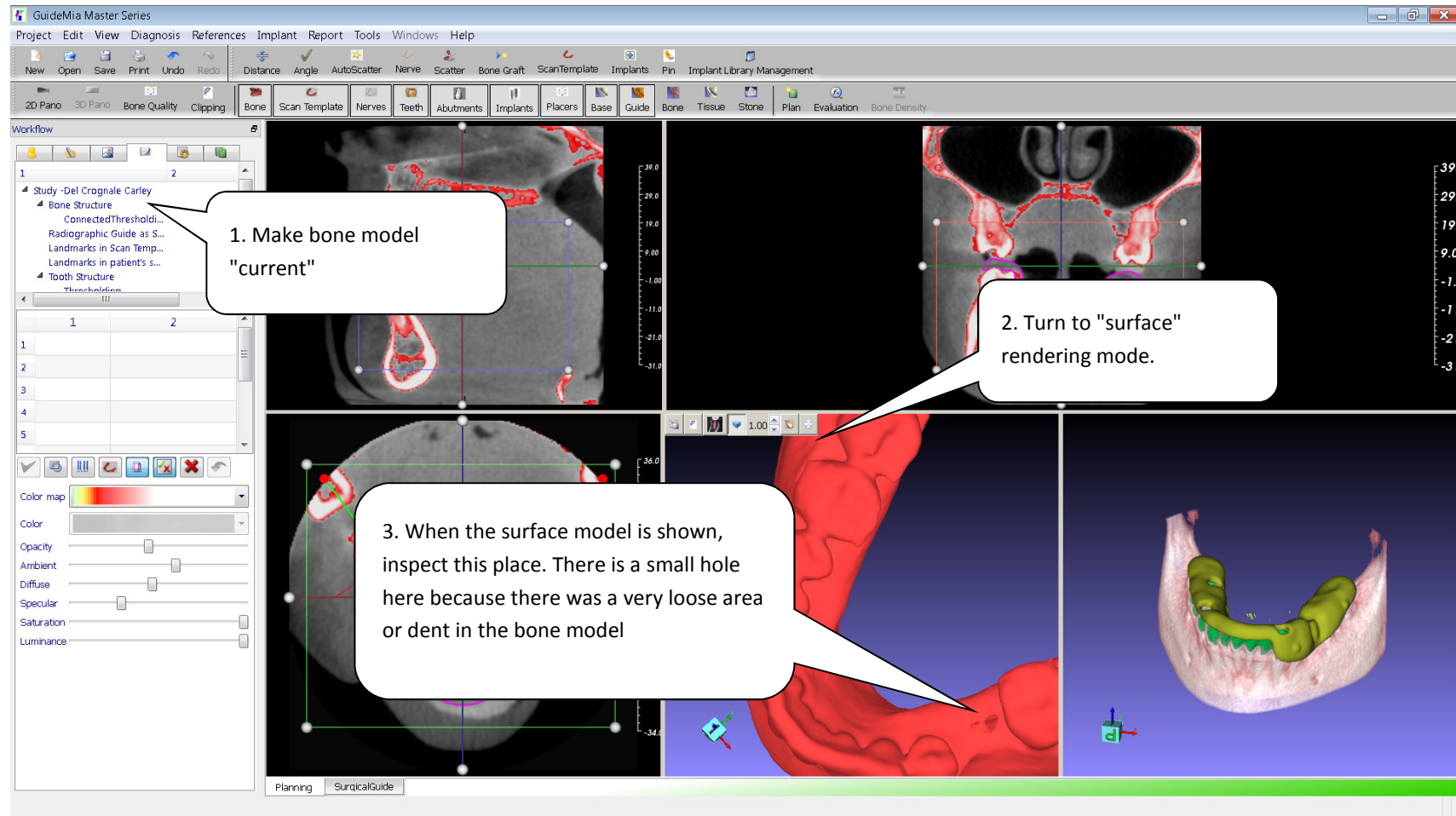
Step 10. Change the threshold of radiographic guide, or, scan template.



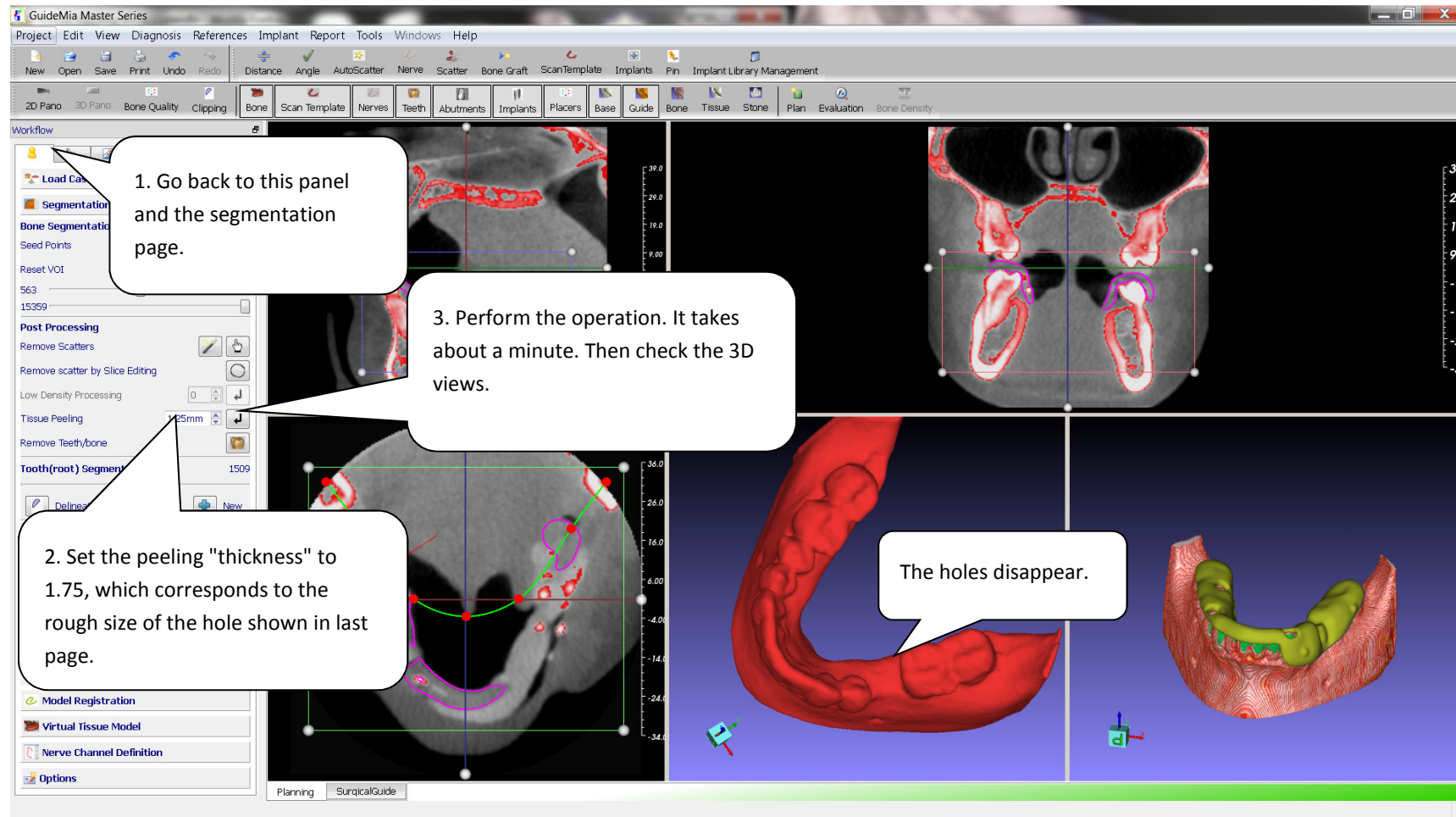
Step 11. Create tooth model by thresholding



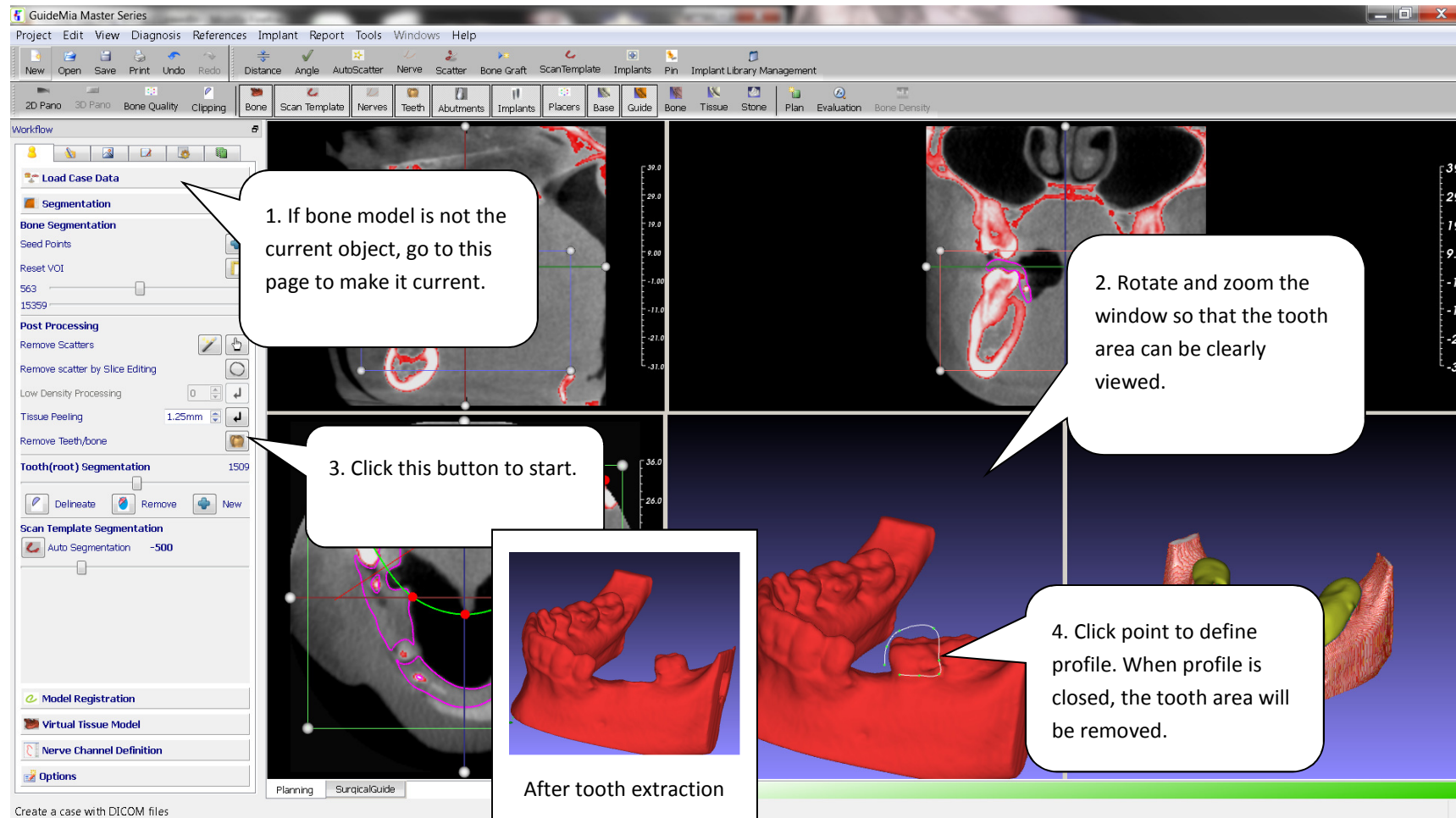
Step 12. Adjust tooth model by cutting



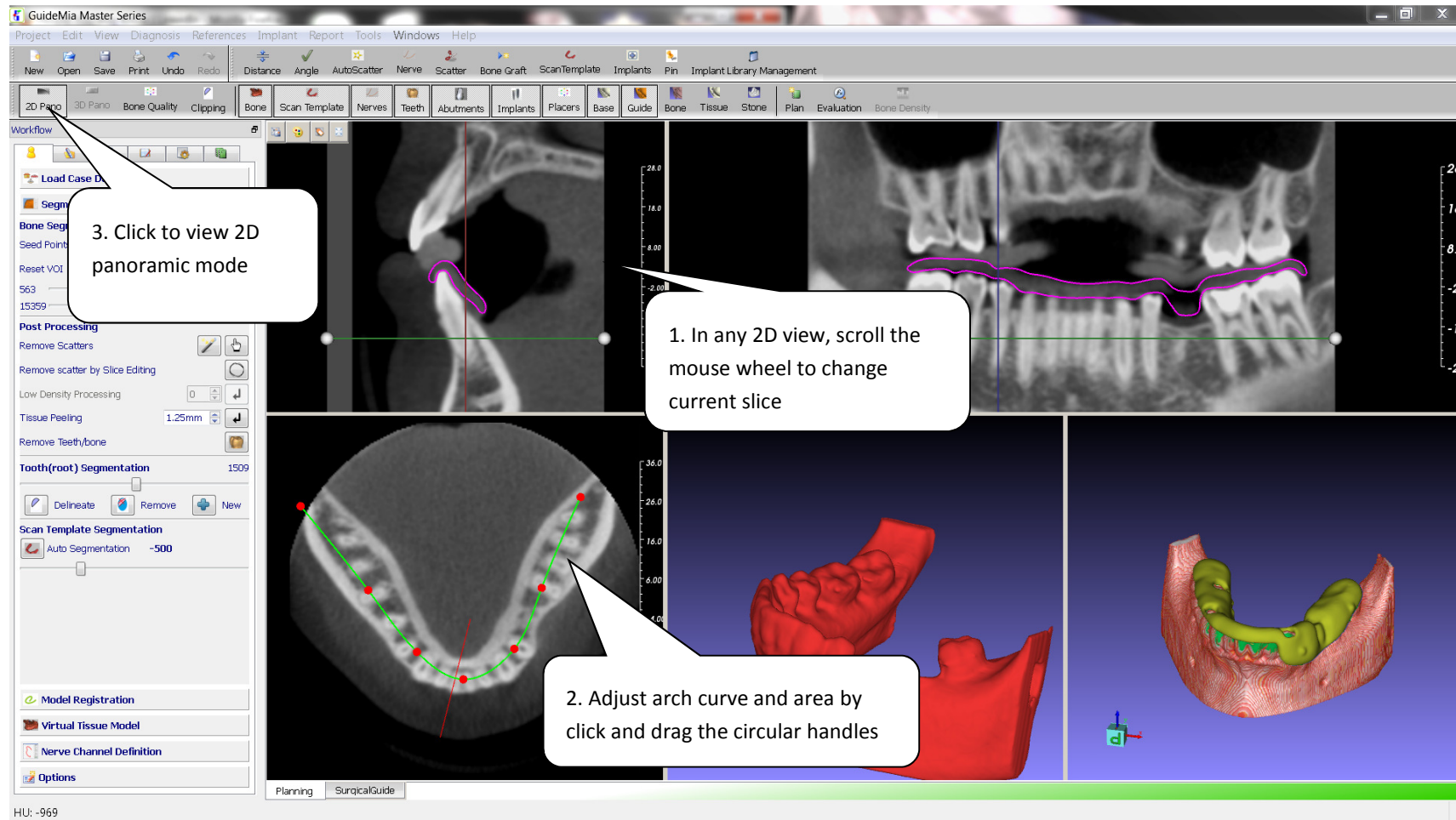
Step 13. Advanced bone modeling topics. Surface rendering,



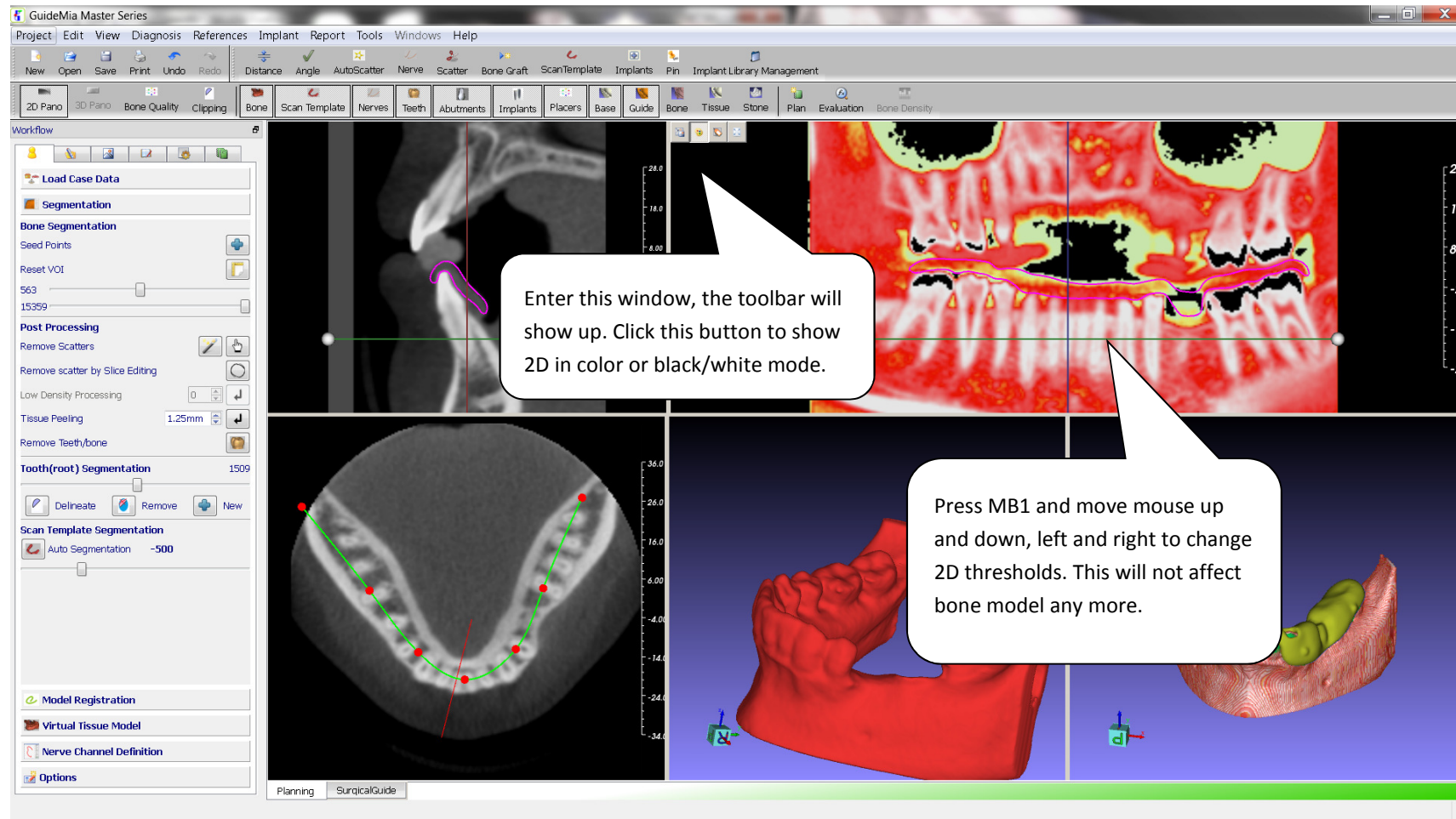
Step 14. Advanced bone modeling topics. Simulate soft tissue peeling. There is also an operation called "low density processing", which is a faster but approximate version of the "surface peeling". For this case, if we will only use radiographic guide to create surgical guide later, we can use this faster version. However, bone-level guide needs more accurate bone model. Surface peeling is a better choice for this.



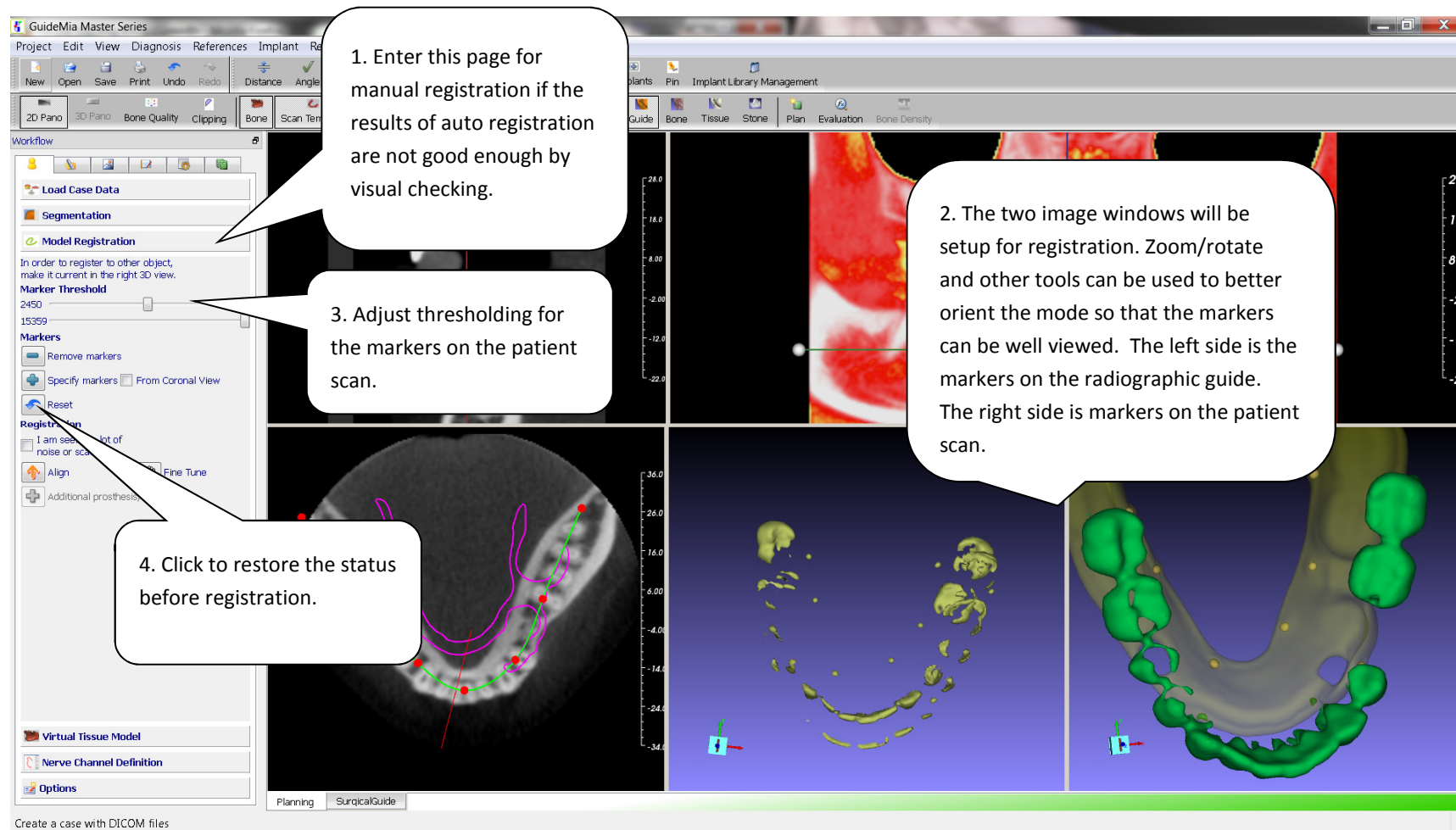
Step 15. Additional bone model processing - tooth extraction. This is for the purpose to place implants and to generate surgical guide that will be used with immediate tooth extraction.

**Step 16. 2D views: panoramic view, arch curve manipulation, slice changes**

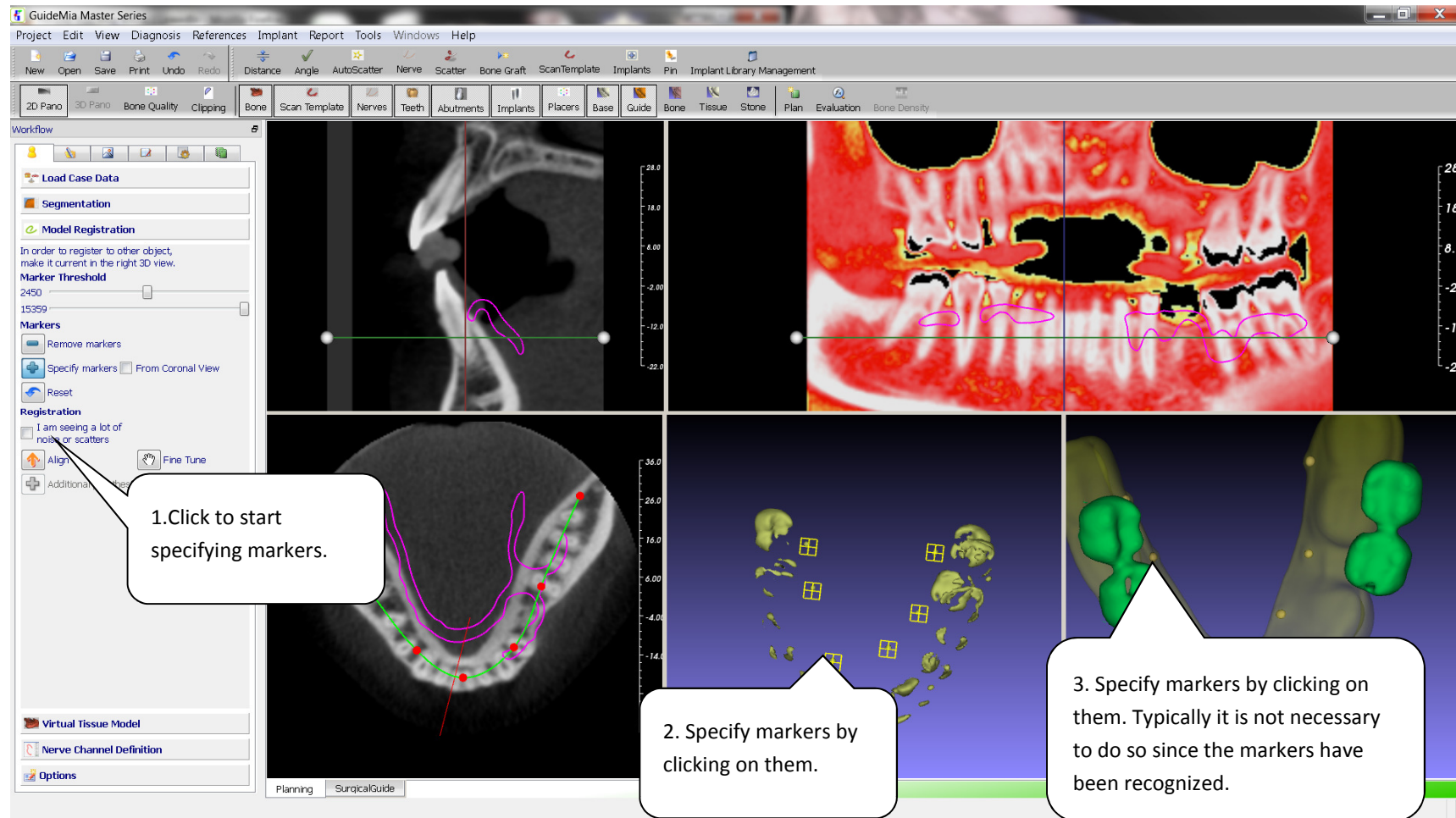
Change slices, adjust arch curve, and show panoramic mode



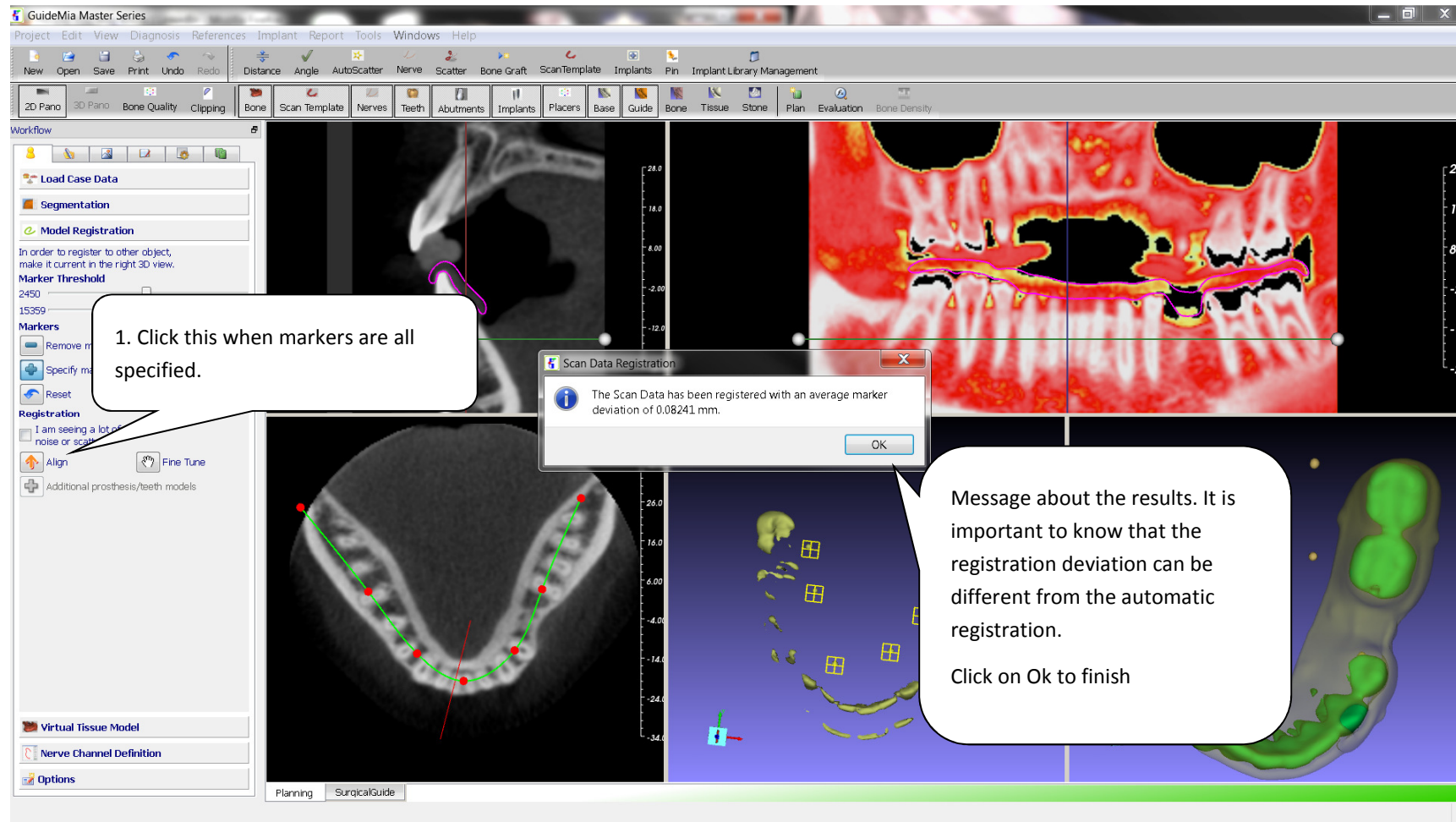
Step 17. **Change 2D views.**

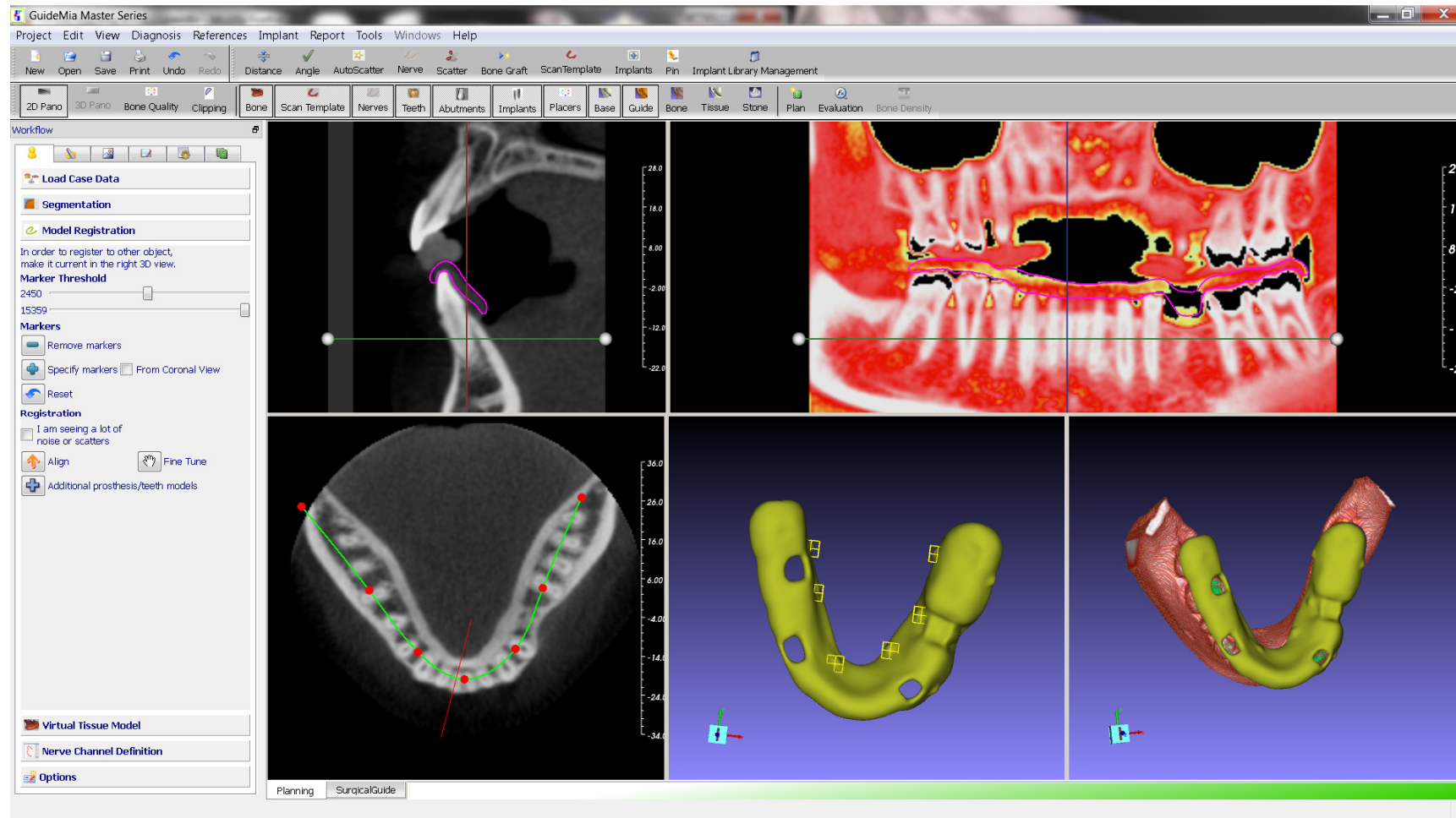


Step 18. Registration of the CT scans of patient and radiographic guide. Most of the time, users don't need to do this. The system requires same number of markers, but the order you specify them does not matter.

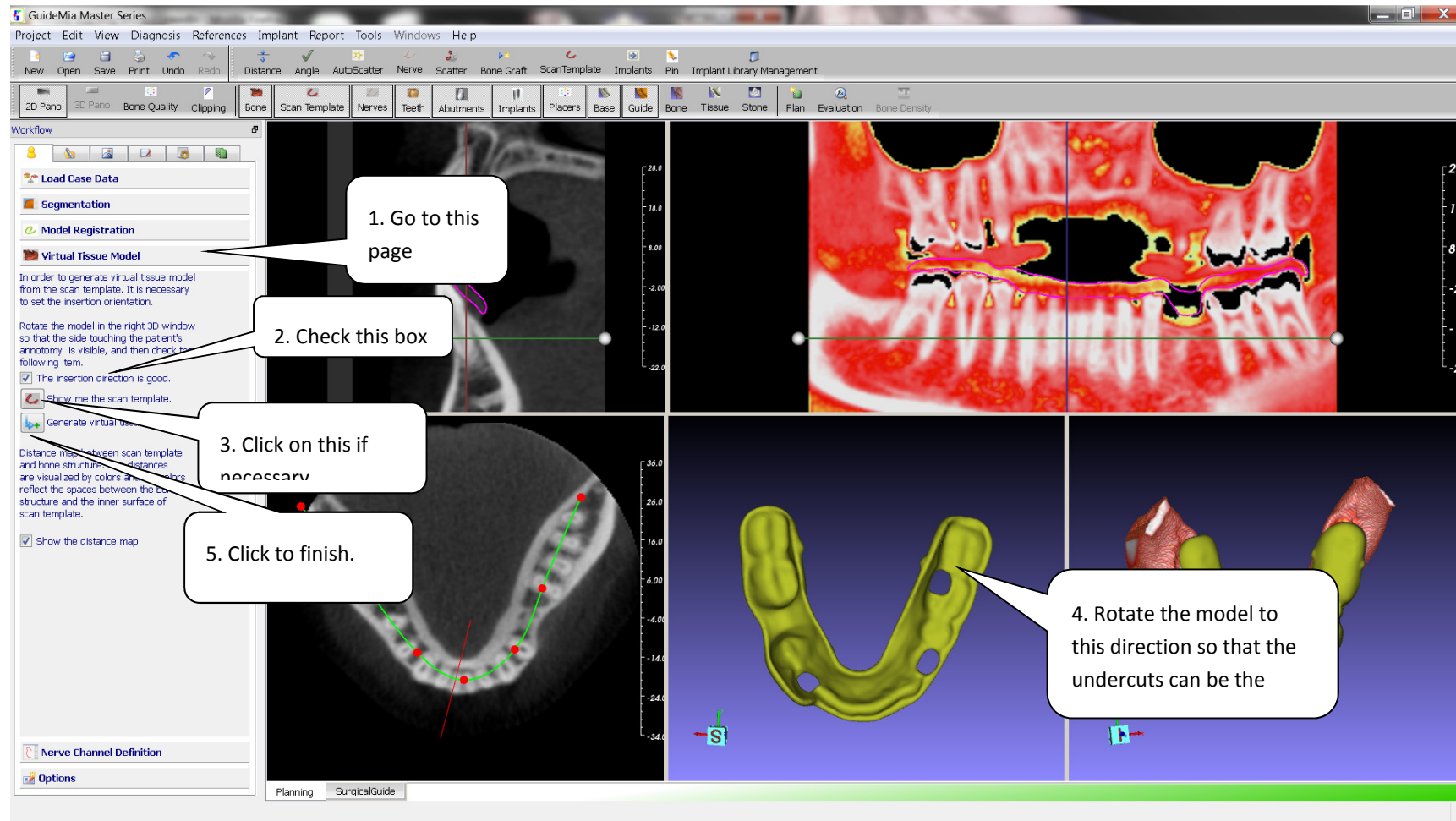


Step 19. Registration. The markers have been specified.

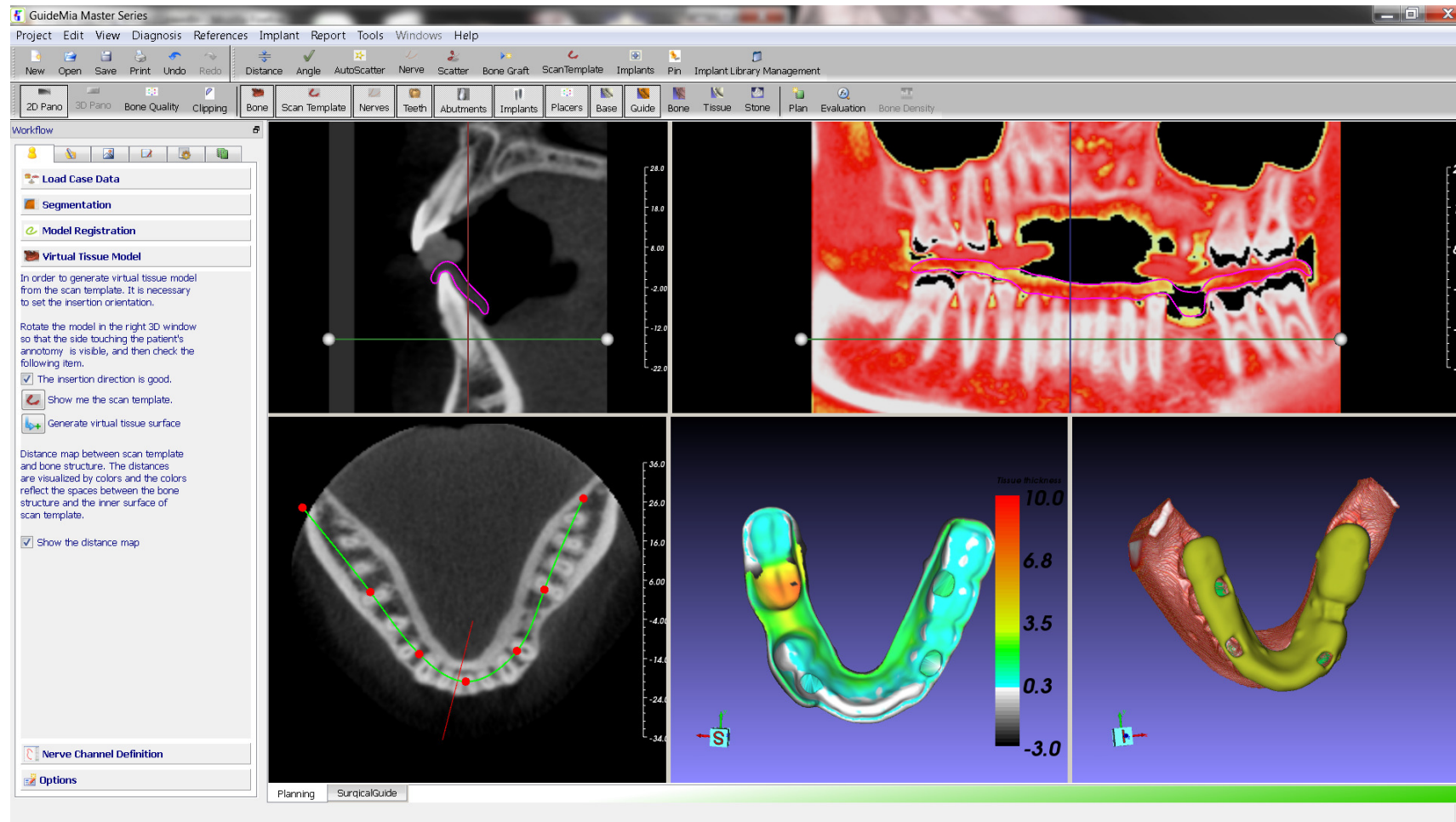
**Step 20. Registration report.**



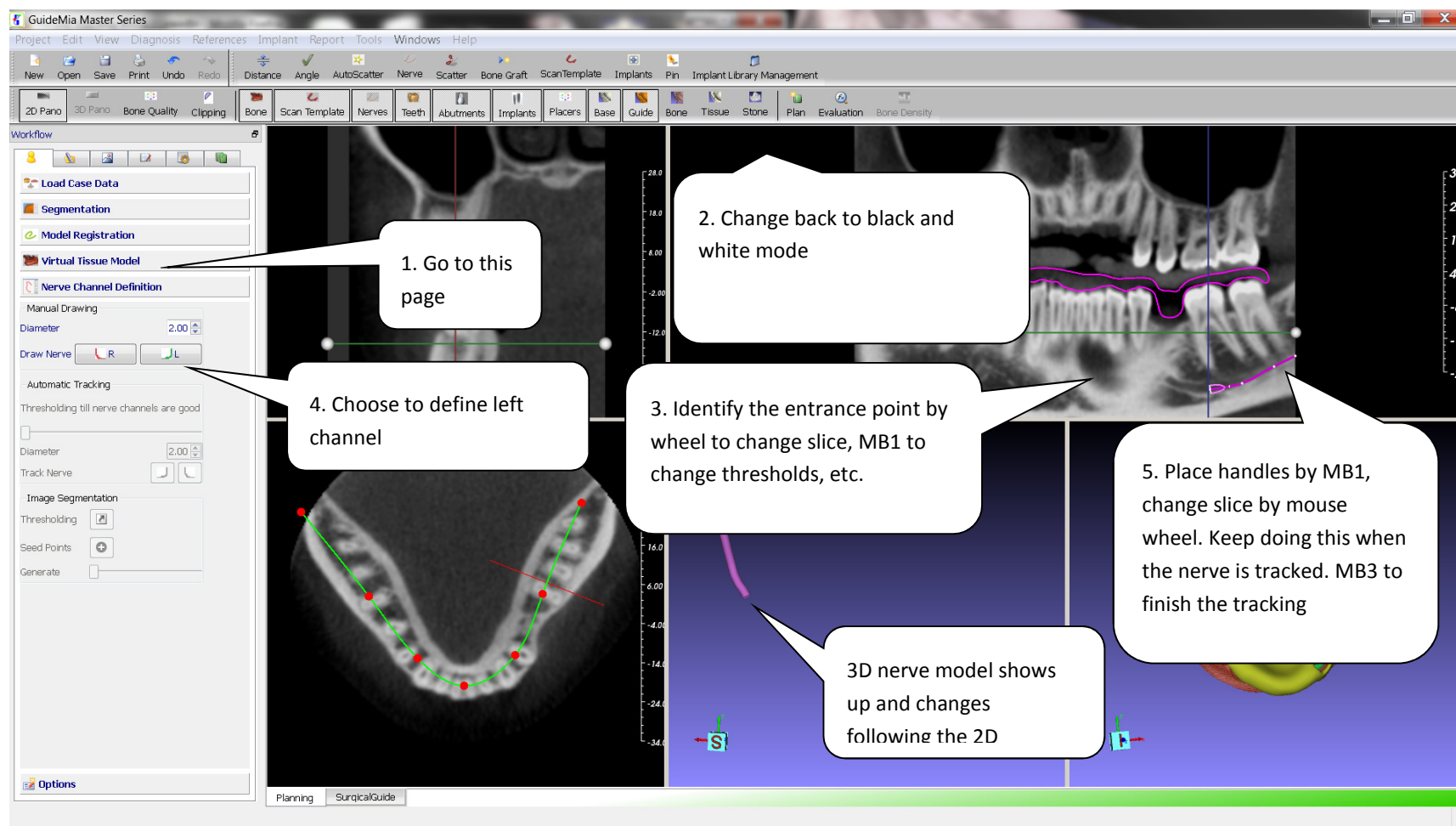
Step 21. Registration is completed. The windows setting shown in the previous step will be changed into the one in this page.



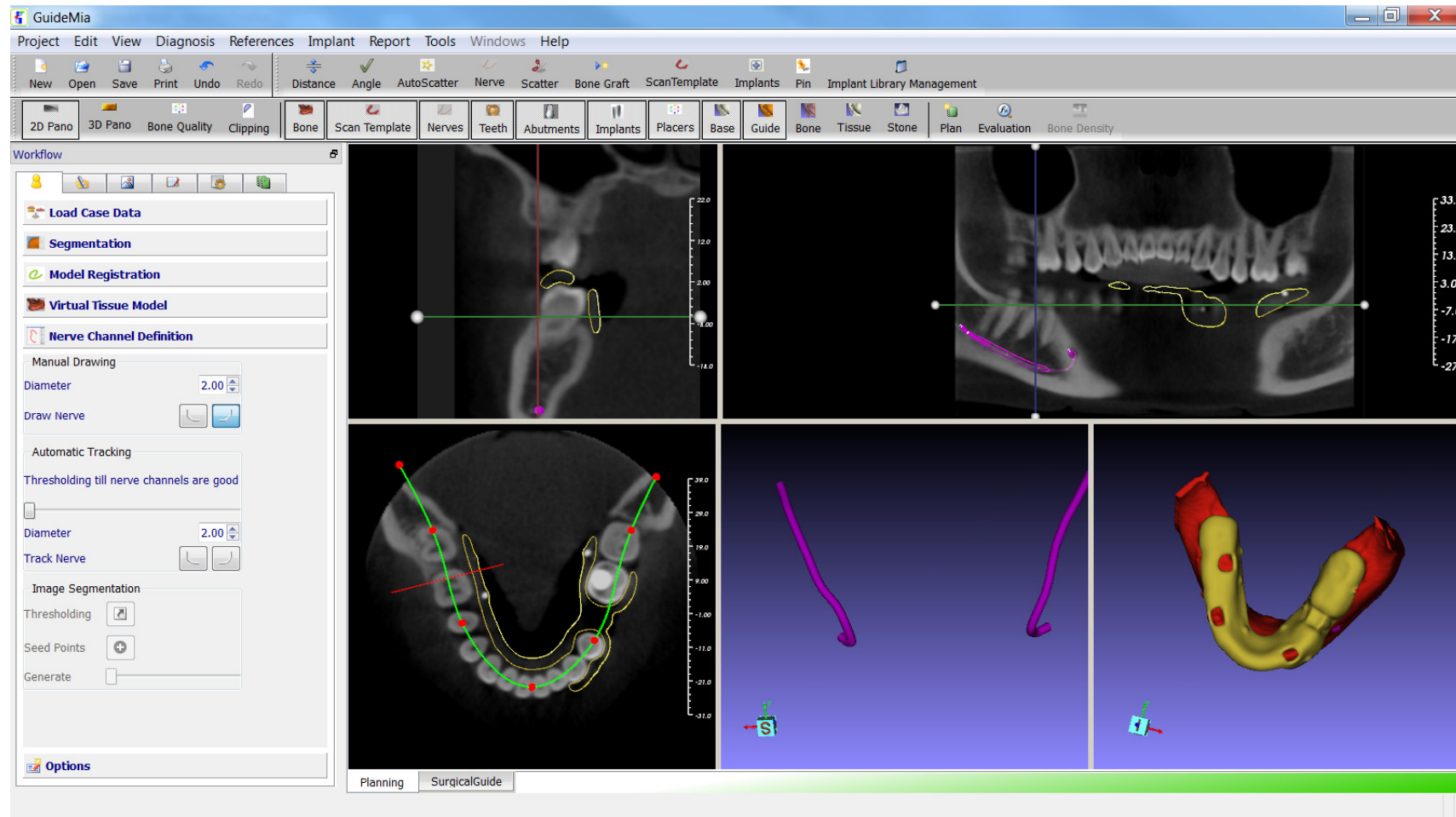
Step 22. Virtual Tissue Model. This function is used to create a tissue surface model as a reference for planning and a way to define surgical guide extraction/insertion direction. This is an optional tool.



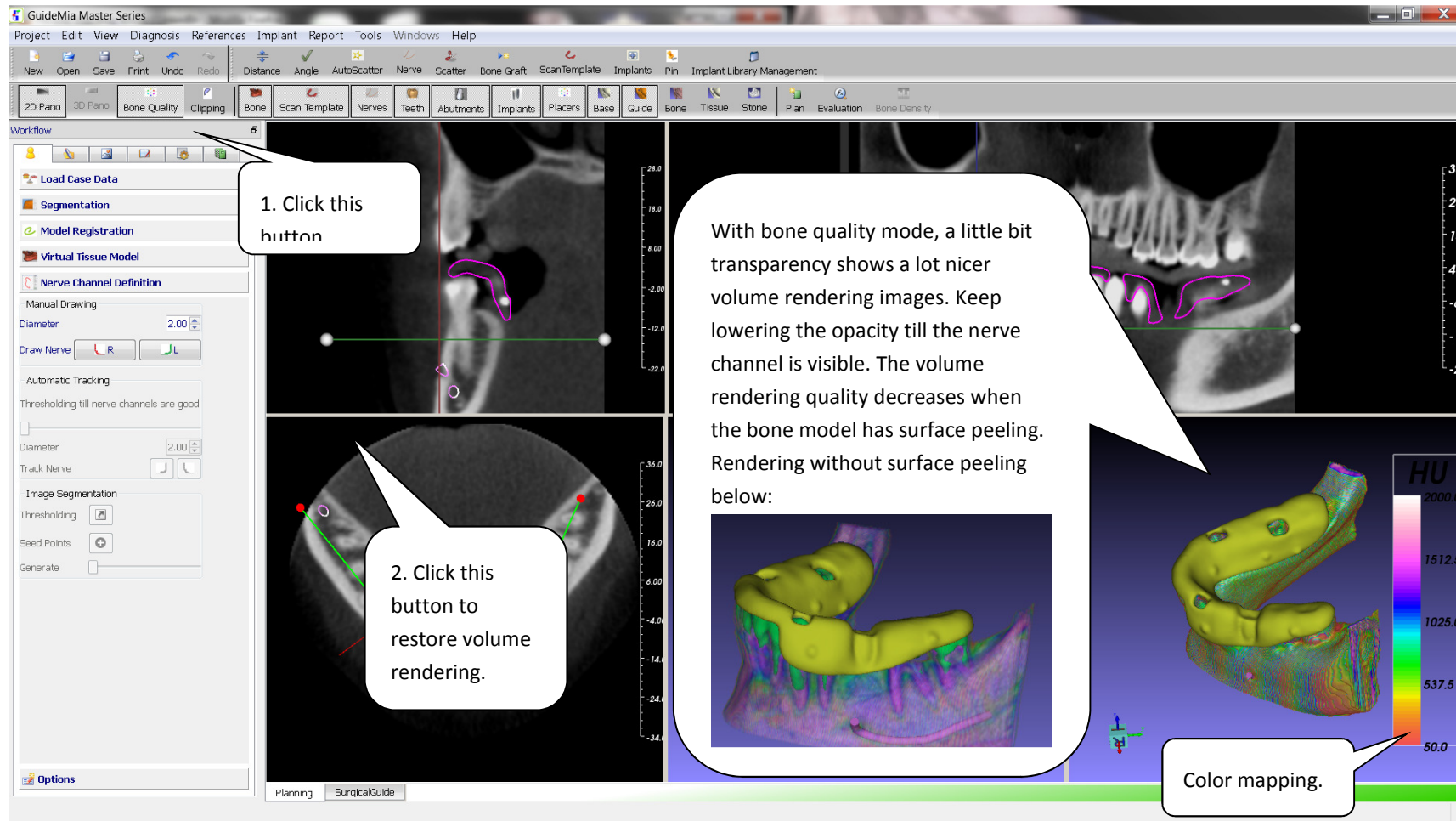
Step 23. Virtual Tissue Model. Operation finished. Color map illustrates the gap between the radiographic guide and bone model. Gray/White are the tooth area, while two models touch each other. Green to black means bigger distances. The orange area is due to the removed tooth. In general if you see the color distribution on the left side and right side are not even, the radiographic guide might not have been placed properly when scanned.

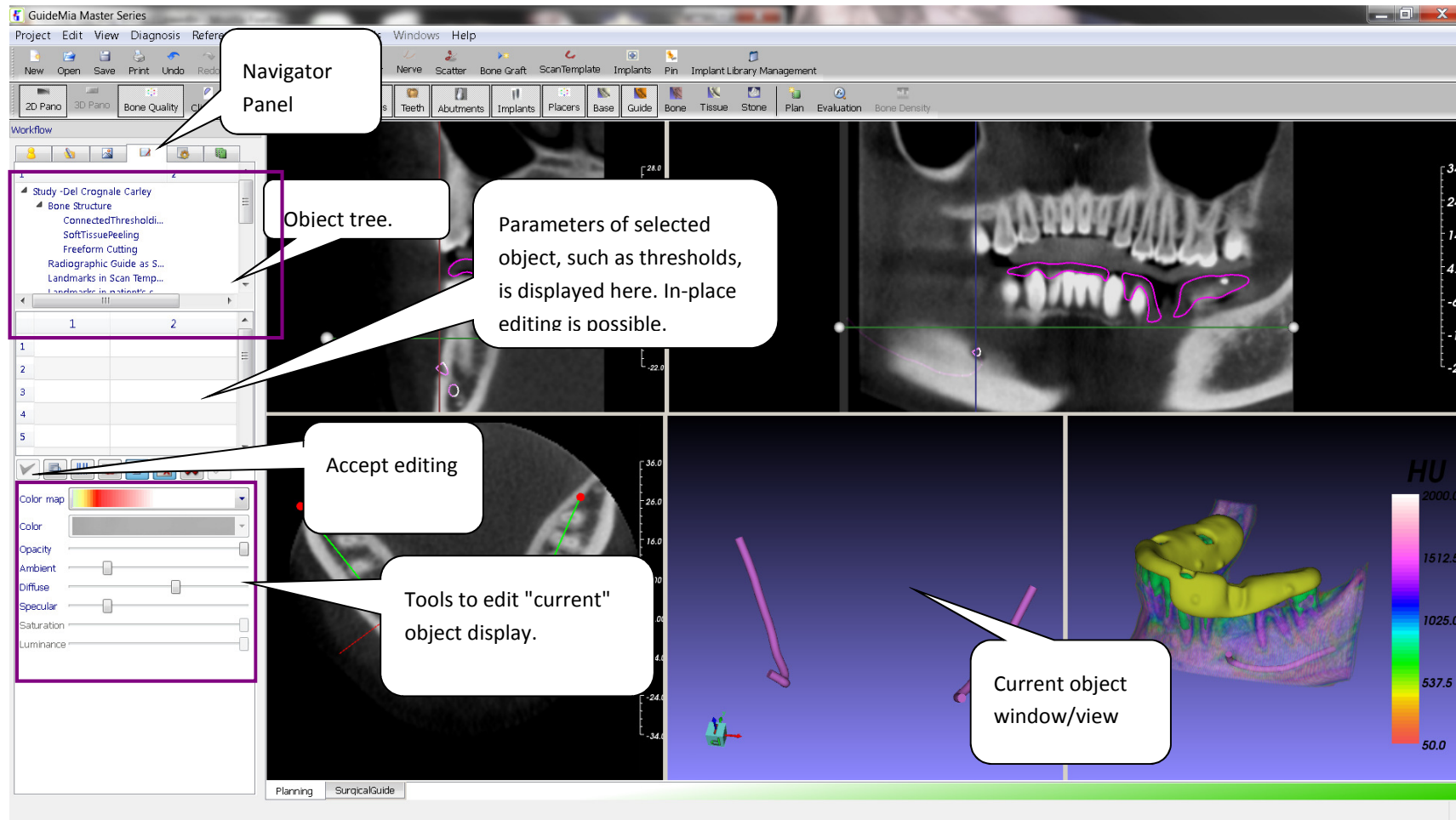


Step 24. Manual nerve tracking.

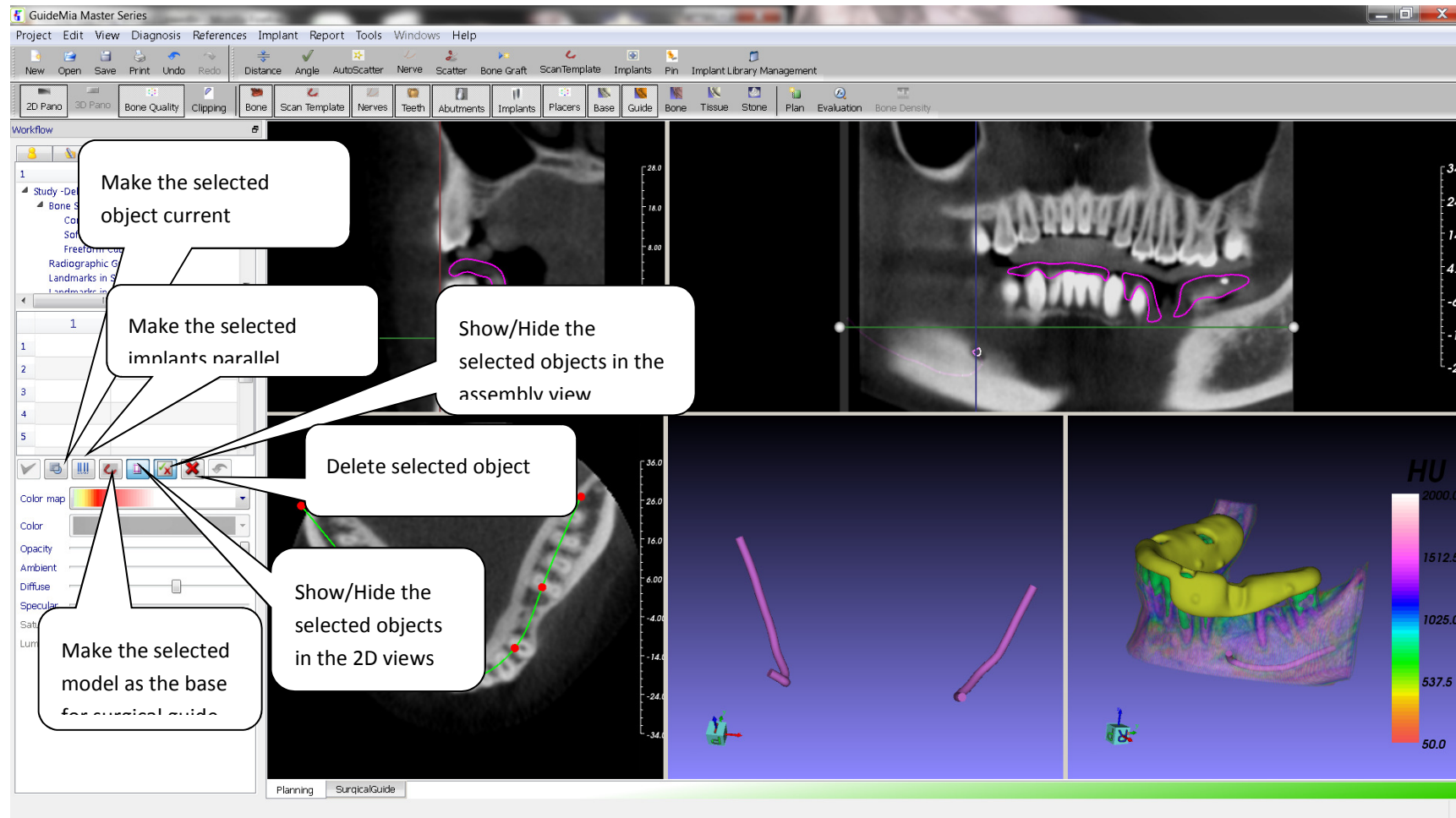


Step 25. Manual nerve tracking. Do the same thing to the right channel. This picture shows both sides are created.

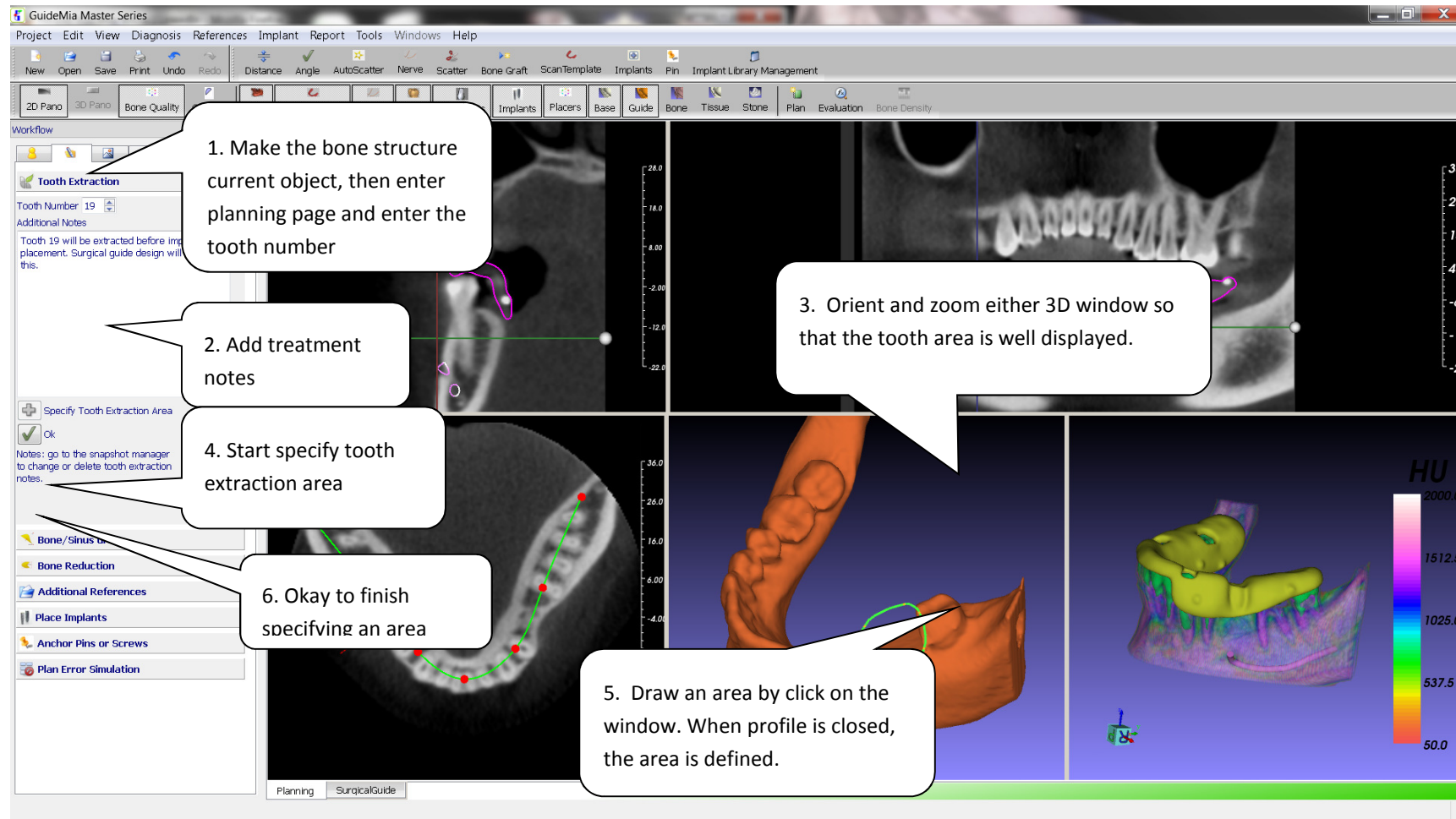
**Step 26. Show Bone Density/Quality**

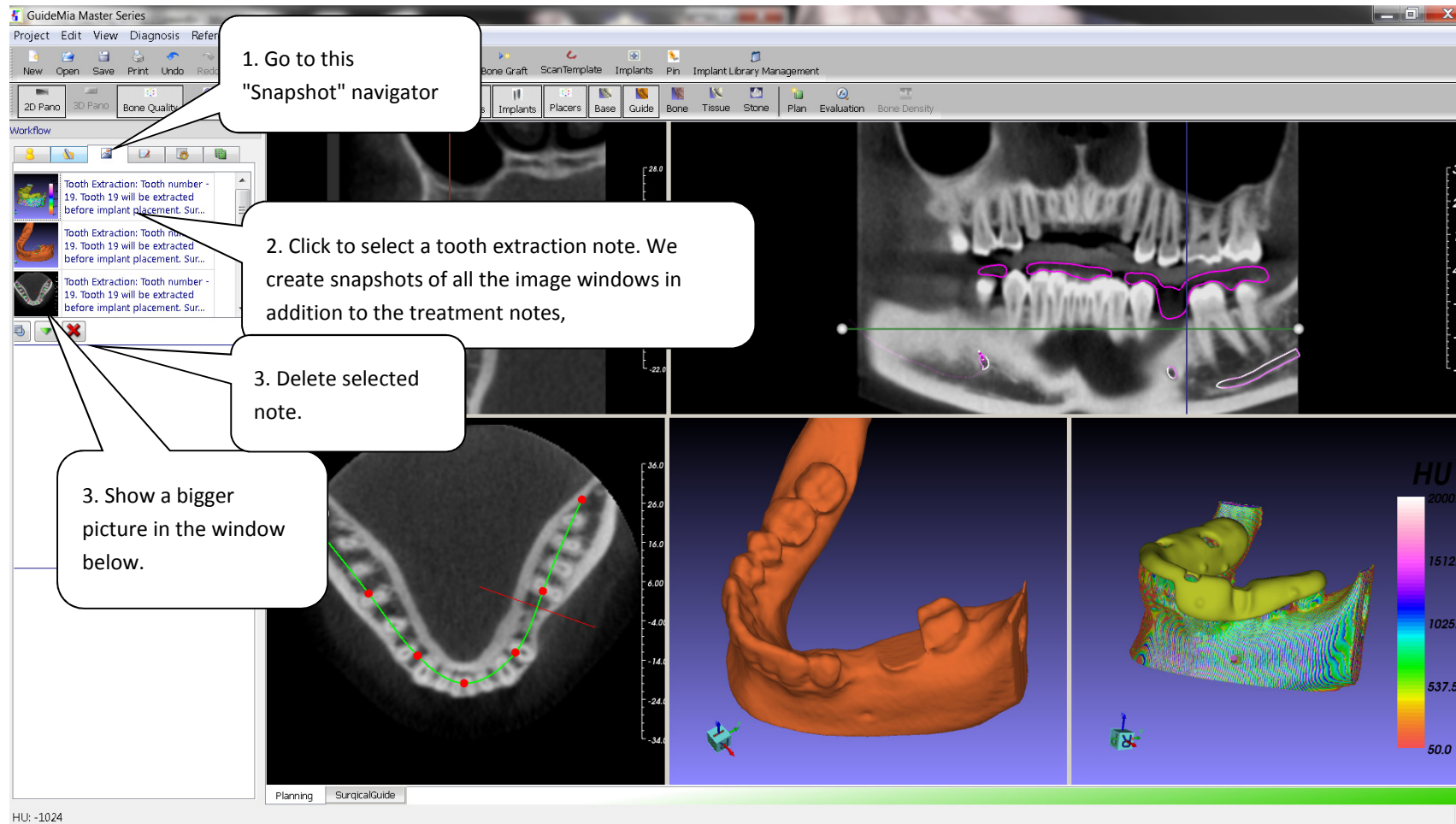


Step 27. Model navigator and model display editing

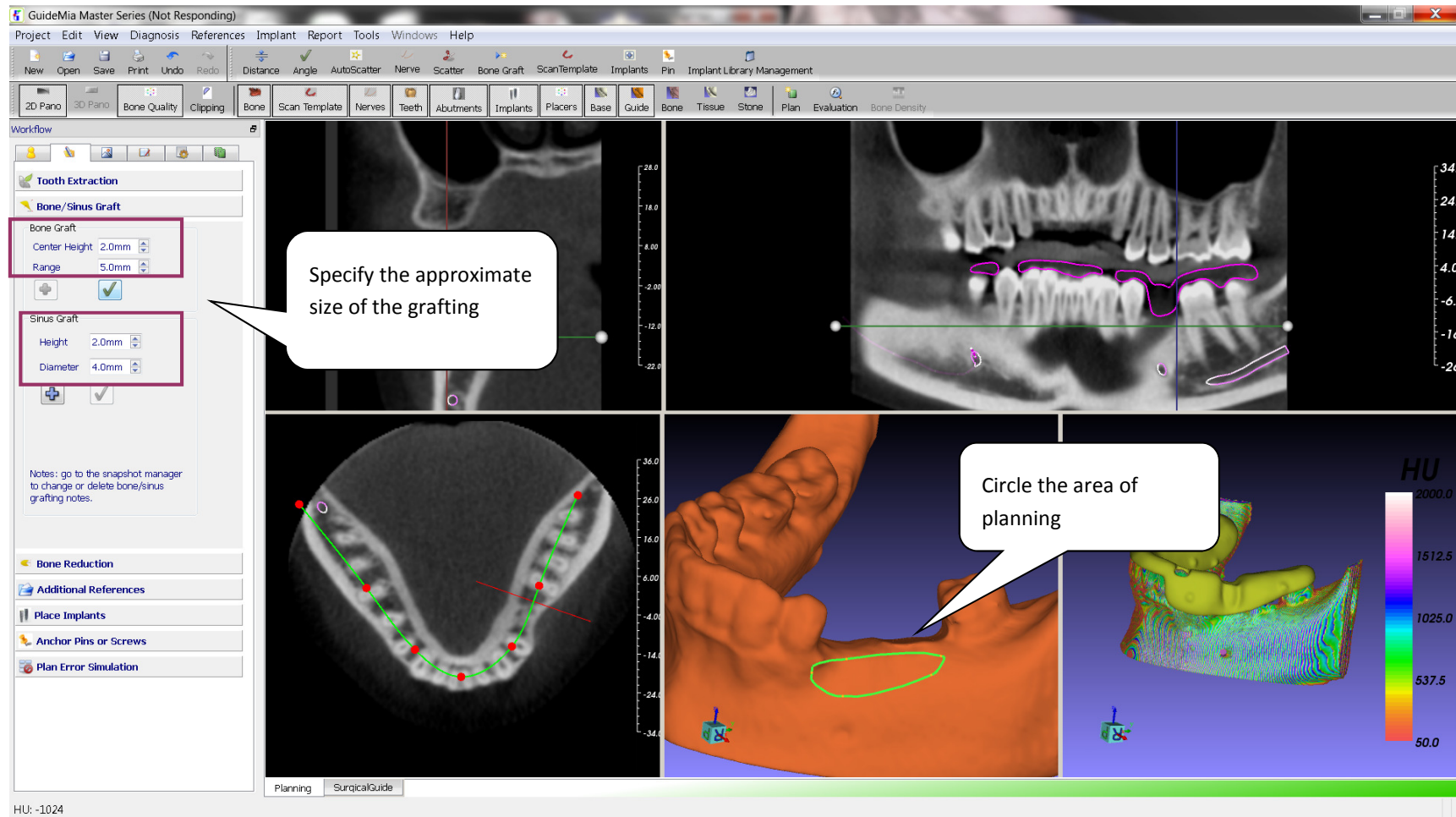


Step 28. More about Model Navigator and display property editing

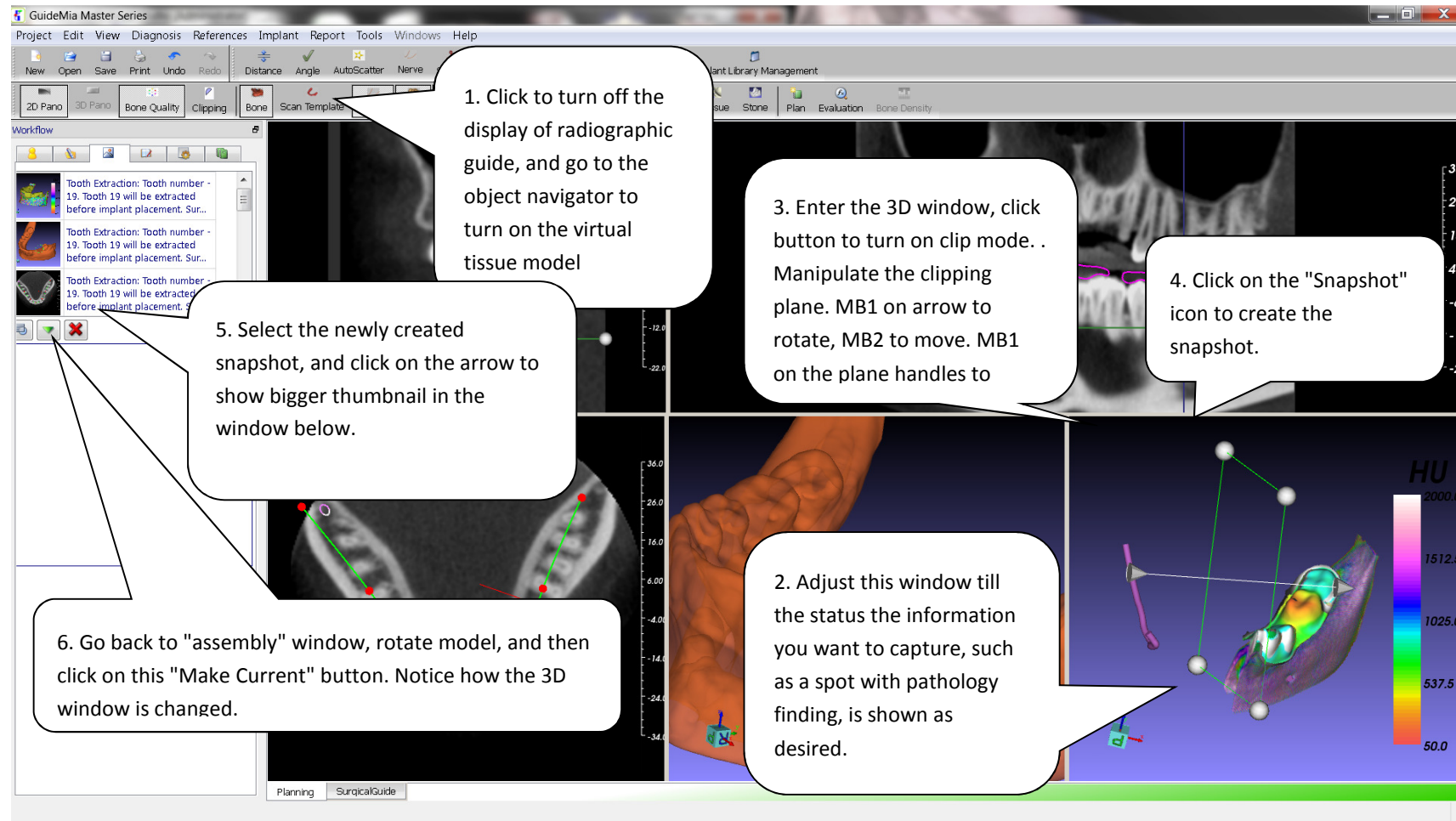
**Step 29. Tooth Extraction Notes**



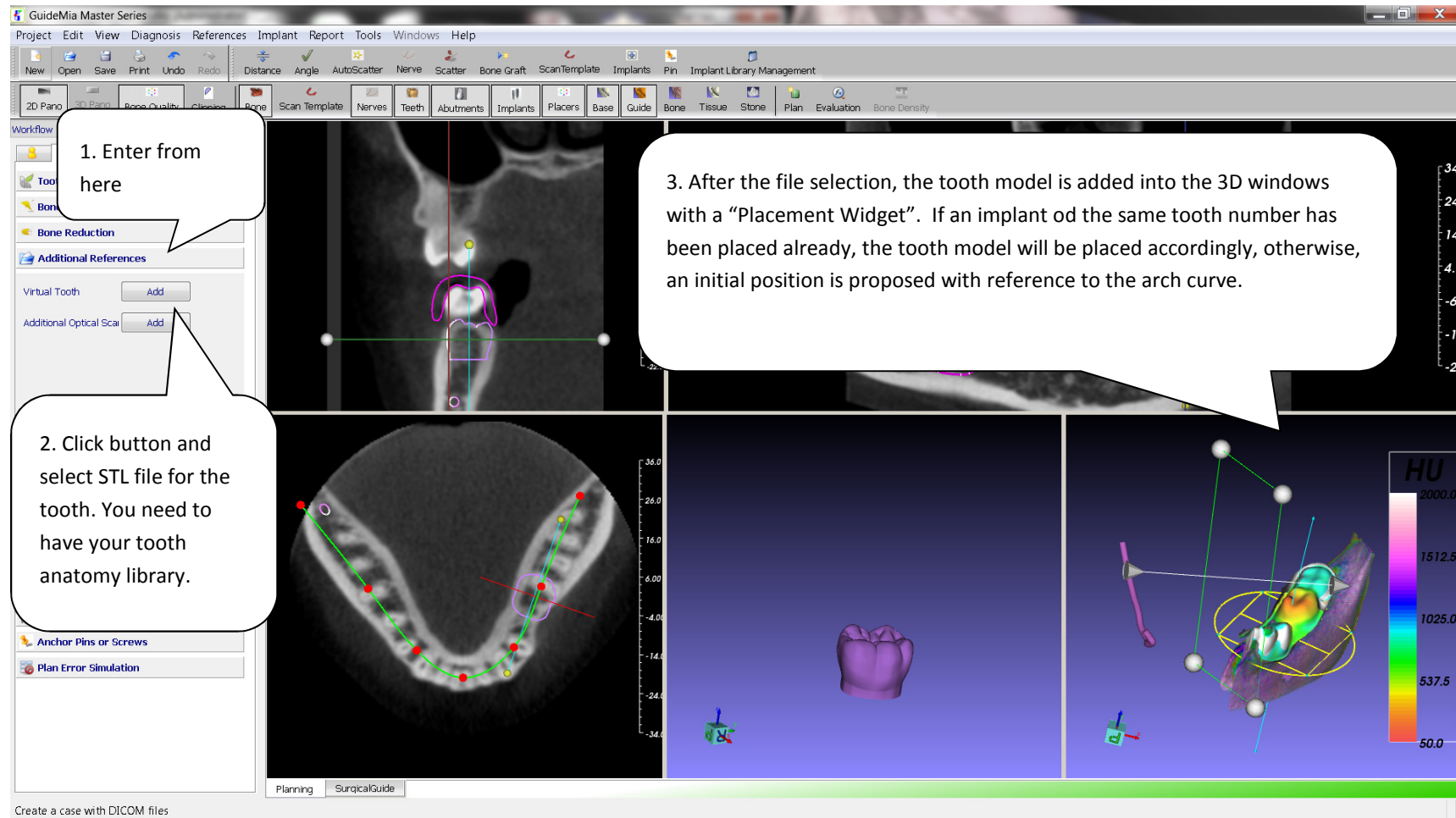
Step 30. Using Snapshot Navigator to see the defined tooth extraction, bone grafting, sinus grafting, or bone reduction.



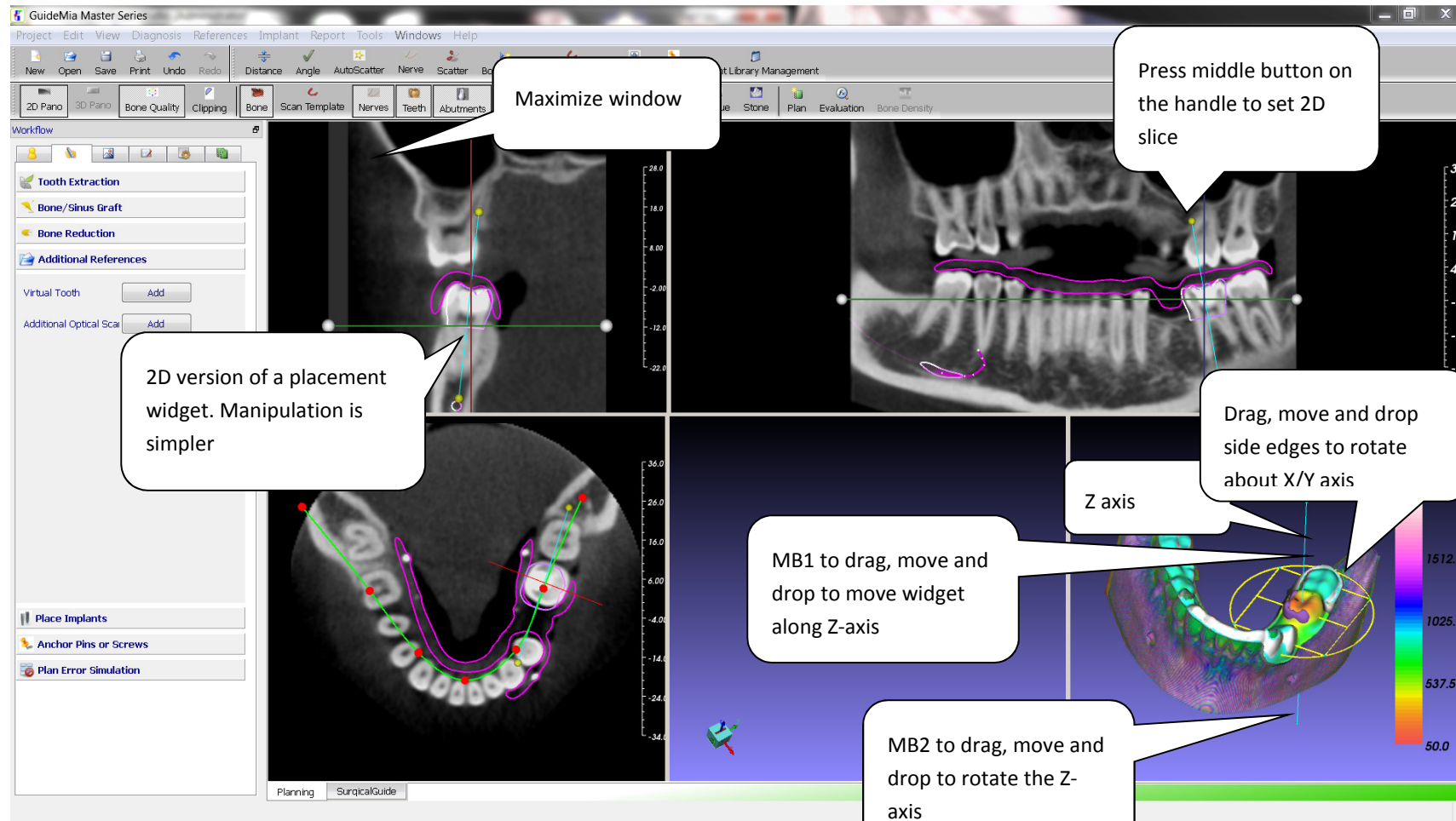
Step 31. Bone and Sinus grafting, Bone Reduction. Same procedure as tooth extraction.



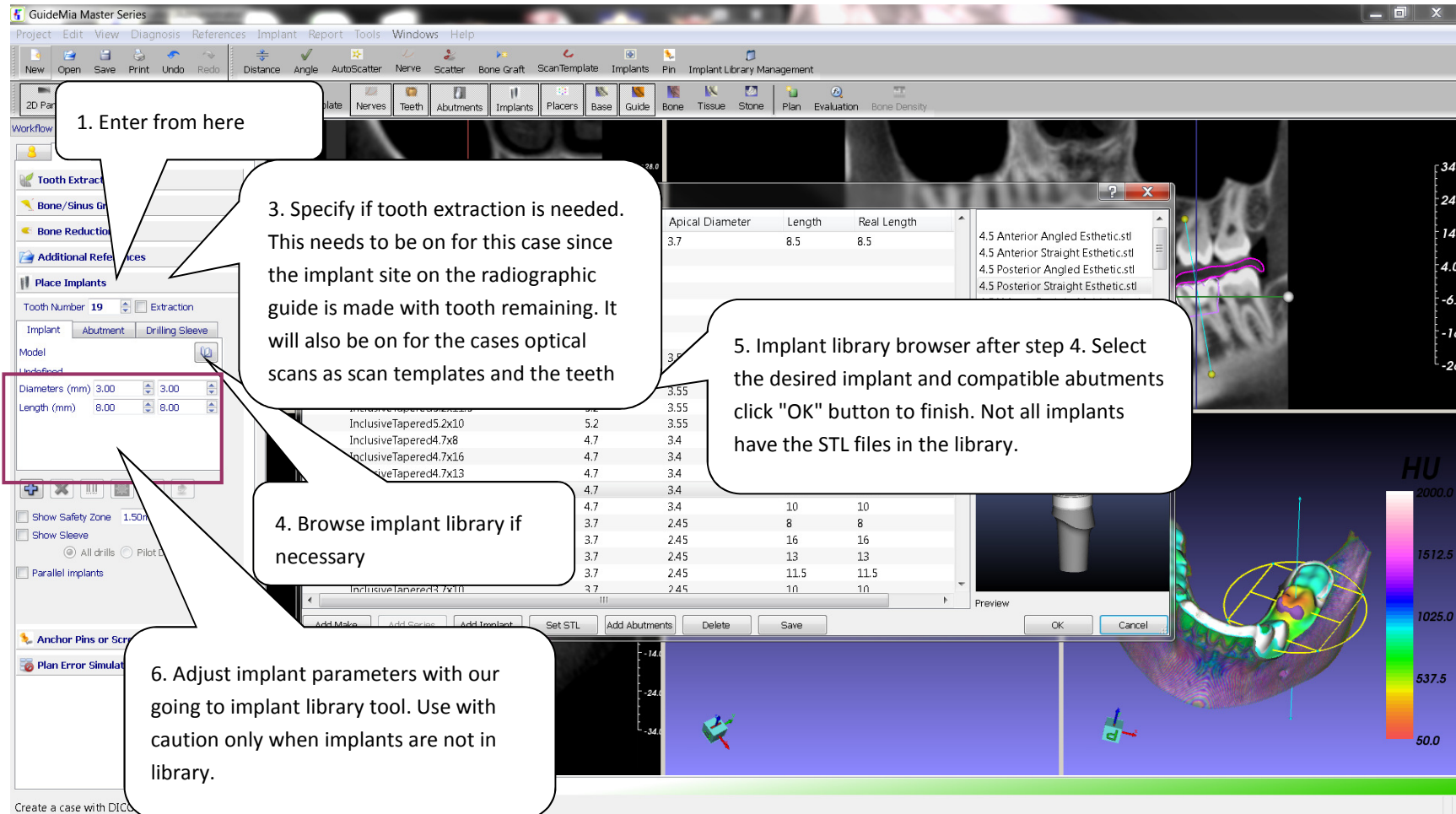
Step 32. Create Snapshot Object, which is a view status of either of the image windows. It captures an image, and let the users to write notes. This is basically a “finding card” for diagnosis or planning. This picture also includes some additional operations.



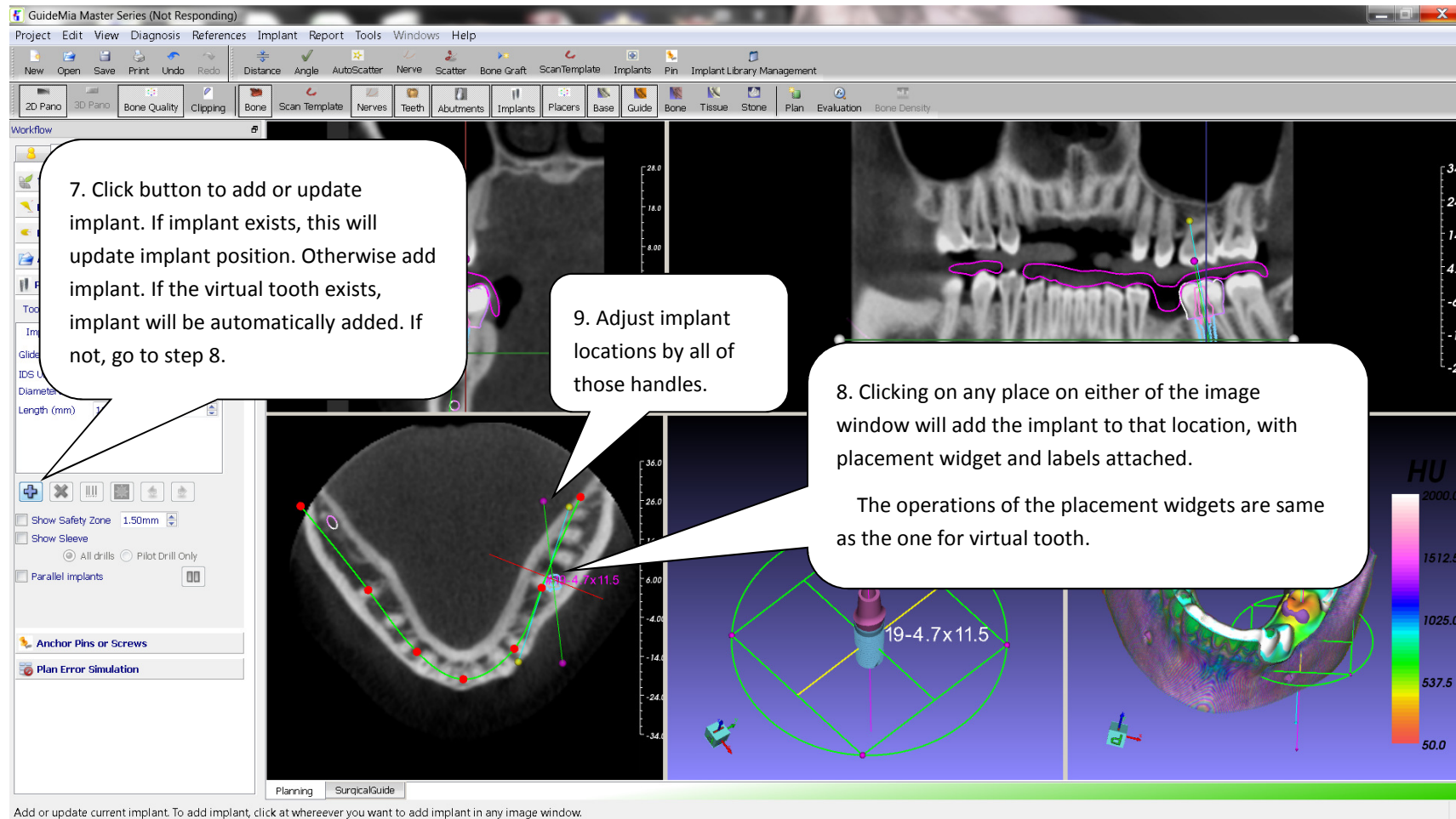
Step 33. Add additional references from STL files. This is to add virtual teeth, and other reference models.



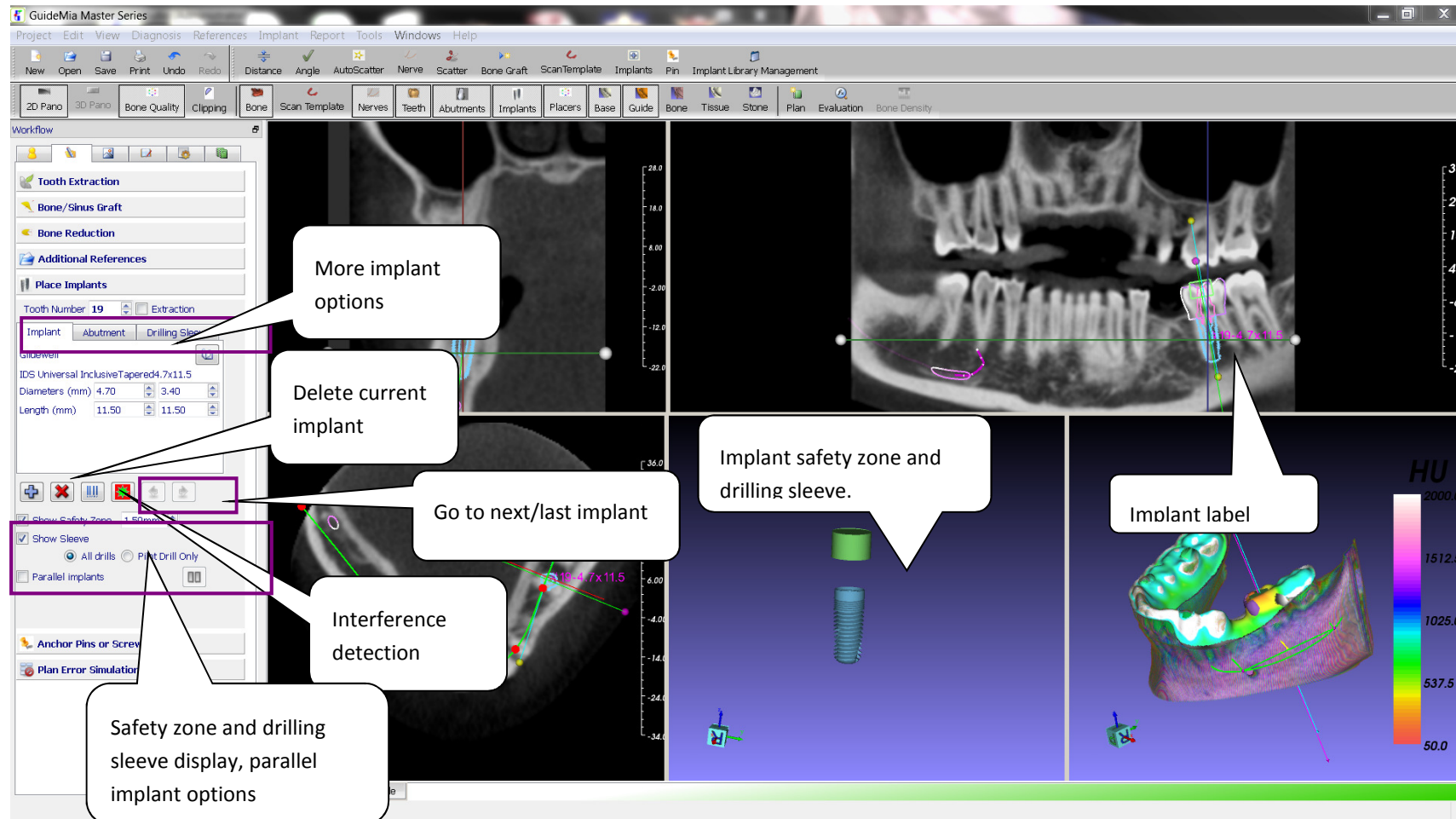
Step 34. Manipulating Placement Widget. Each object has a placement widget in all the windows. All the placement widgets of one single object are all associative. Any changes of one of them will be propagated to the others.



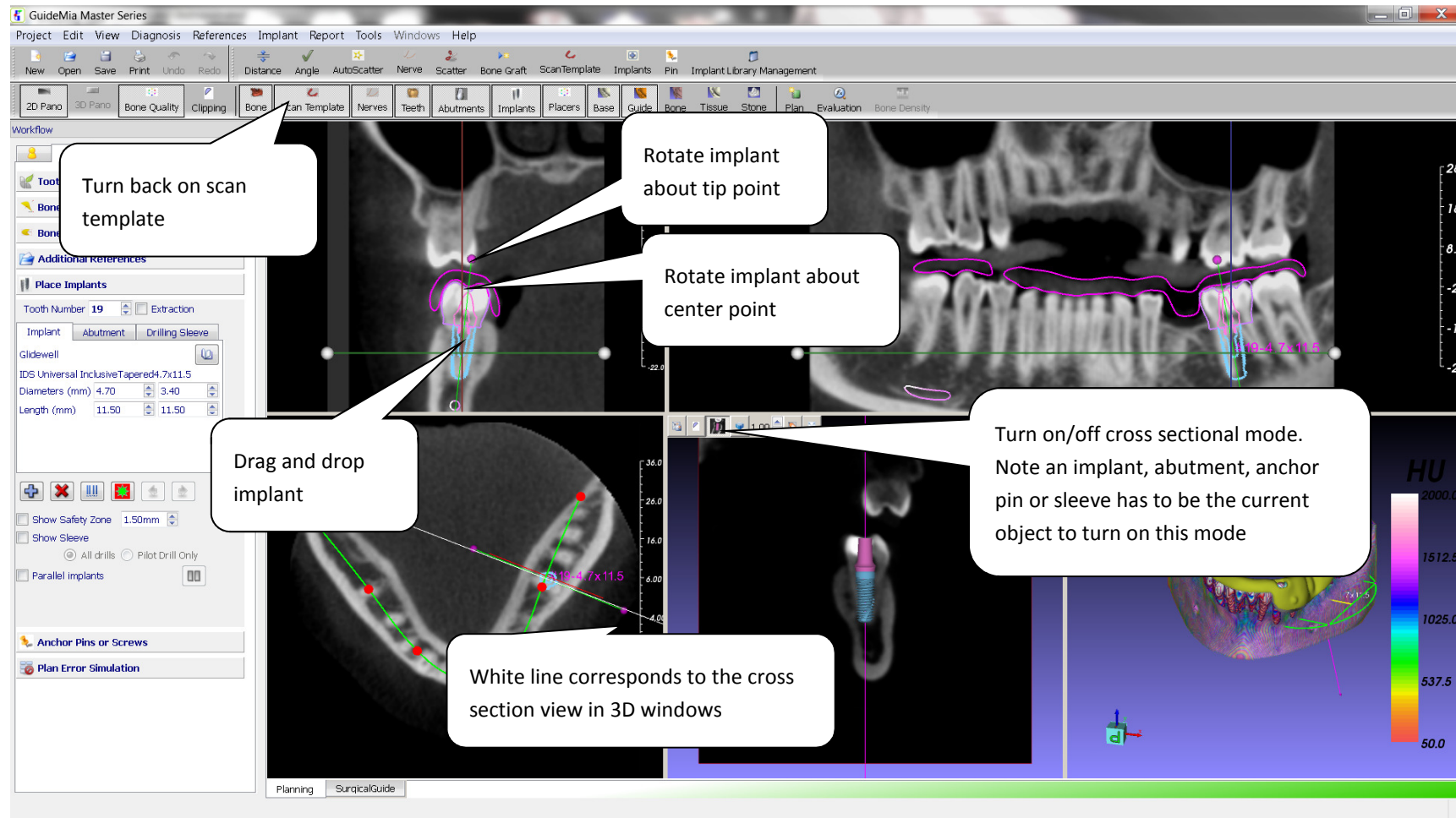
Step 35. Place Implants (1) - Select Implant Model/Type from library.

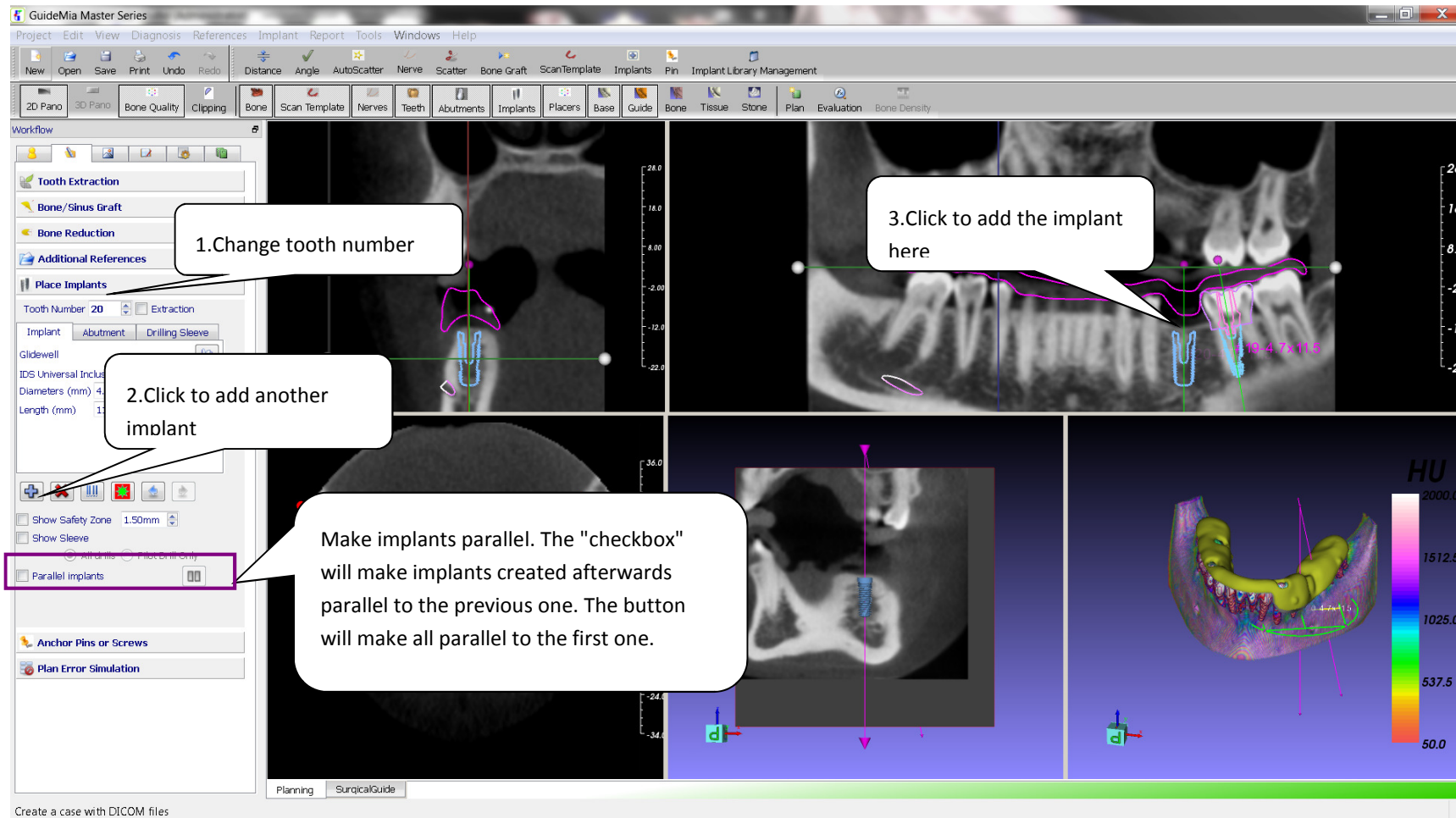


Step 36. Place Implants (2) - Add an implant.

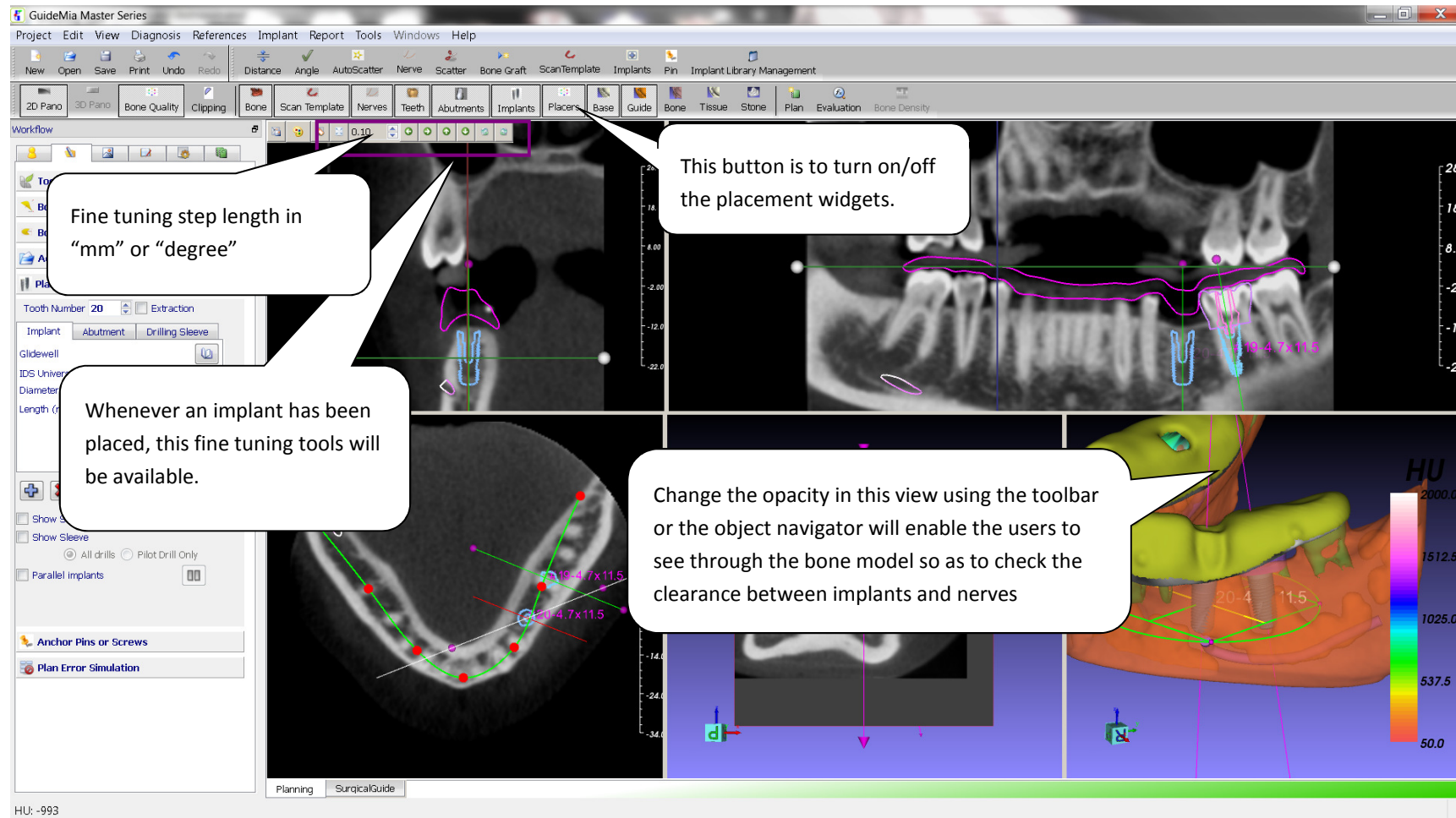


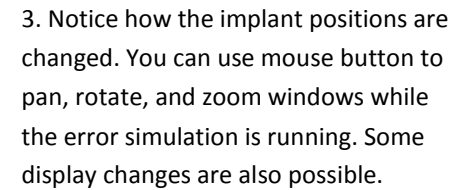
Step 37. Place Implants (3) Adjust the implant location with either of the placement widgets in either of the image windows. See the virtual tooth page for placement widget manipulation.

**Step 38. More implant placement**

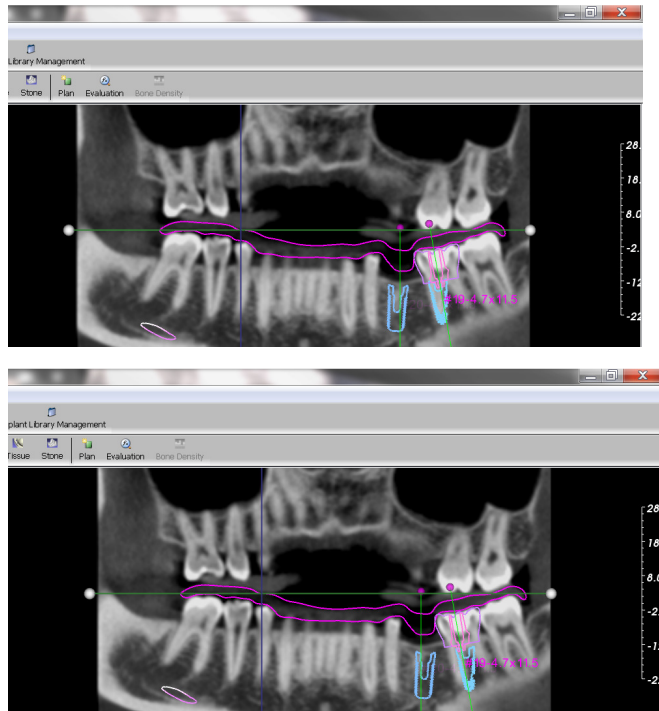


Step 39. Place Implants (4). After making implants parallel. There is also a button in the navigator panel, which make all selected implants parallel to the first selected.

**Step 40. Place implant – 4**



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Error Simulation. Series Implant locations.

This concludes our Implant Placement part of the workflow.

7. SURGICAL GUIDE DESIGN

7.1 BASIC SURGICAL GUIDE TYPES

The following tables show some of the possible surgical guide types. This shows you the basics how treatment plan cases can vary in terms of surgical guide design. This is NOT a complete list, and not all the combinations are possible or supported. The right column of the table marks what are supported in this release. "F" and "P" means "fully edentulous" or "partially edentulous". The surgical guide creation will also generate an object shown in the object navigator.

Surgical Guide Case	Surgical guide features								Is Supported
	Tissue-based			Bone-based	Made by drilling	Made by Printing or milling	With Surgical Kit	With Tooth Extraction	
	Radiographic Guide CT	Stone model Optical Scan based	Impression Optical Scan based						
1.	x					x	x		F, P
2.	x					x			F, P
3.	x				x		x		F, P
4.	x				x				F, P

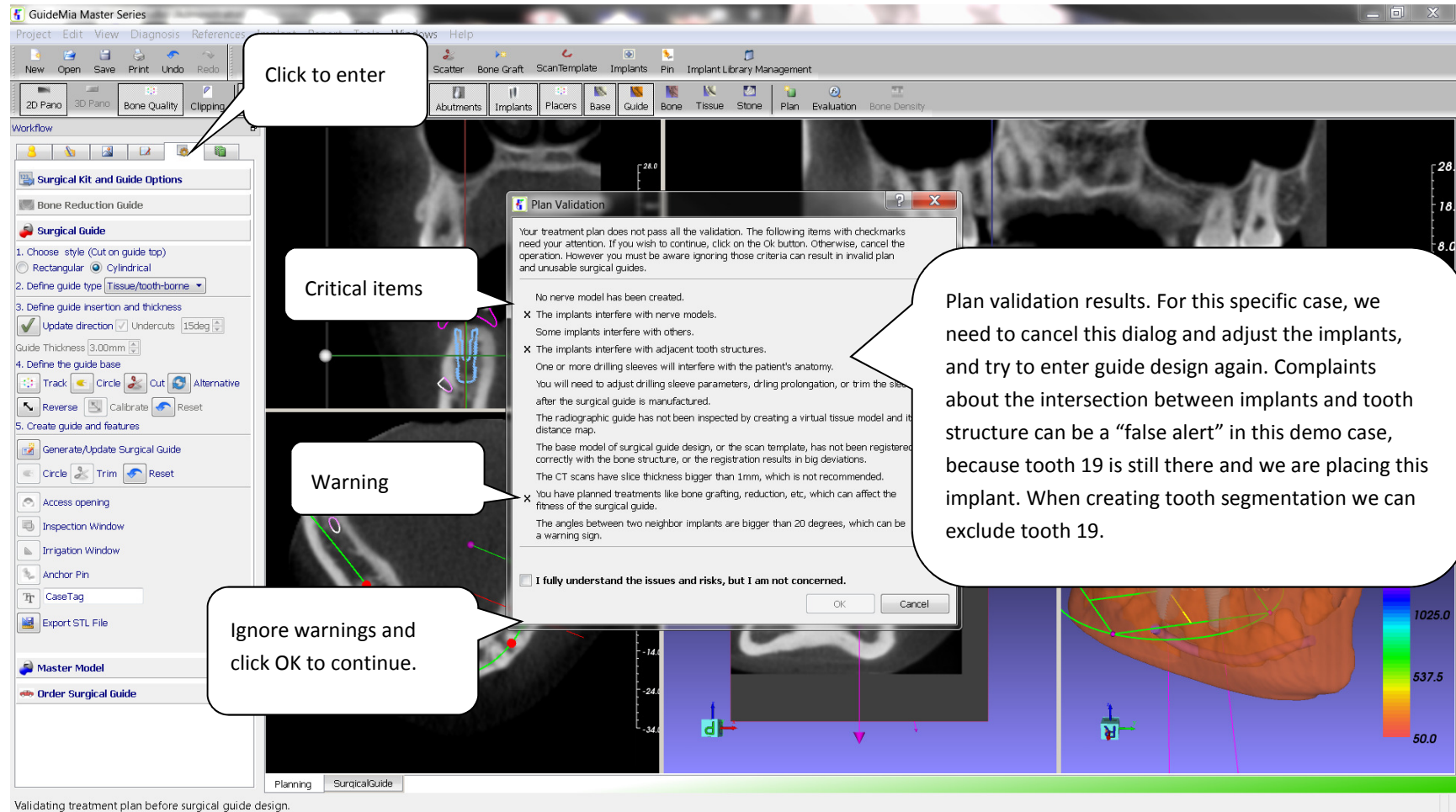
7.2 GUIDE DESIGN

The following is a list of the operation steps to complete surgical guide design. They correspond to the screenshots with annotations in the reminder of this chapter. The components of a report are illustrated after all those steps.

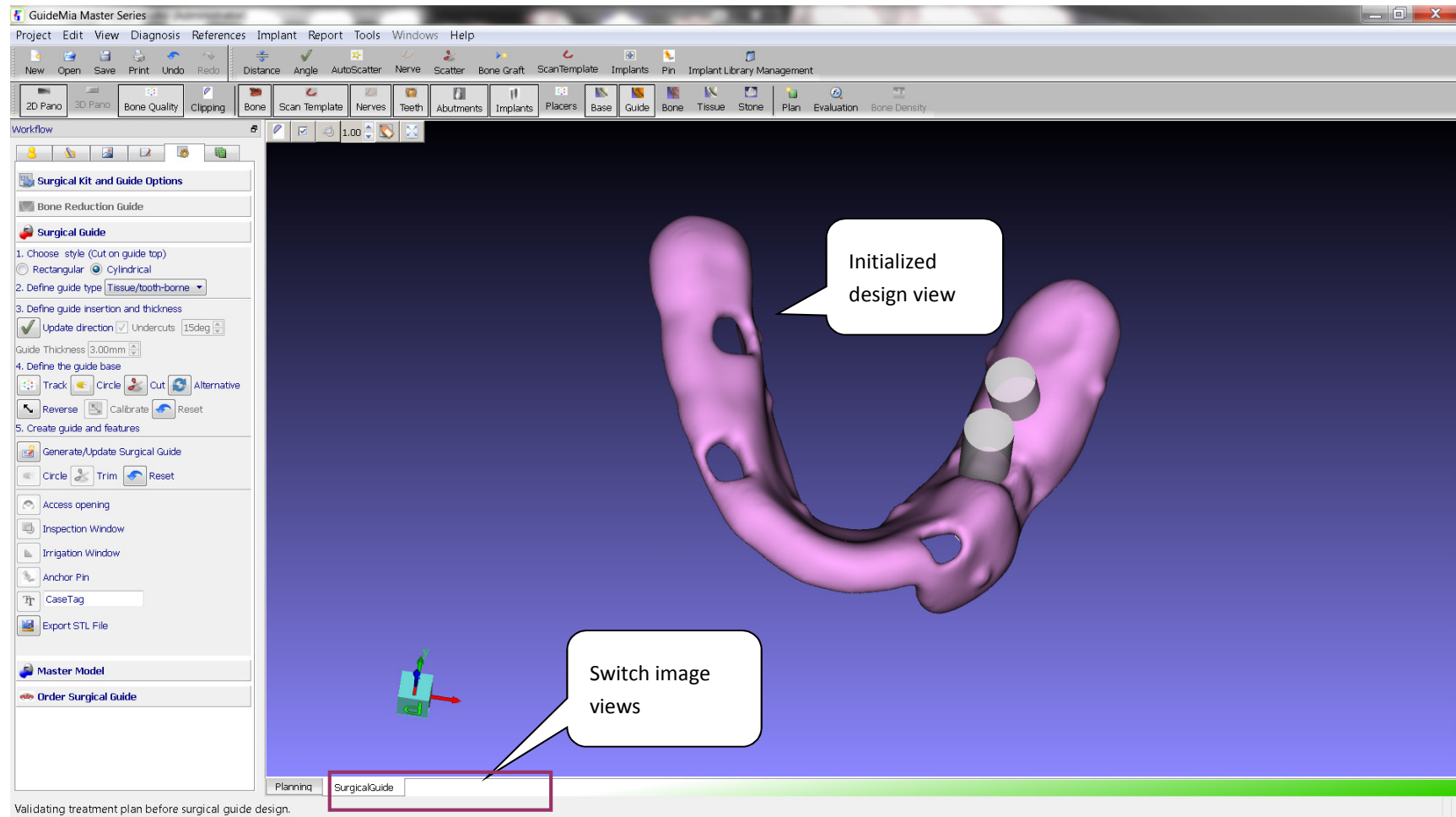
1. Enter design module, plan validation.
2. Choose and configure surgical kit. With the supported implant library and surgical kit types, the software can automatically choose surgical kit for you, therefore this is an optional step.
3. Specify user defined surgical kit.
4. Configure surgical kit
5. Basic steps to design a surgical guide for dual scan case.
6. Trim surgical guide by a profile.
7. Add inspection window
8. Add irrigation window

9. Add case tag
10. View surgical guide in planning view.
11. Enter master model tool box.
12. Create master anatomy model.
13. Edit implant after surgical guide design.
14. Update surgical guide design after choosing different implant.
15. Choose to design bone level surgical guide.
16. Define a surface area as the base for surgical guide design.
17. Generate bone level surgical guide.
18. Generate treatment planning report.
19. Save report file.
20. Browse report in web browser.

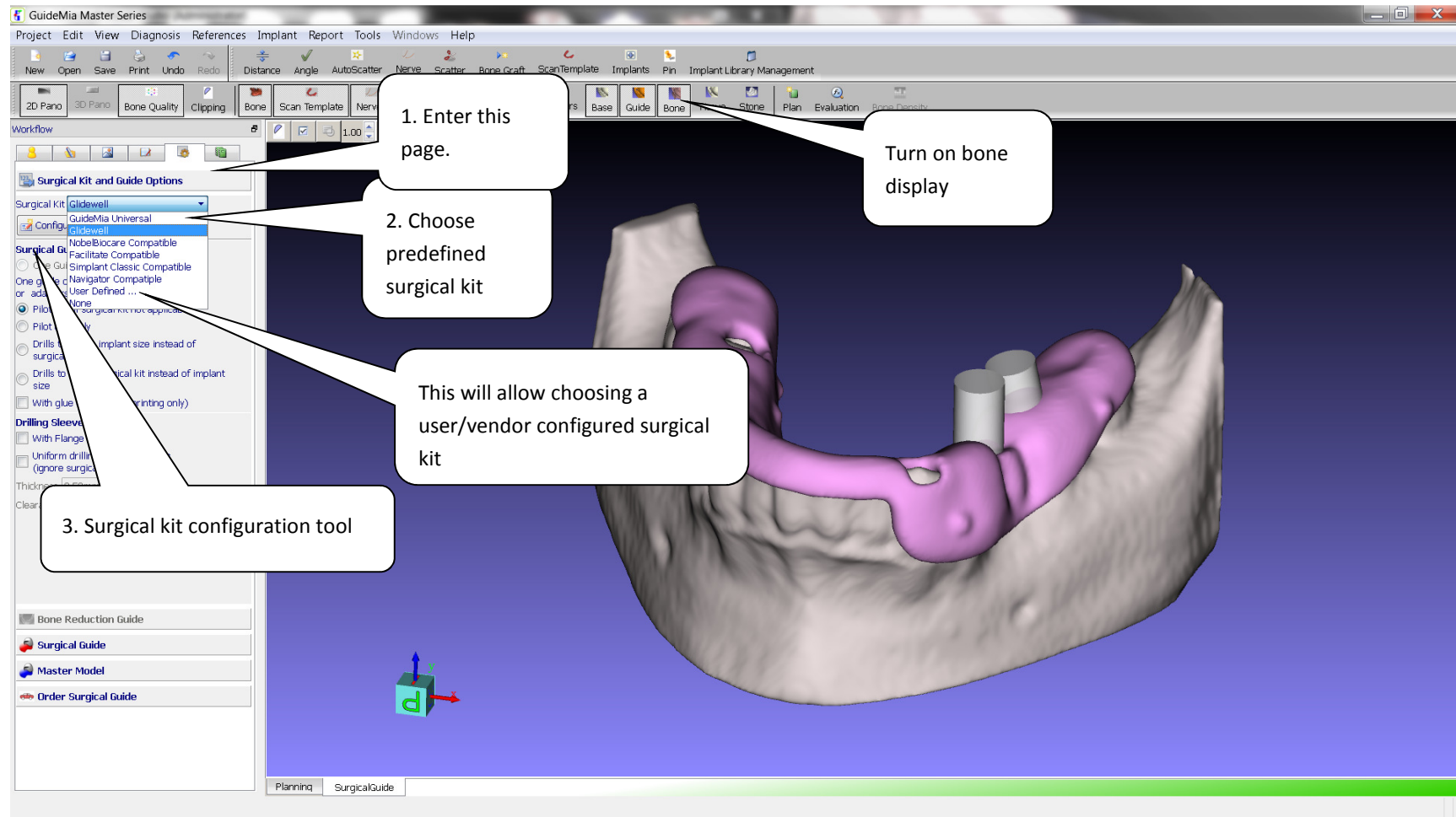
SPECIAL CASES , removing materials underneath the surface

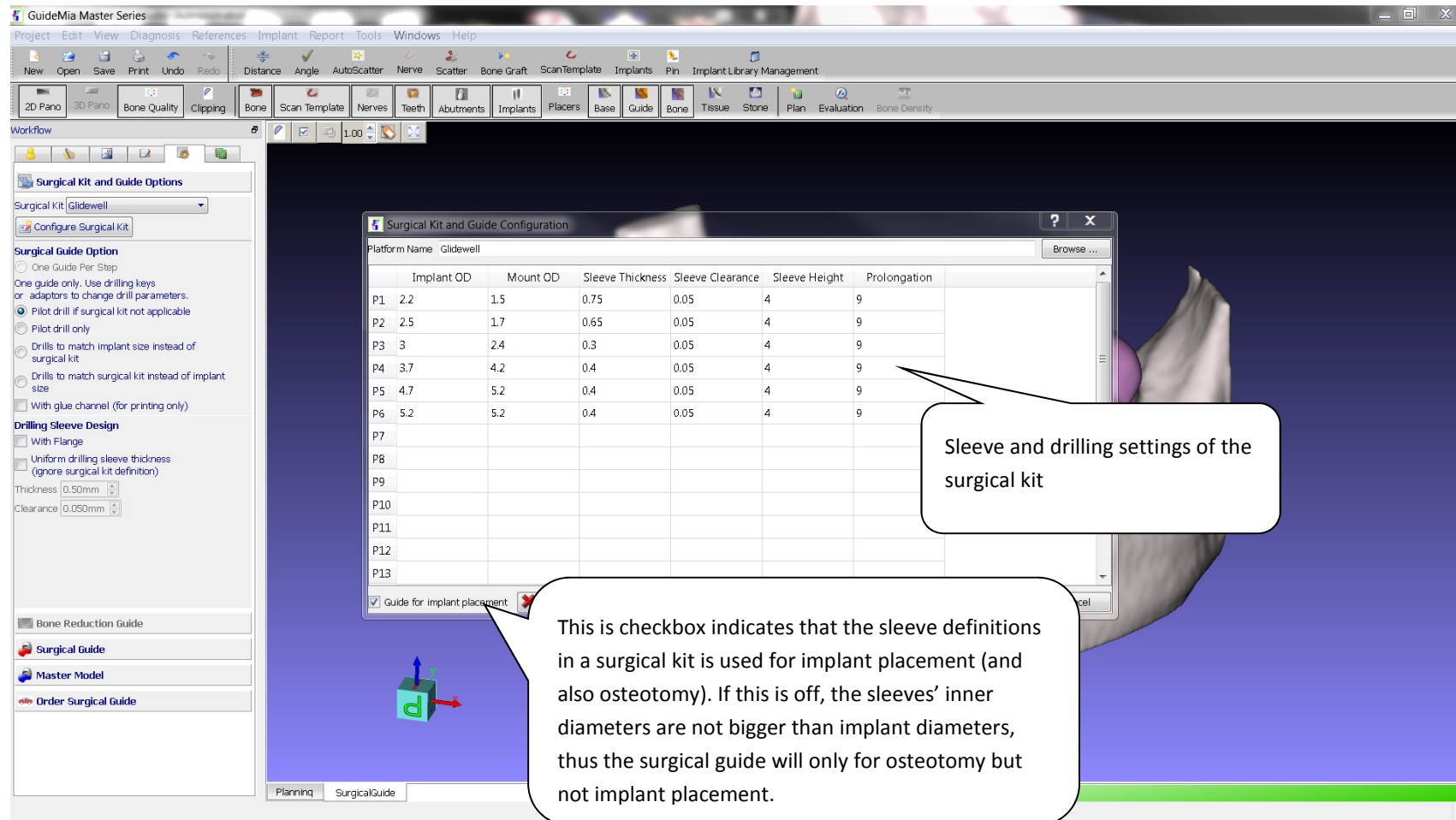


Step 1. Plan validation before the system gets into the guide design environment.

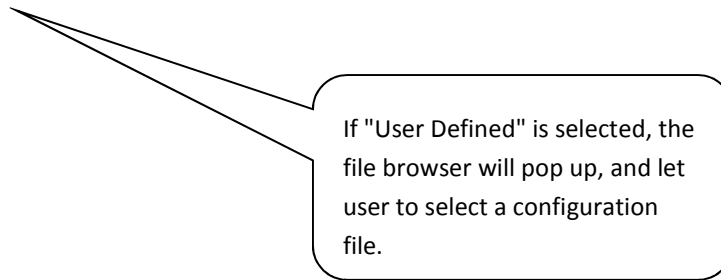


Step 2. Enter Surgical Guide Module

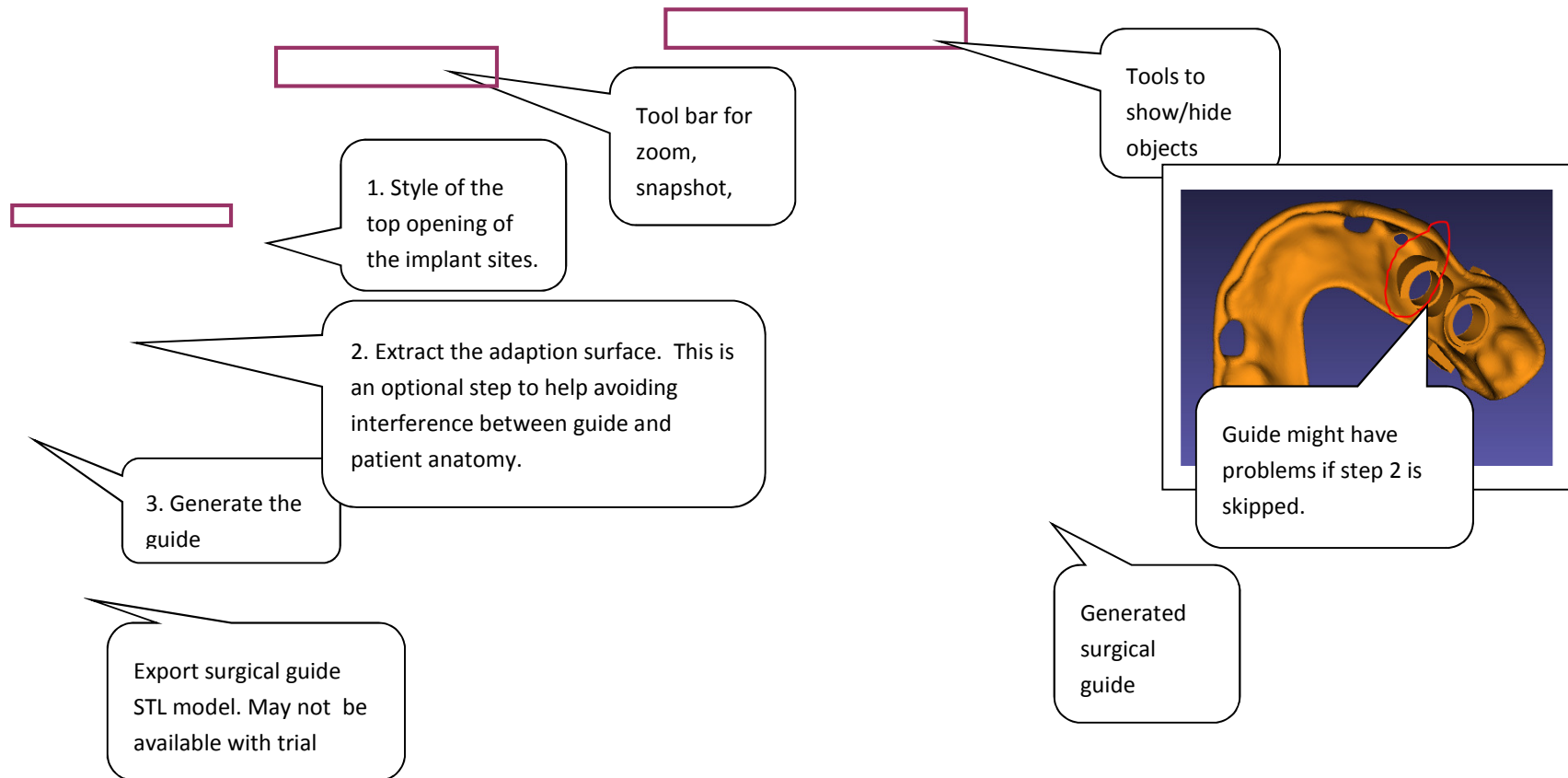
**Step 3. Choose surgical kit**



Configure Surgical Kit. This tool allows the users to define implant platforms, drilling prolongation, sleeve thickness, etc. The kit configuration is not supposed for individual cases. It is to add support to kits from different vendors.



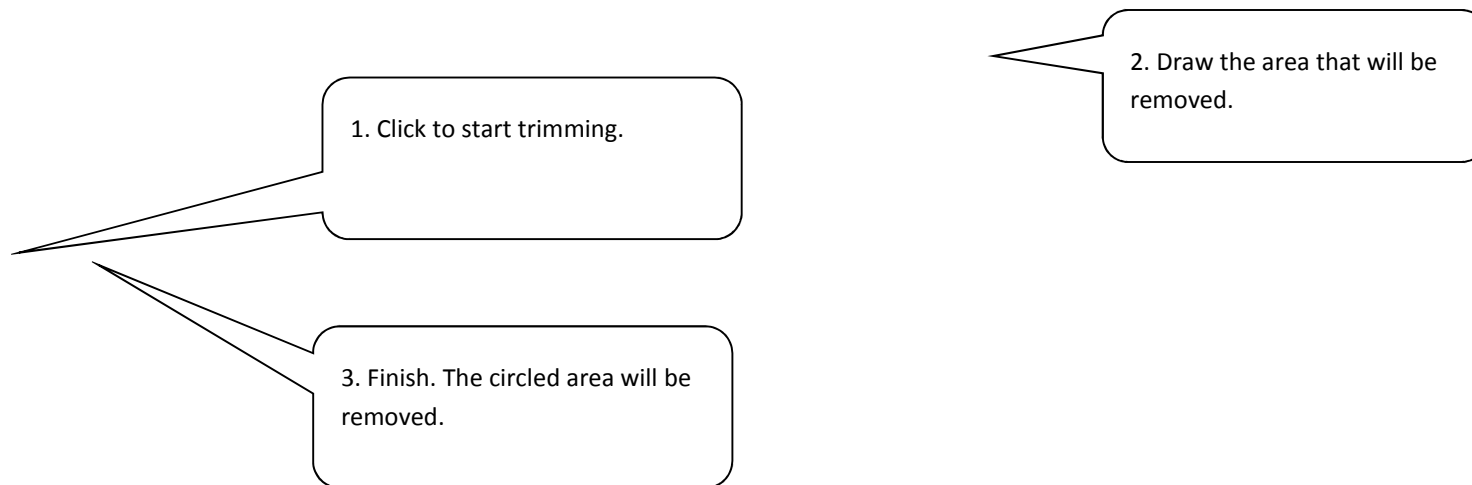
Select user's surgical kit configuration file.



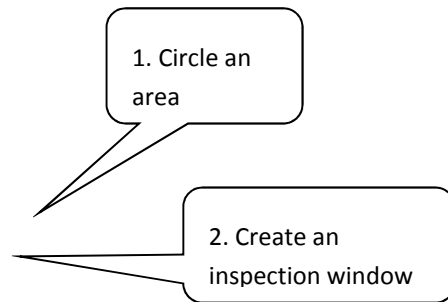
Step 4. Tissue-base surgical guide design (1).



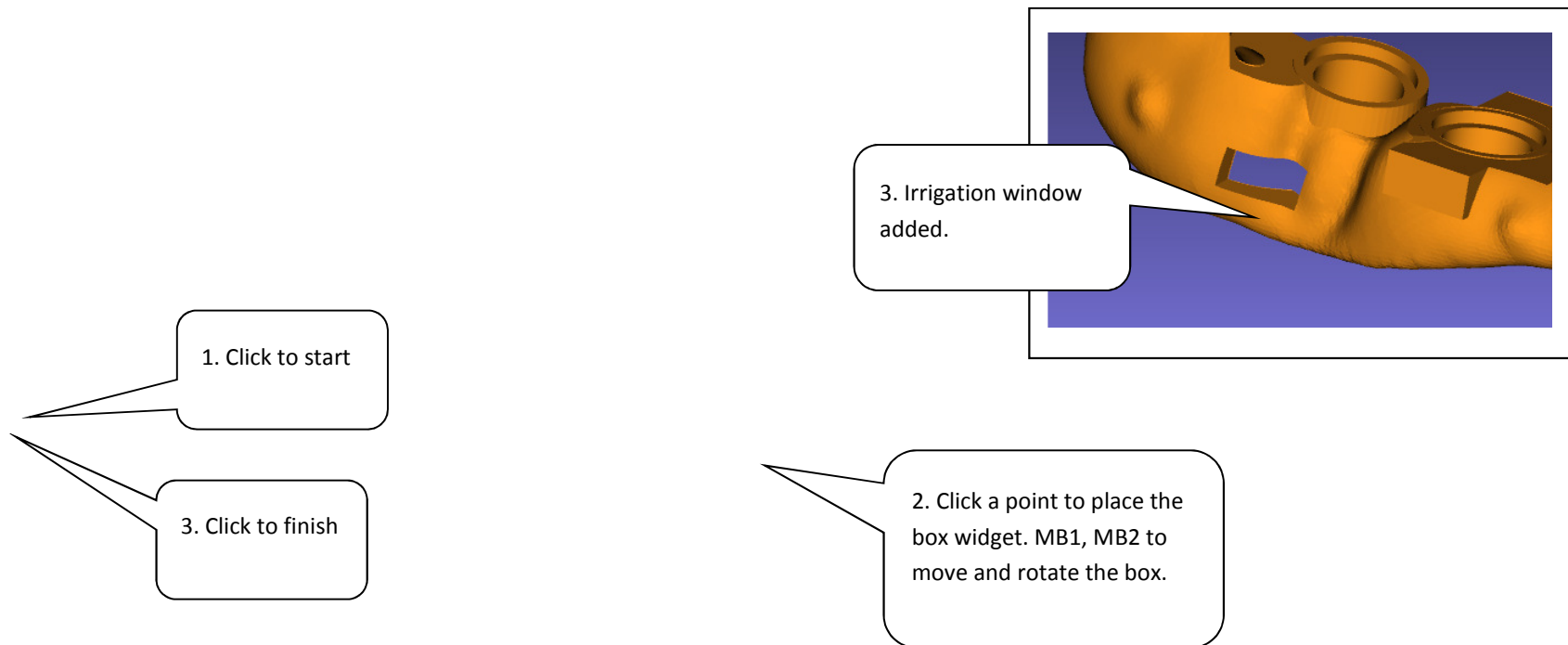
Step 5. Surgical guide design (2). Result.



Step 6. Tissue-based guide design (3) - Trim by profile



Step 7. **Tissue-based guide design (4) - Add inspection window. Same process as "trimming".**

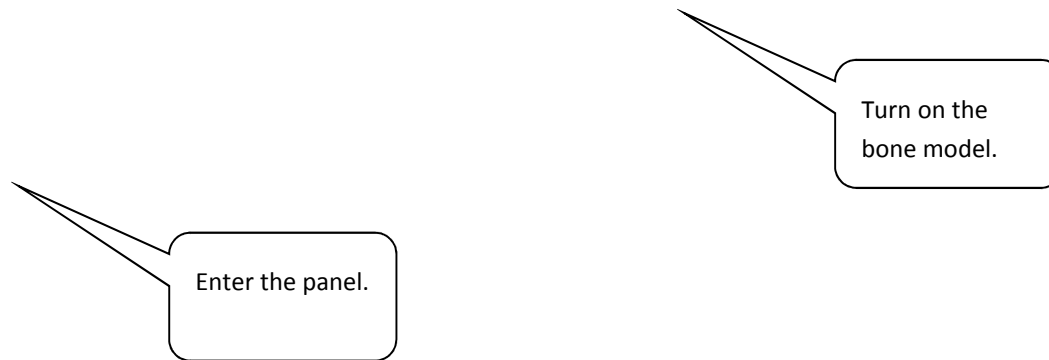


Step 8. **Tissue-based guide design (5) - Add irrigation window.**

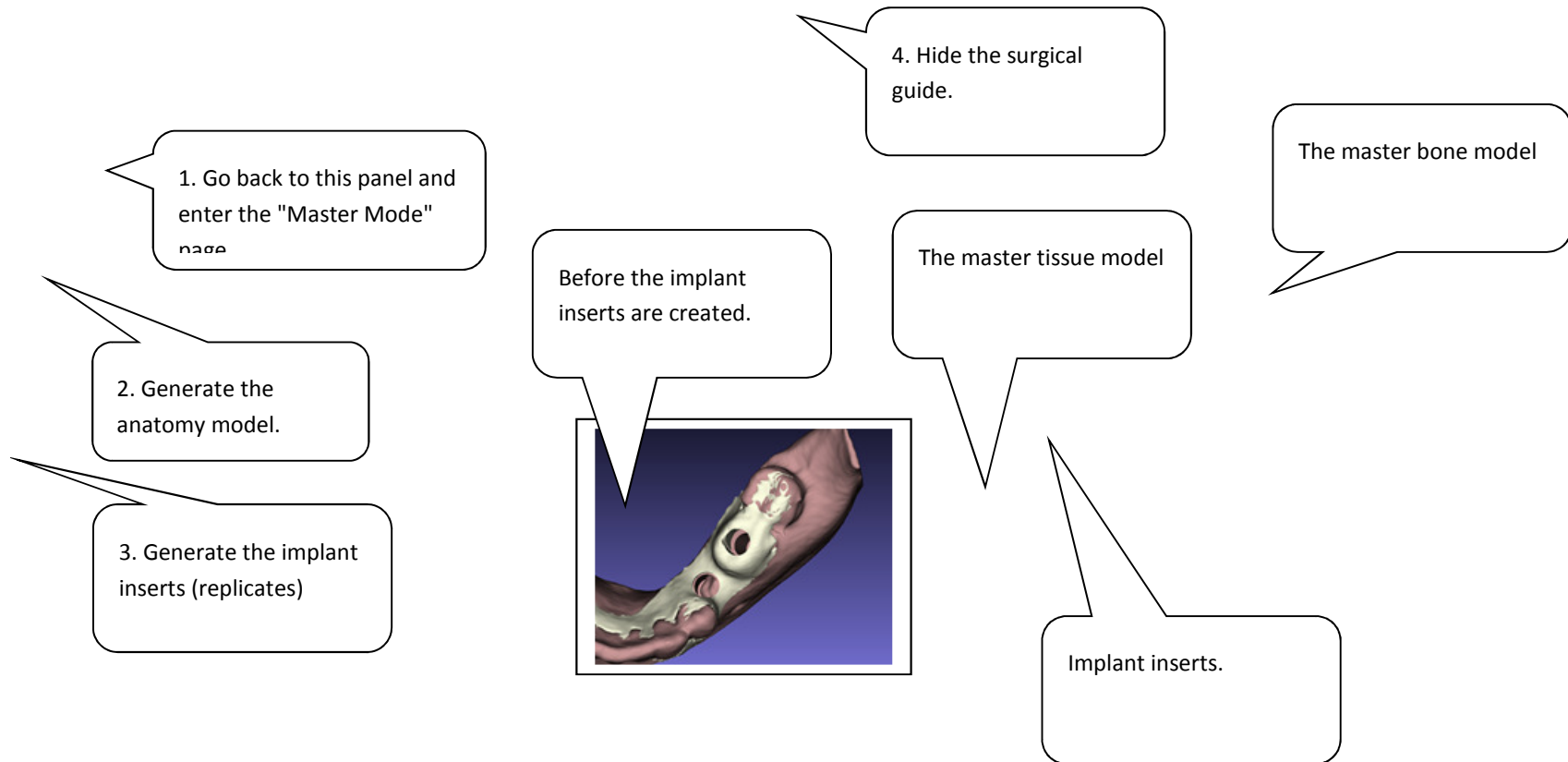


Step 9. Tissue-based guide design (5) - Add case tag.

Step 10. View surgical guide in the planning view.

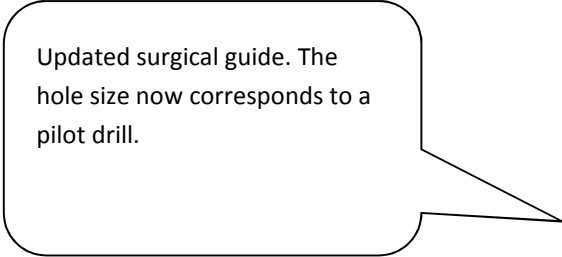


Step 11. Master Model (1) - Enter the task



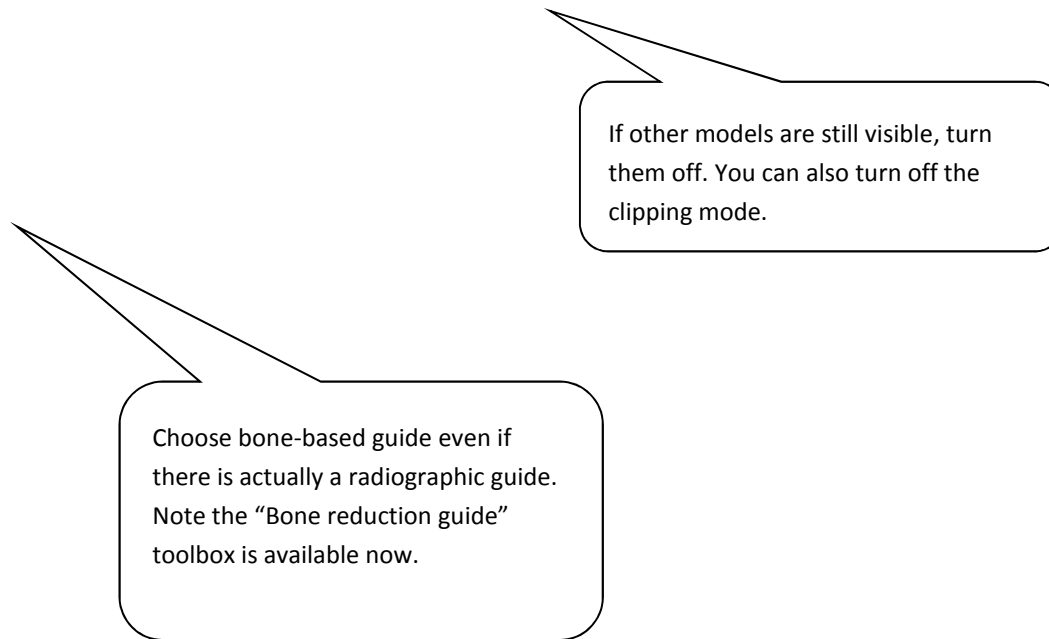
Step 12. Master Model (3) - Master models finished.

Step 13. **Implant editing.** Change the implant #19. Reselect one with diameter of 4.3mm, which will is not in the surgical kit supported list.

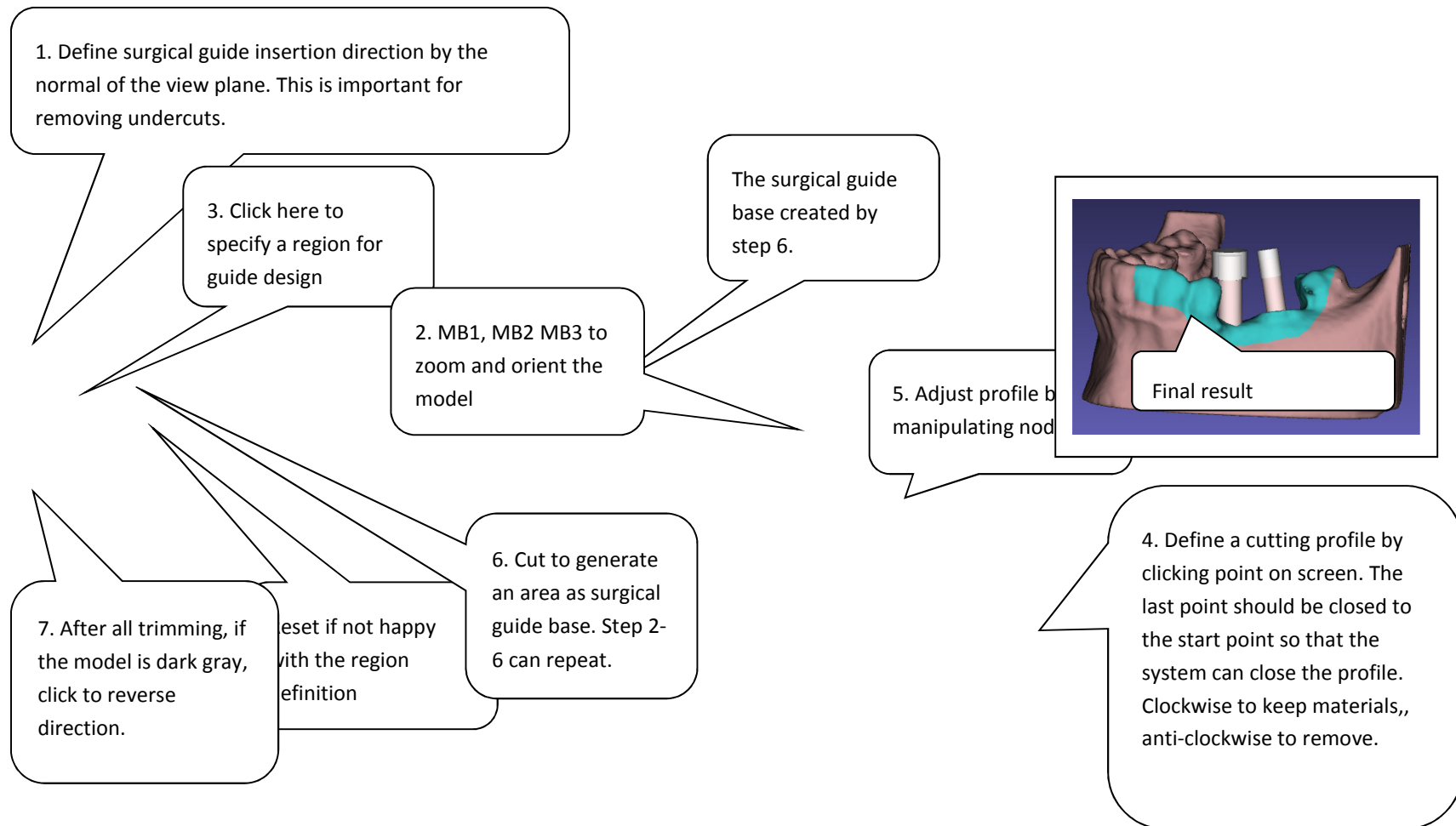


Updated surgical guide. The hole size now corresponds to a pilot drill.

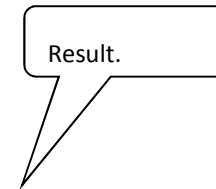
Step 14. Surgical guide regeneration. Go back to surgical guide panel, click "Generate/Update Surgical Guide". See the guide features are for pilot drills only. Then regenerate the master model.



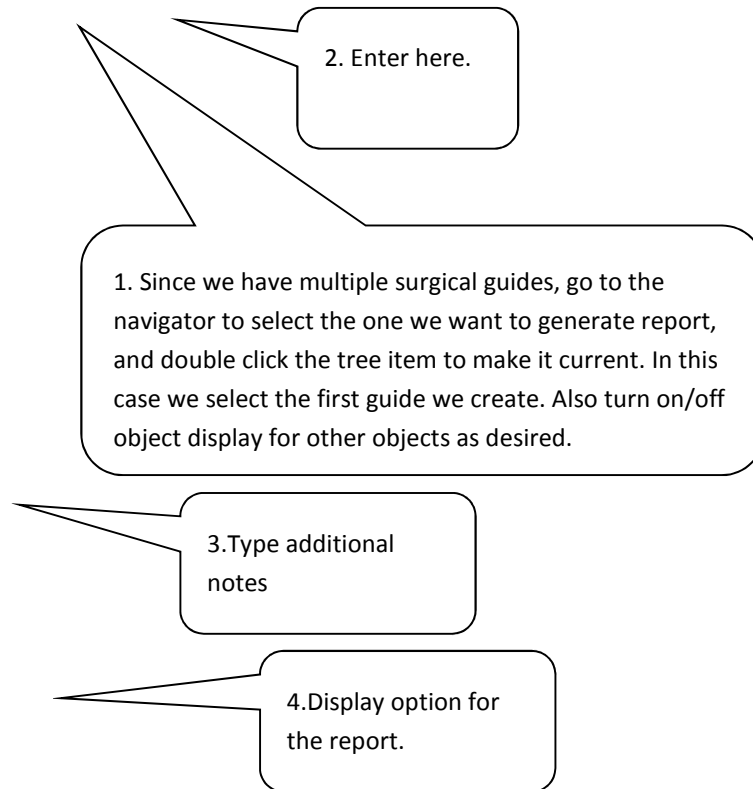
Step 15. Design bone-based Surgical Guide (1). With or without radiographic guide, this can always be done.



Step 16. Design bone-based Surgical Guide (2). Data preparation. Step 2,4,5 and 6 can be repeated as many times as desired.



Step 17. Design bone-based Surgical Guide - (3). Generate the guide. This step can take a half minute or more. It does a couple of things including generating model, smoothing, removing undercuts, etc. The post processing like trimming, inspection window, anchor pin, etc can be added as in tissue-based guide design.

**Step 18. Generate Treatment Plan (1)**

Step 19. Generating Report. Once the button "Generate report" is clicked. system will ask for an html file name.
This will generate a HTML page and a set of image files, which can be browsed and printed with web browser anytime.



GUIDEMIA© IMPLANT TREATMENT PLAN

John Smith
 ABD Dental Clinic
 Tel: 123-456-7890
 email: abc@abcdental.com

Visit www.guidemia.com
 for a complete sample of
 a treatment plan report.

Patient Name
Sex
DOB
Case Number Undefined
Planning Date Tue Jun 4 2013

Plan Overview

Implant List

ToothNumber	Implant Diameter	Apic Diameter	Implant Length	Implant Make	Implant Part#
19	4.300000000000002	3.4	11.5	Glidewell	InclusiveTapered4.7x11.5
20	4.7	3.4	11.5	Glidewell	InclusiveTapered4.7x11.5

Anchor Pins

Number of Anchor Pins: 0
 Anchor Pin Diameter: N/Amm

Step 20. Treatment Plan - Cover Page has patient information and plan overview.

Drilling Instructions

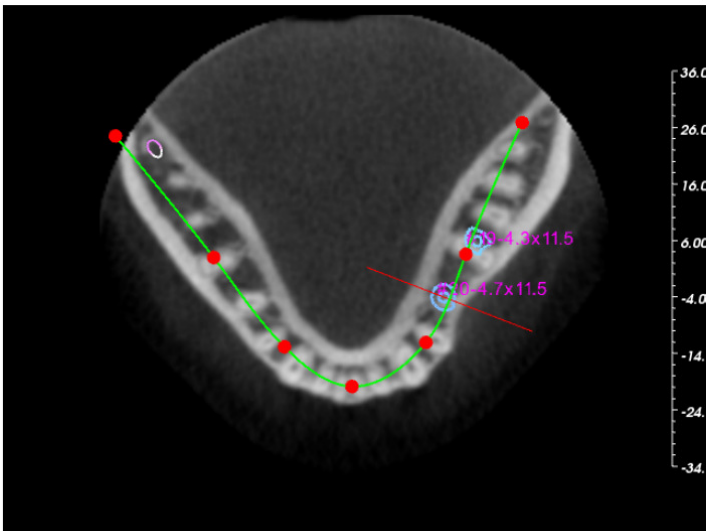
ToothNumber	Surgical Kit	Drilling Instruction
19	Glidewell	<p>Pilot drill only with surgical guide: No</p> <p>Surgical guide designed to match surgical kit: No</p> <p>Surgical guide designed to match implant size: No</p> <p>Drill sequence: Follow Surgical Kit Information</p> <p>Drill prolongation: 9mm. Total drill depth: 20.5mm. This does not include the drill tip or surgical kit key thickness, which can add to the drilling depth.</p>
20	Glidewell	<p>Pilot drill only with surgical guide: No</p> <p>Surgical guide designed to match surgical kit: No</p> <p>Surgical guide designed to match implant size: No</p> <p>Drill sequence: Follow Surgical Kit Information</p> <p>Drill prolongation: 9mm. Total drill depth: 20.5mm. This does not include the drill tip or surgical kit key thickness, which can add to the drilling depth.</p>

Note: By default a surgical guide is designed for the matching surgical kit. If a surgical guide is design for pilot drill only, the holes match the pilot drills defined by the implant platform or surgical kit, or 2mm, whichever is smaller. If a surgical guide is designed to match surgical kit, the holes are not designed for the final drilling corresponding to implants, but the matched diameters of drills of the selected surgical kit.

Surgical Guide

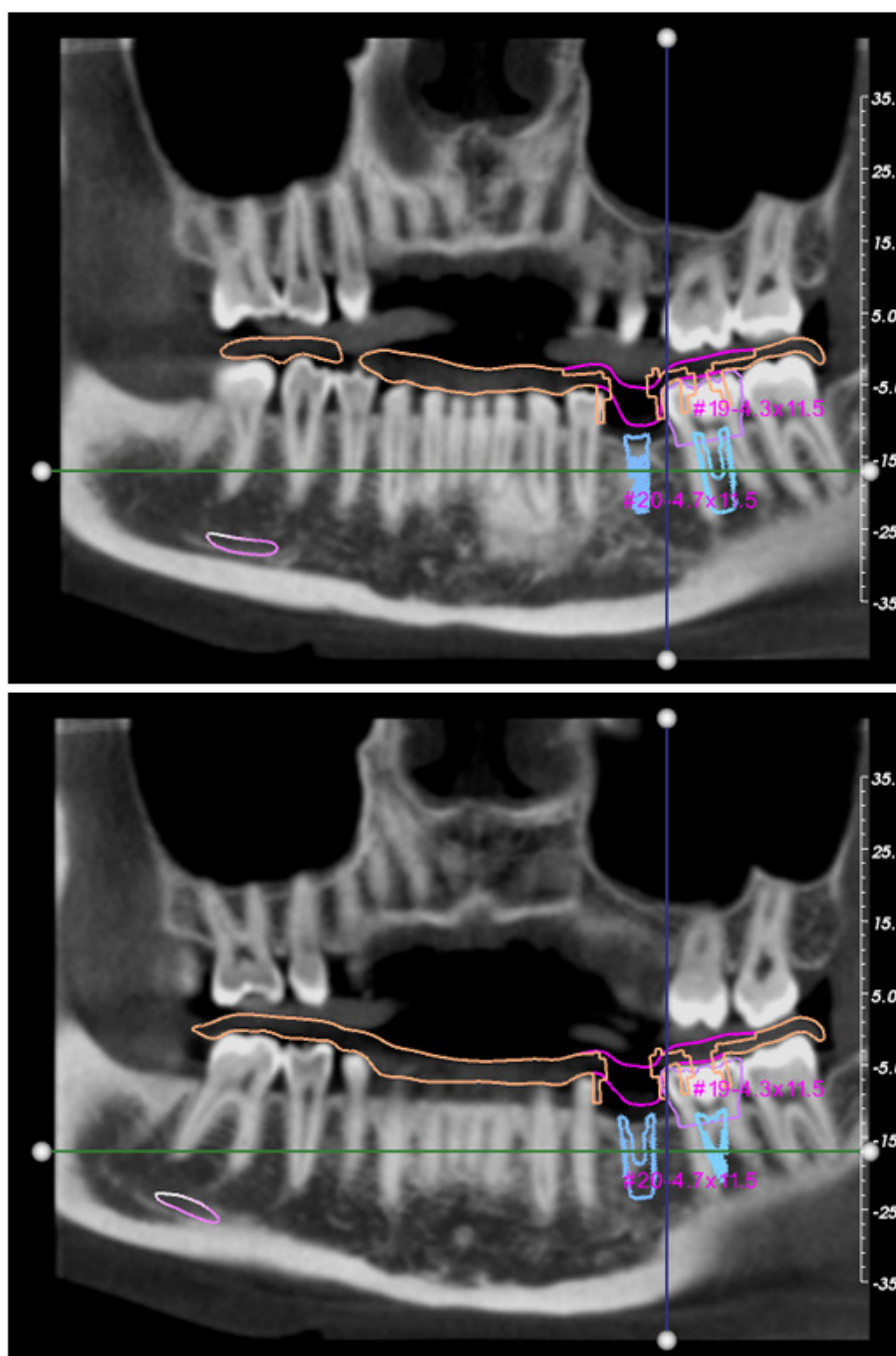
Surgical Guide Status:OUT OF DATE. The implant slice images generated in this report may be not consistent with the surgical guide design. Guide
Timestamp:232140798
Surgical Guide Type: Bone Borne
Surgical Guide Manufacturing: Cylindrical cut on implant sites.

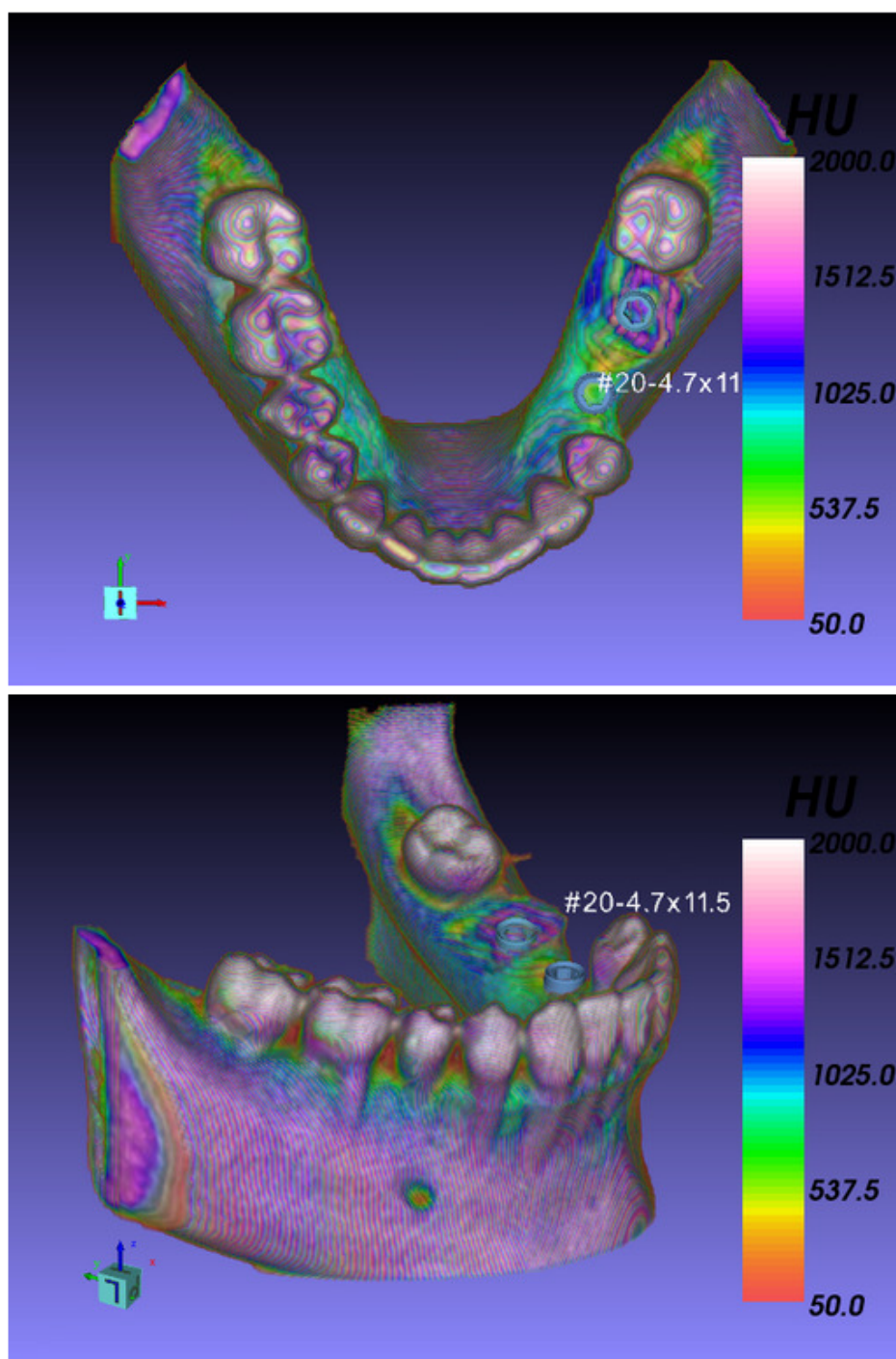
Additional comments: None.

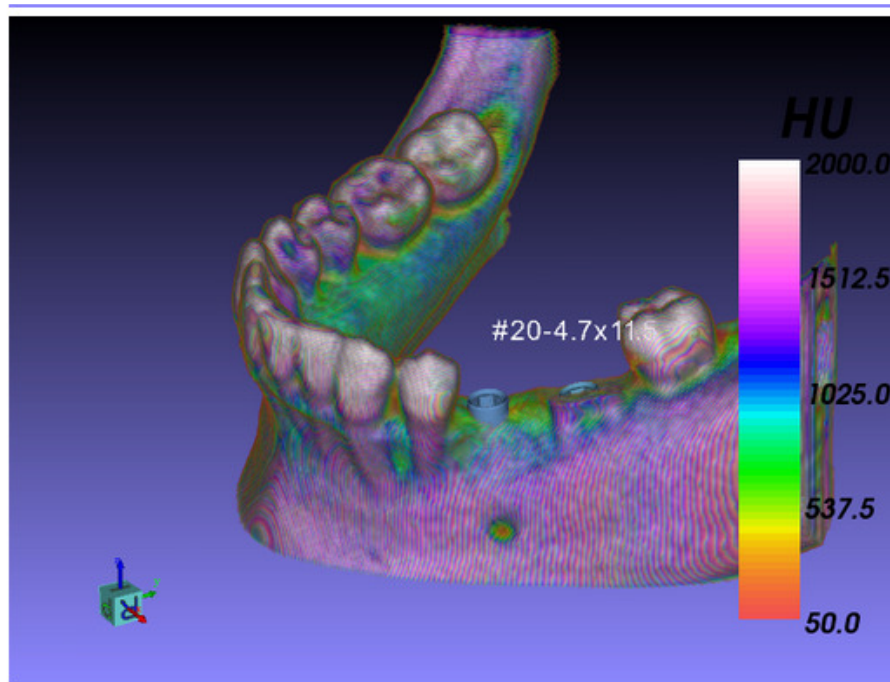


Plan Overview - Axial

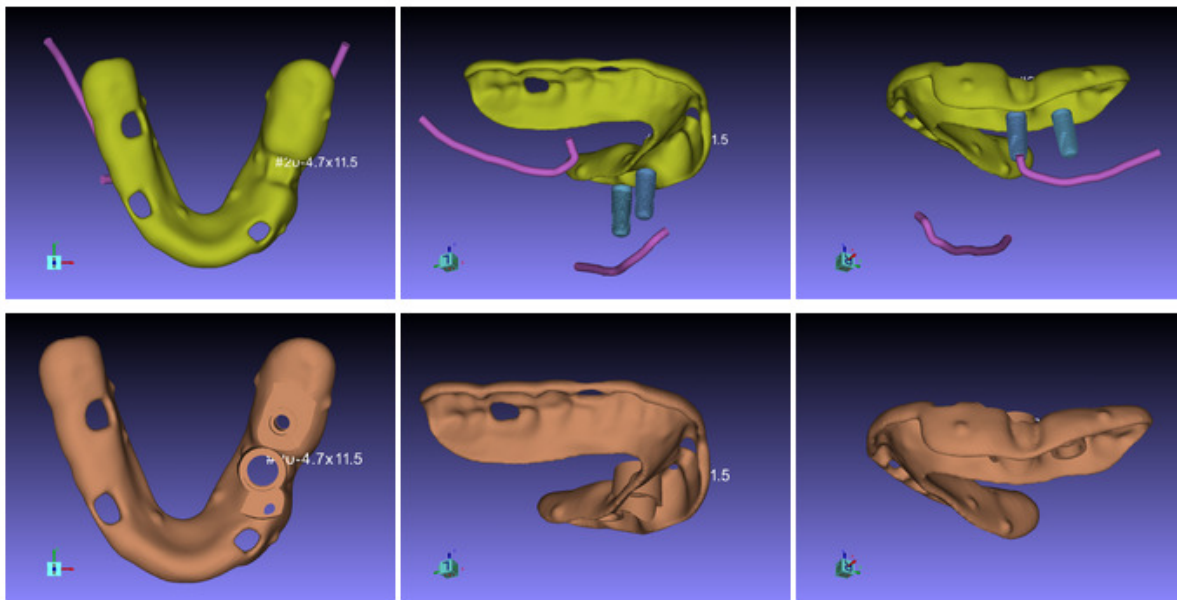
Treatment Plan - Drilling instructions and overview images. Please note only the last surgical guide you designed will be treated as the final plan.



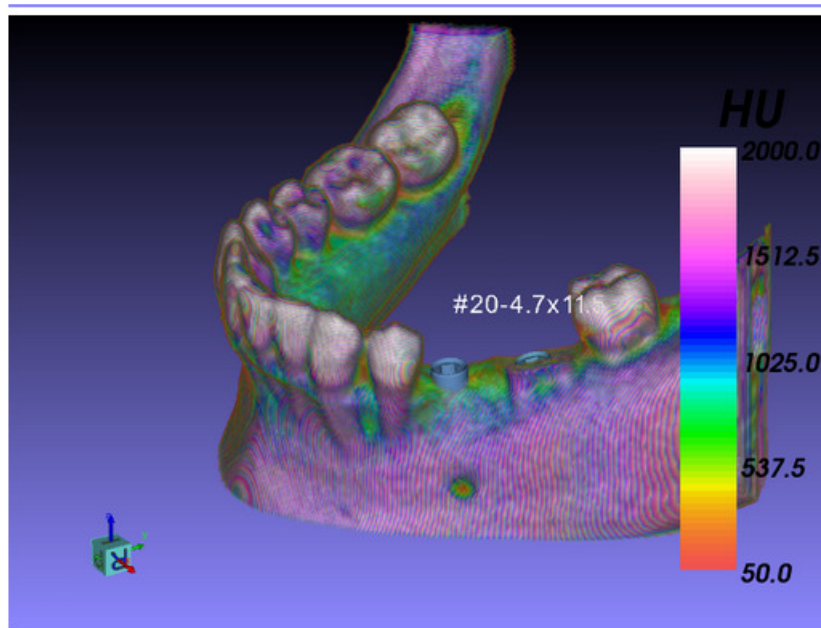




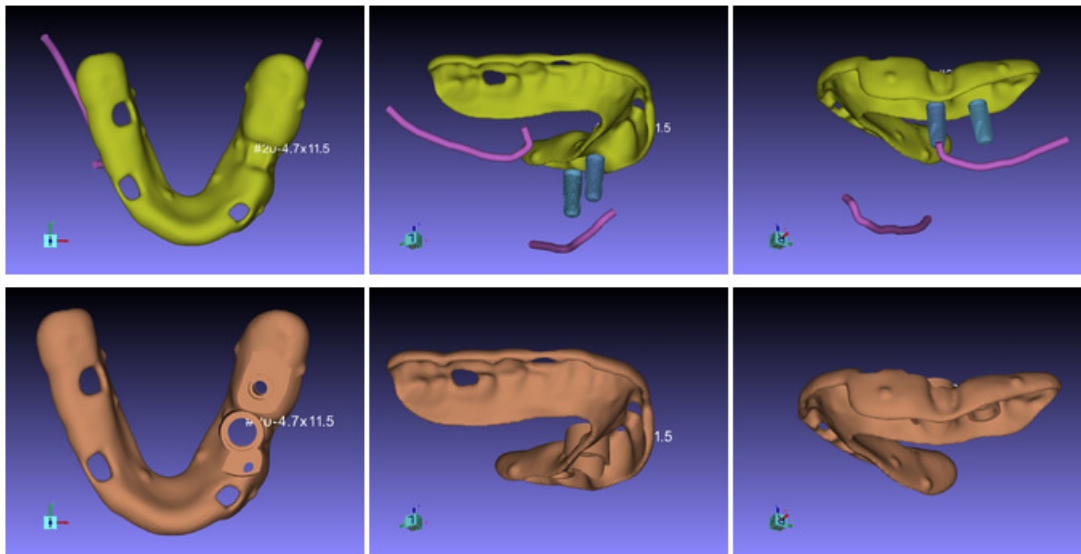
Plan Overview - 3D Bone and Implants



Plan Overview - 3D Radiographic Guide, Surgical Guide and Implants

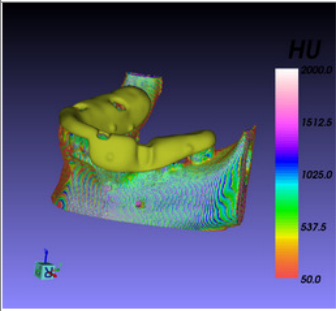
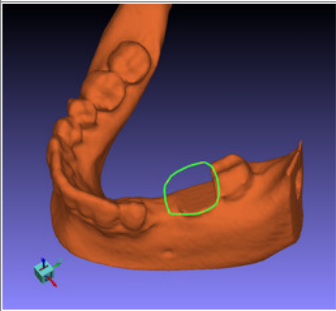
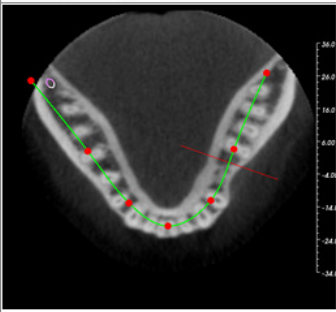


Plan Overview - 3D Bone and Implants



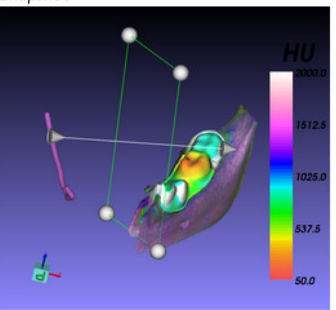
Plan Overview - 3D Radiographic Guide, Surgical Guide and Implants

Tooth Extraction

Tooth Extraction	Notes
	Tooth Extraction: Tooth number - 19. Tooth 19 will be extracted before implant placement. Surgical guide design will consider this.
	Tooth Extraction: Tooth number - 19. Tooth 19 will be extracted before implant placement. Surgical guide design will consider this.
	Tooth Extraction: Tooth number - 19. Tooth 19 will be extracted before implant placement. Surgical guide design will consider this.

Sinus Grafting

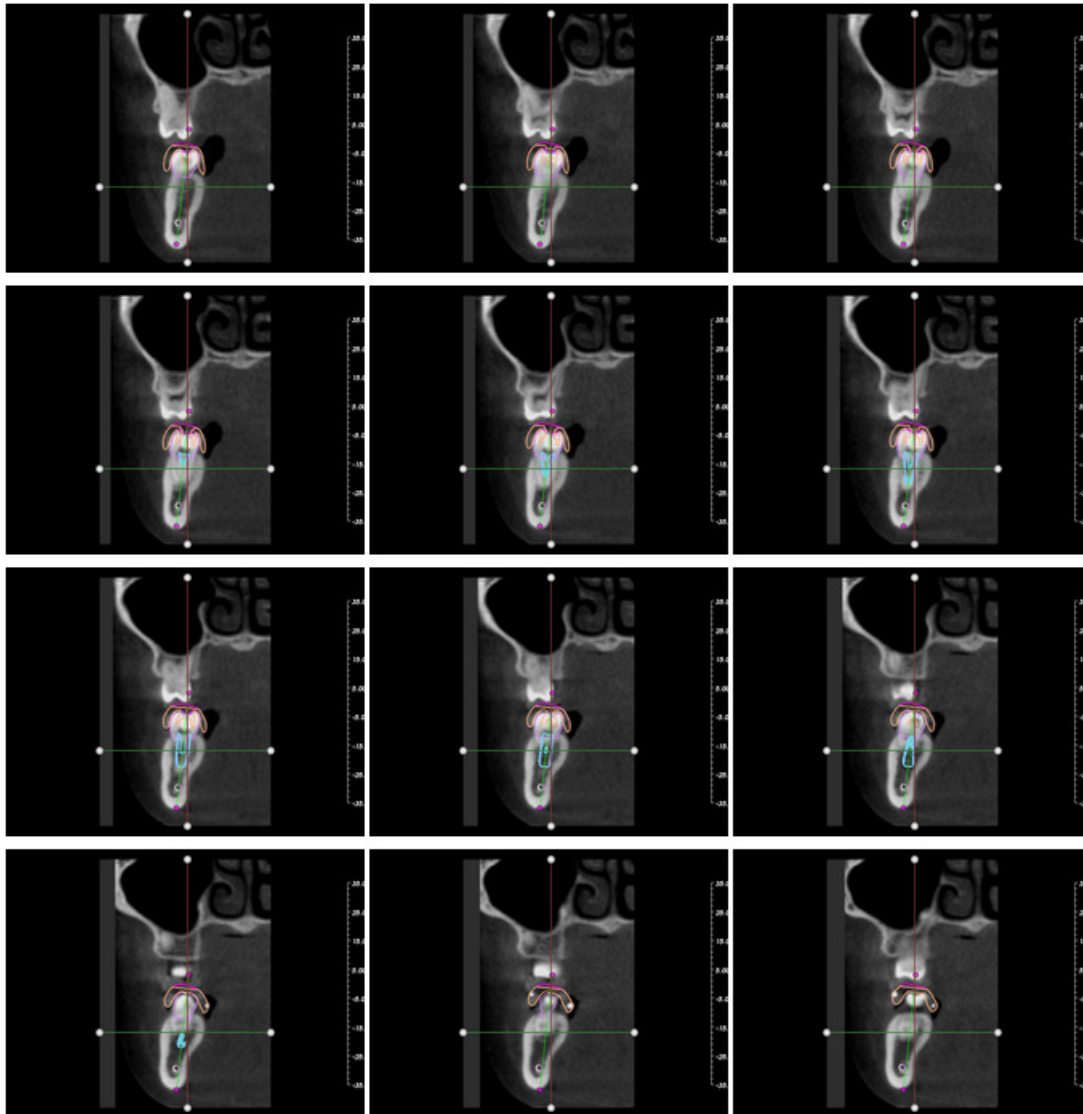
Diagnosis And Planning Notes

Snapshot	Notes
	

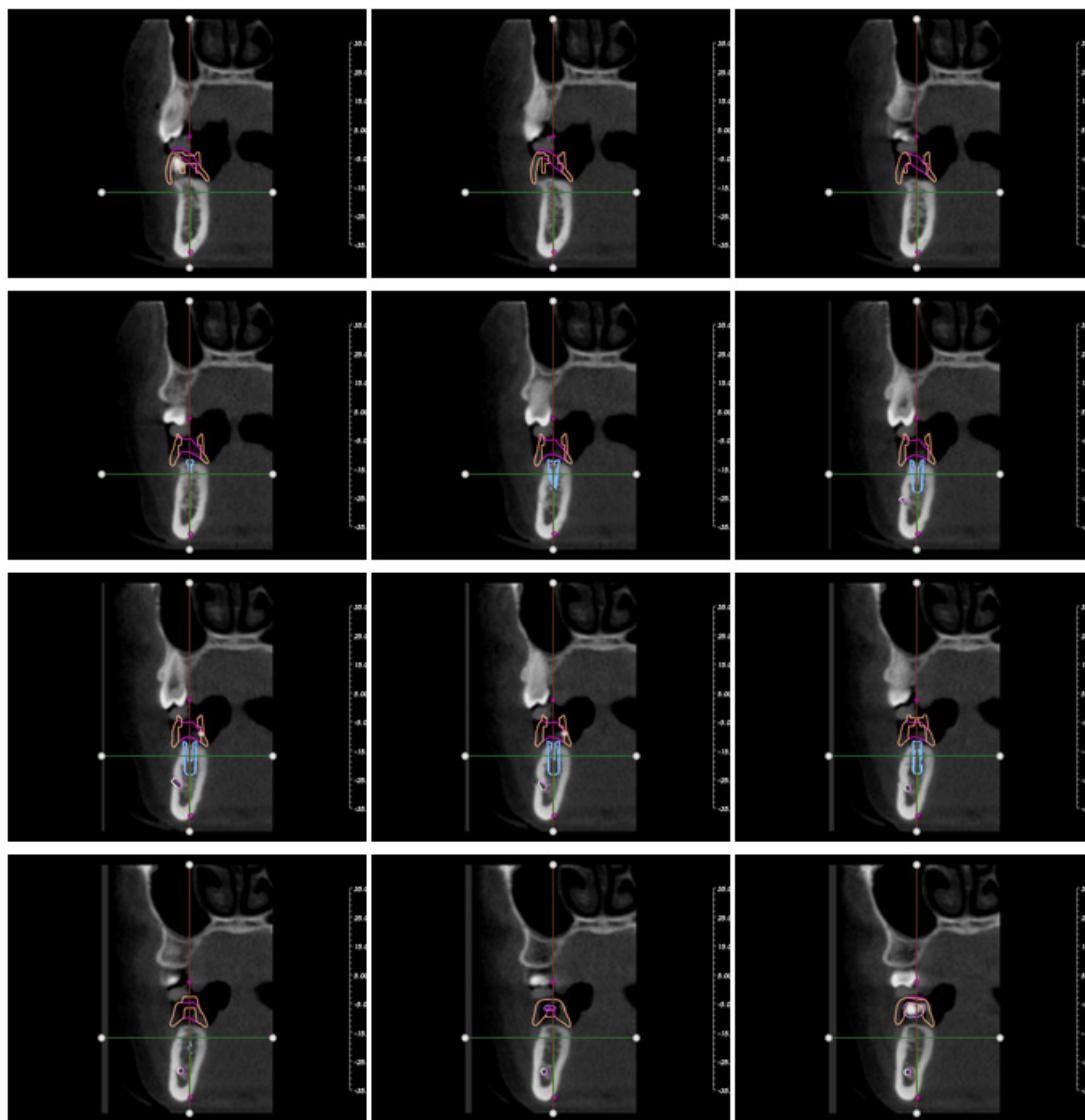
Implants

Slice Images:

Tooth Number: 19



Tooth Number: 20



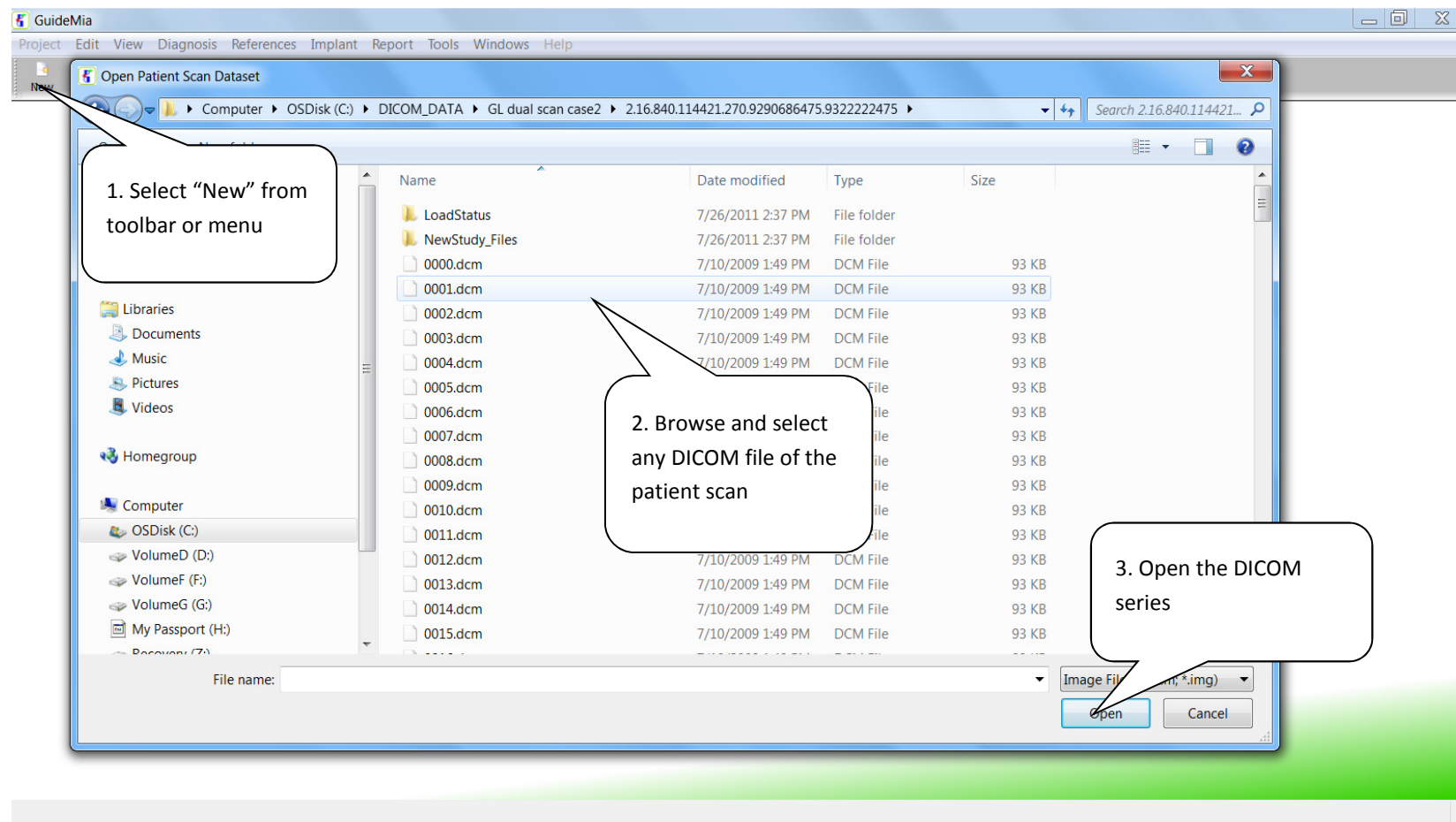
(c)2011 GuideMia Dental Technology. All Rights Reserved.

8 . A MORE ADVANCED CASE

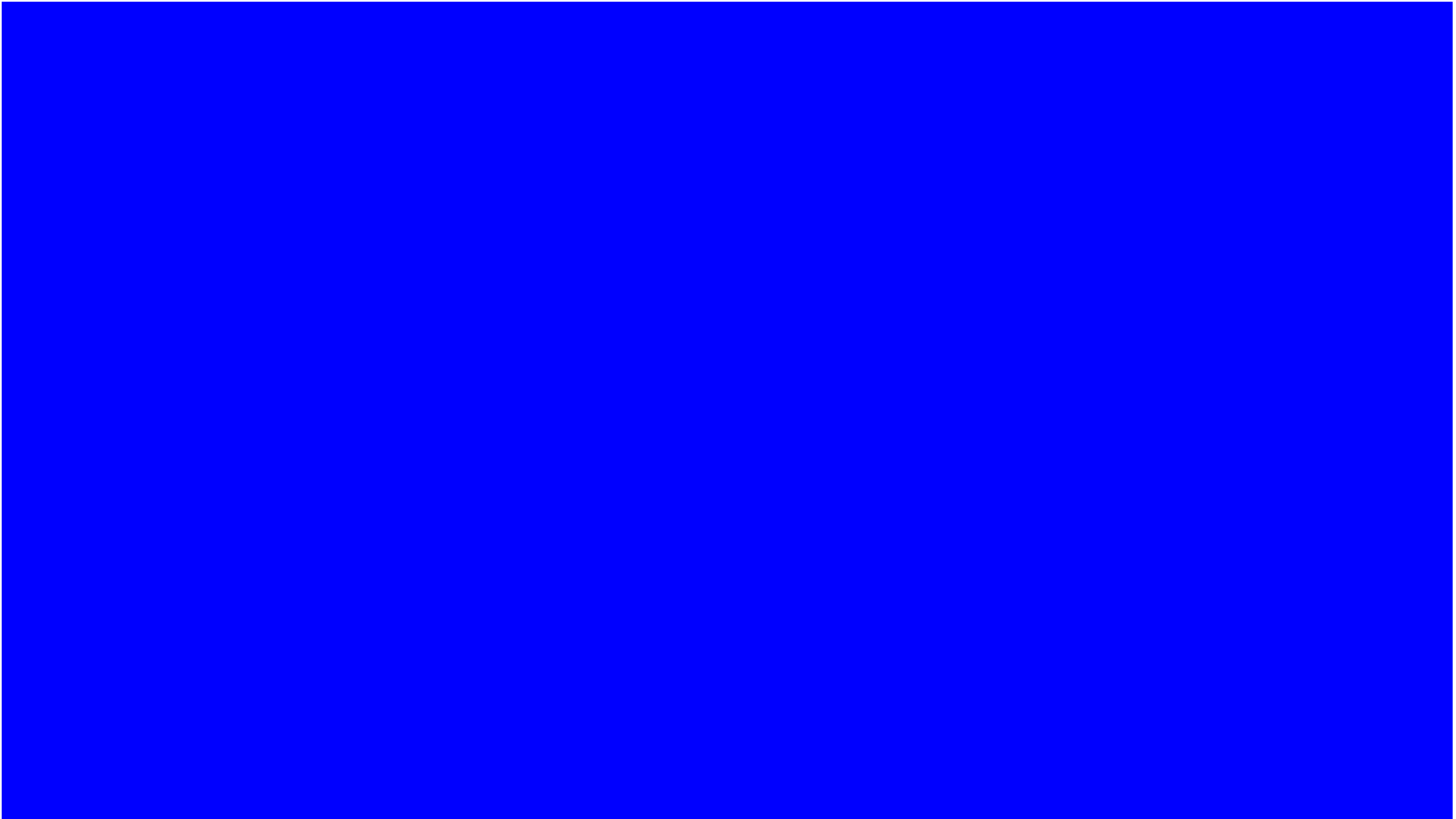
The organization of this chapter is also workflow-based. Instead of going through the functions and UI items, a treatment workflow is used to ensure that the functions are organized in a sensible manner. The workflow used in this section is a typical one. The patient is partially edentulous, and is scanned without any radiographic guide. Then an intra-oral scan is obtained. Alternatively, an optical scan of a plaster/stone model will serve the same purpose. This model is loaded and registered with patient scan, and used to design surgical guide after the treatment planning.

The following is the quick index to the steps. Each step of the workflow is illustrated in the pictures following this index. Some of them may not have detailed instructions if in chapter 5 and 6 already.

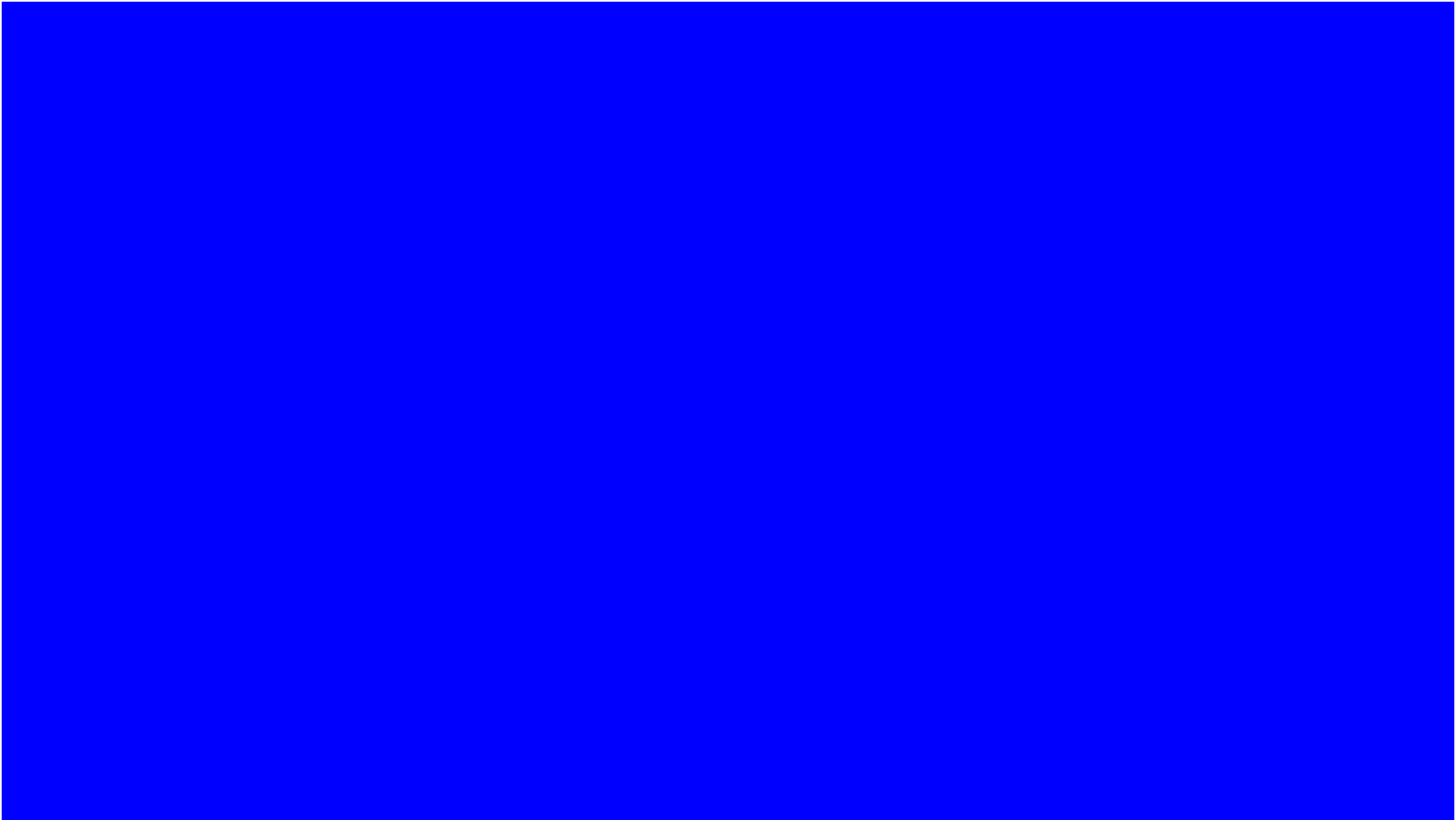
1. New project by loading DICOM files
2. View the DICOM files upon loaded
3. Bone segmentation
4. Automatic scatter removal
5. Tooth segmentation
6. Load intraoral scan STL model
7. Enter model registration
8. Specify markers for registration
9. Finish registration
10. View registered models
11. Load antagonist model/scan
12. Relocate placement widget and adjust model locations
13. Create nerve drawing
14. Finish nerve drawing
15. Plan implant - select from library
16. Plan implant - place and adjust implant
17. Plan implant - cross section model
18. Change cross section mode
19. Inspect implant drill sleeves, etc.
20. Perform error simulation
21. Inspect implant neighborhood
22. Create and review snapshots
23. View objects navigator and pop up window in 3D views
24. Enter surgical guide design
25. Design boundary of base model - tracking and trimming
26. Create surgical guide
27. Review surgical guide in planning views
28. Generate report



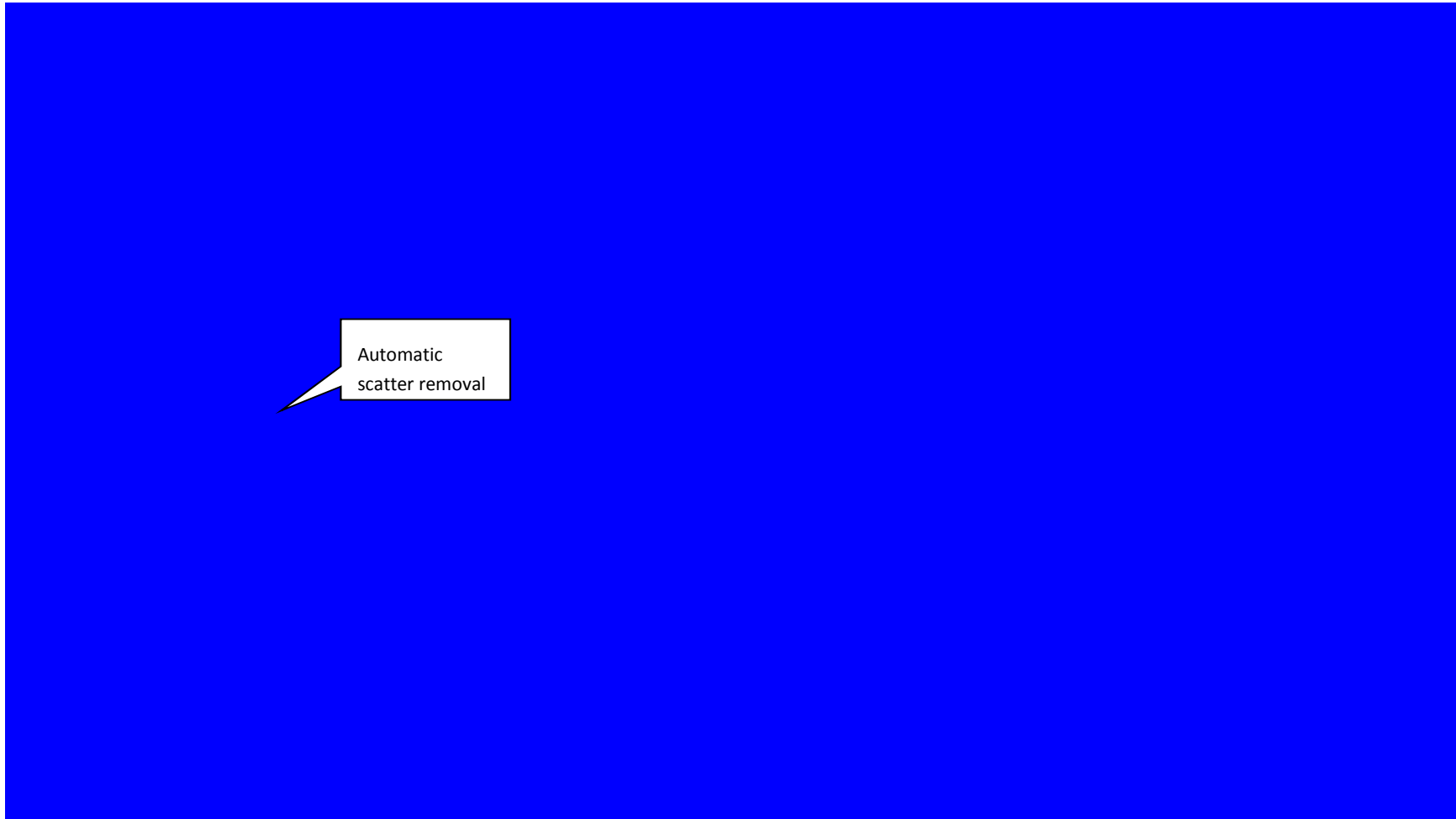
Step 1. Create a project by DICOM series.



Step 2. View the DICOM files upon loaded. Please see chapter 5 for the manipulation of thresholds, region of interest, slice lines, color/black mode, opacity, etc.



Step 3. Bone segmentation. Go to the segmentation tool box, adjust the thresholds, the region of interest box, and specify a seed point on one of the 2D views. The system will instantly update the bone segmentation for you.

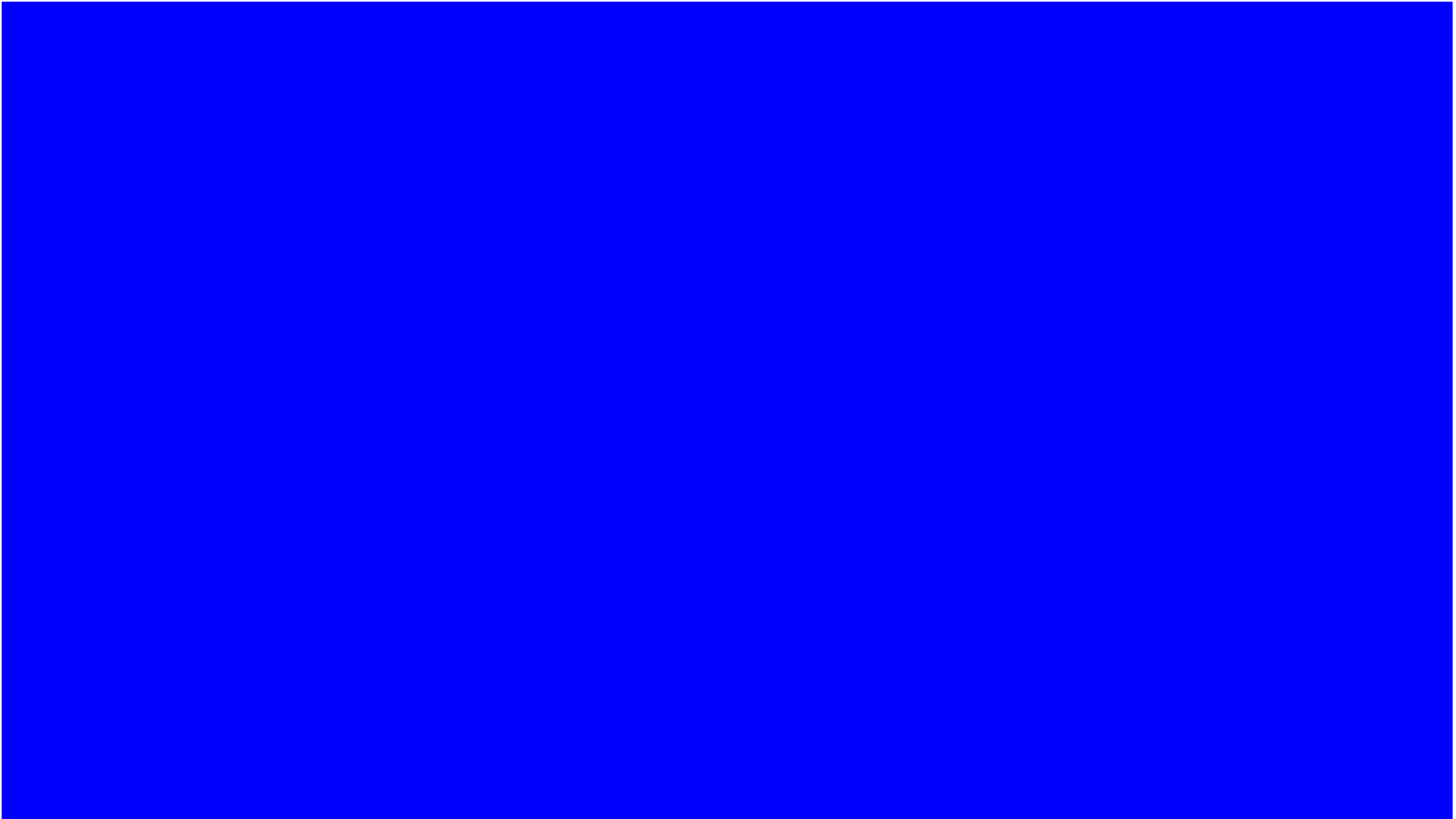


Step 4. Automatic scatter removal. Find the 'remove scatter' label and the two buttons at its right side. The majority of the scatters should be removed by this function.

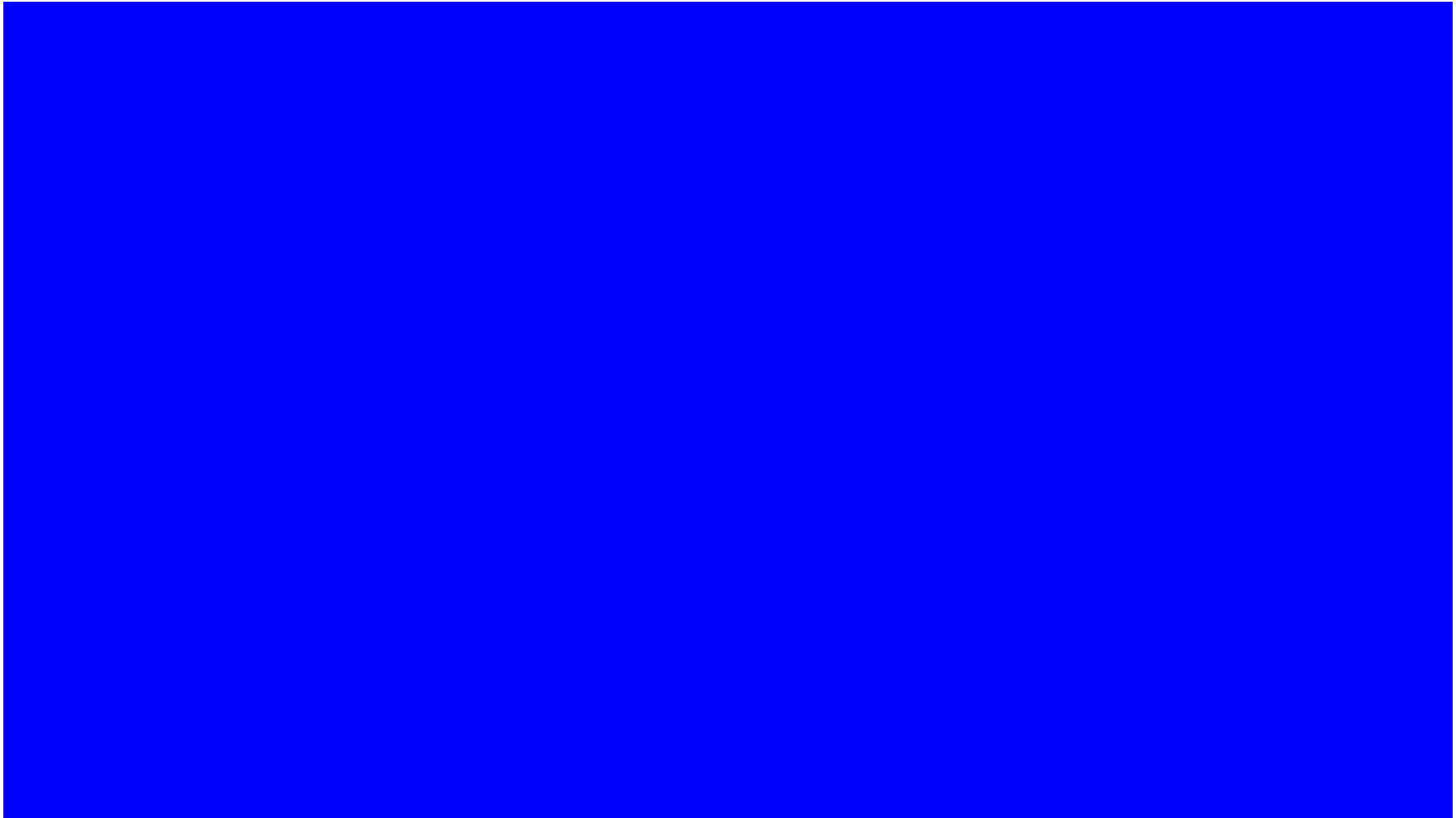
Step 5. Tooth model created. Directly move the slider named as "Tooth (root) Segmentation" will create or update the tooth model for you.



Step 6. Select and stone model STL file or intra-oral scan.



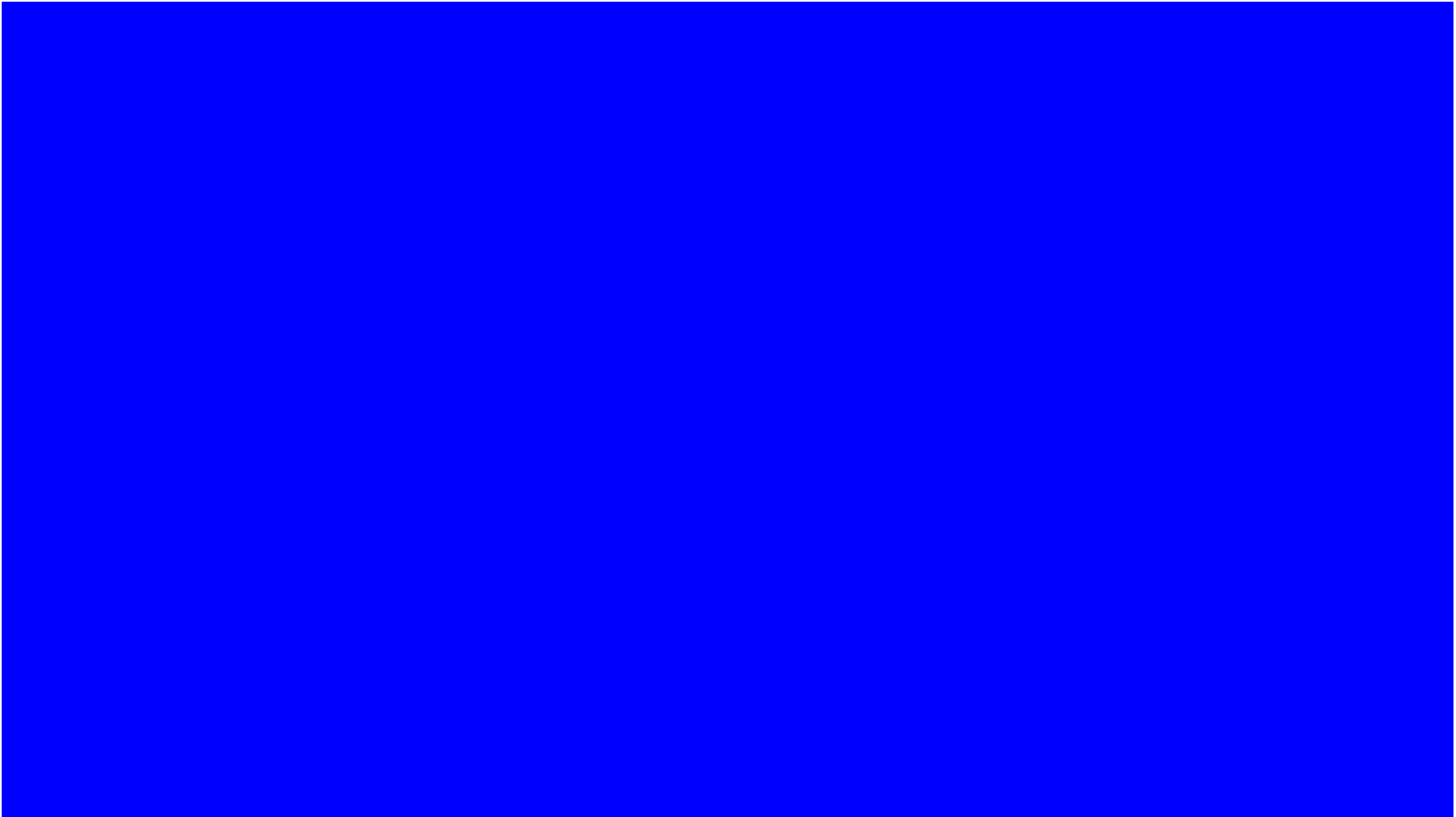
File loaded. If you are not seeing the model on any of the views, the model is probably far away. Use the "Fit" button and the context tool bar of the view windows. Notice the toolbar will not show if the cursor is not in the window.



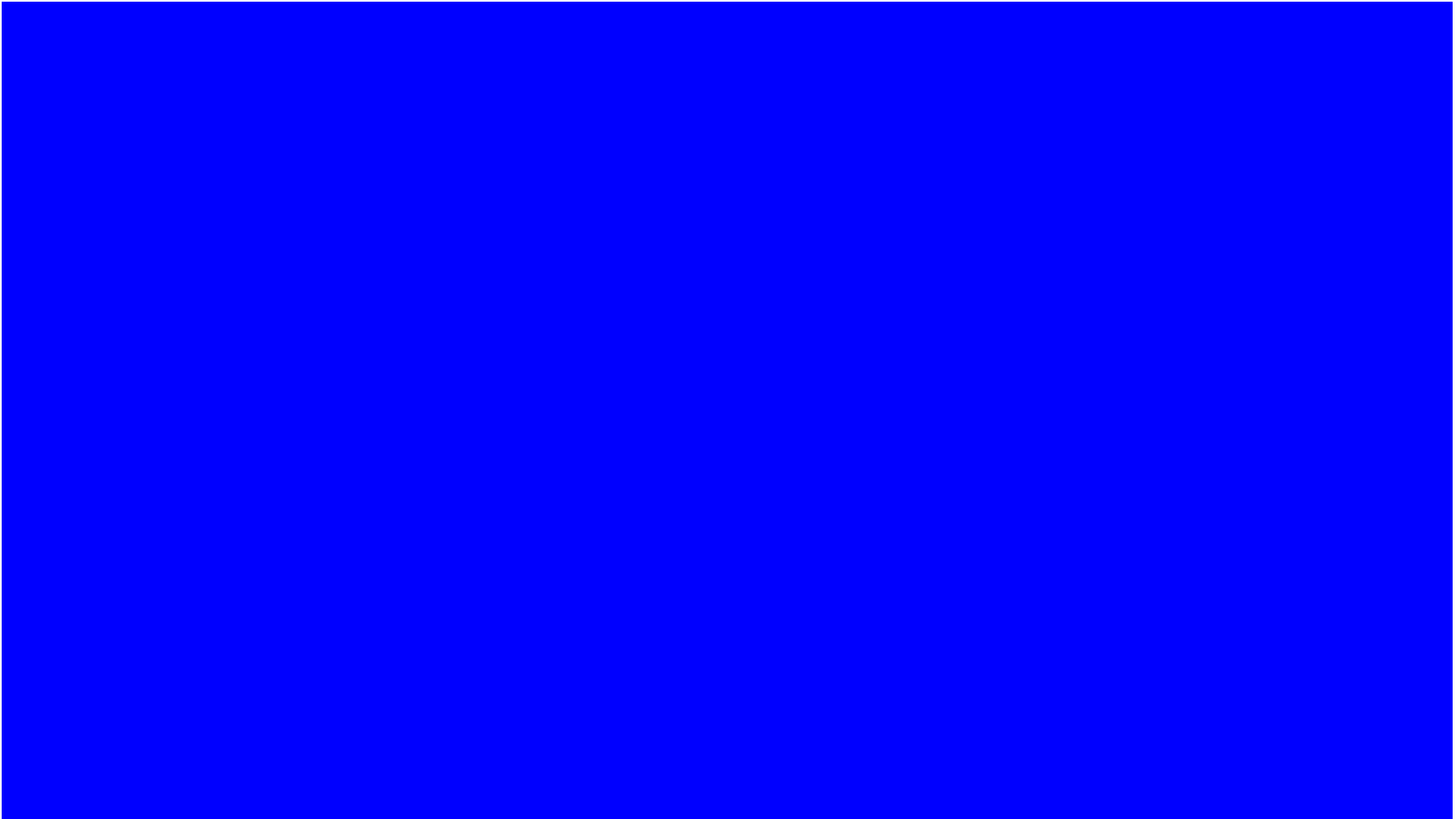
Step 7. Enter registration mode. Just click on the registration tab in the toolbox, the image windows will be reorganized for the registration purpose. The bone model is in the current object window, the intra-oral scan is in the assembly view. See how-to guide (chapter 8) if you want to specify another model as the registration base.



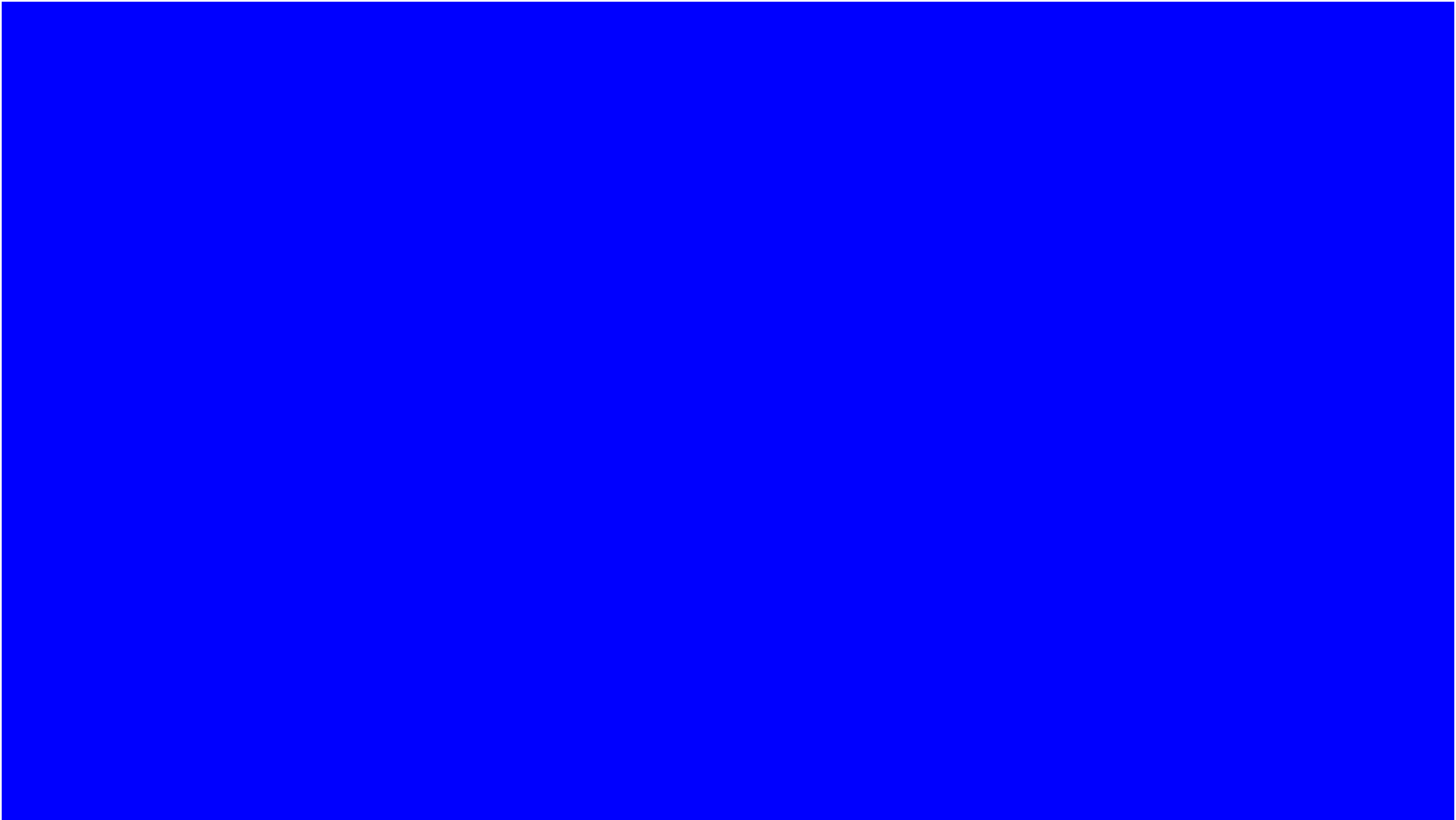
Step 8. Specify markers for registration. Once the models in 3D views are zoomed and placed properly you can click on "Specify Markers" icon in the tool panel, and then place markers on the 3D views. Remember: you do not need exactly same number of markers, you do not need the same orders of the markers, and you do not need to specify markers at a very accurate position. If no marker is specified, entire model could be used for registration purpose. To rotate the models during this procedure, move cursor off the model and use MB1 to rotate as you normally do.



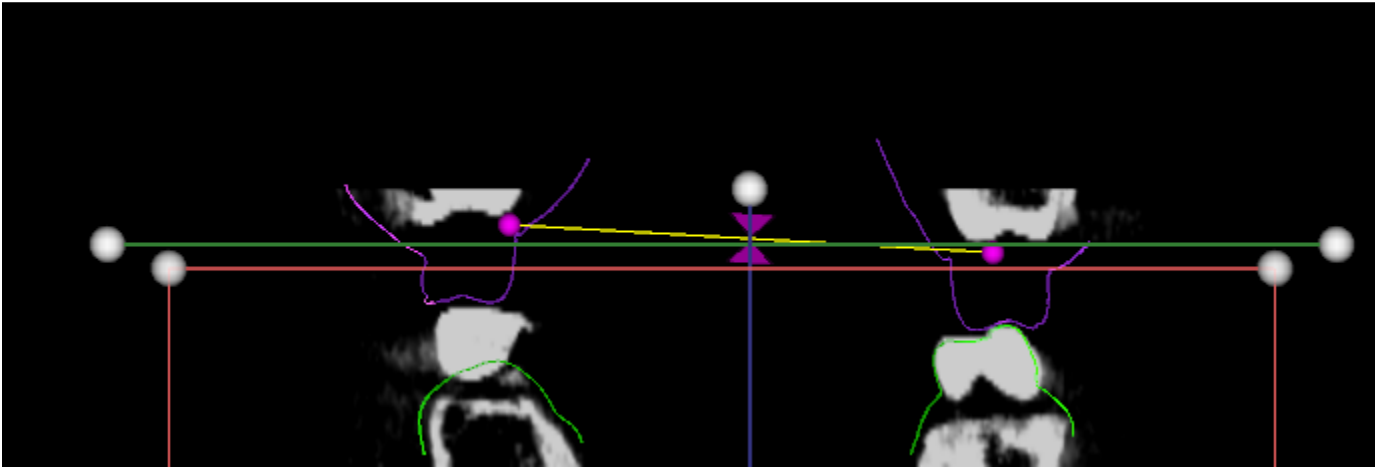
Step 9. Finish registration. After markers are specified, check the box "Template is positioned properly" and then click "Align". The resulted model deviation will be shown in a message box.



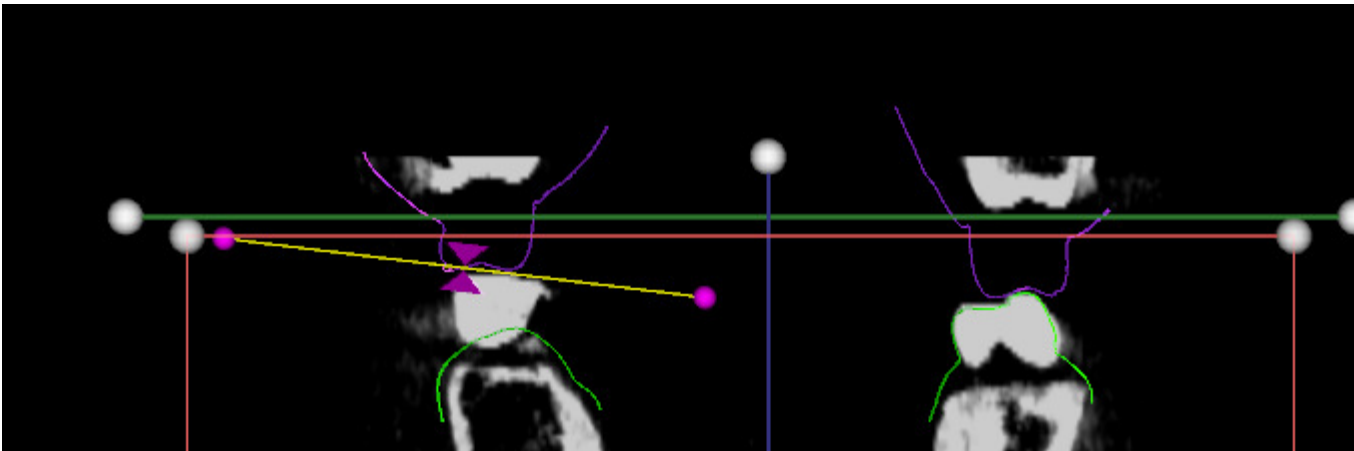
Step 10. View registered Models. Use fit, zoom, etc. You can also use context menu to show/hide models in 2D views. Move mouse cursor on the model you are interested in, and then press MB3.



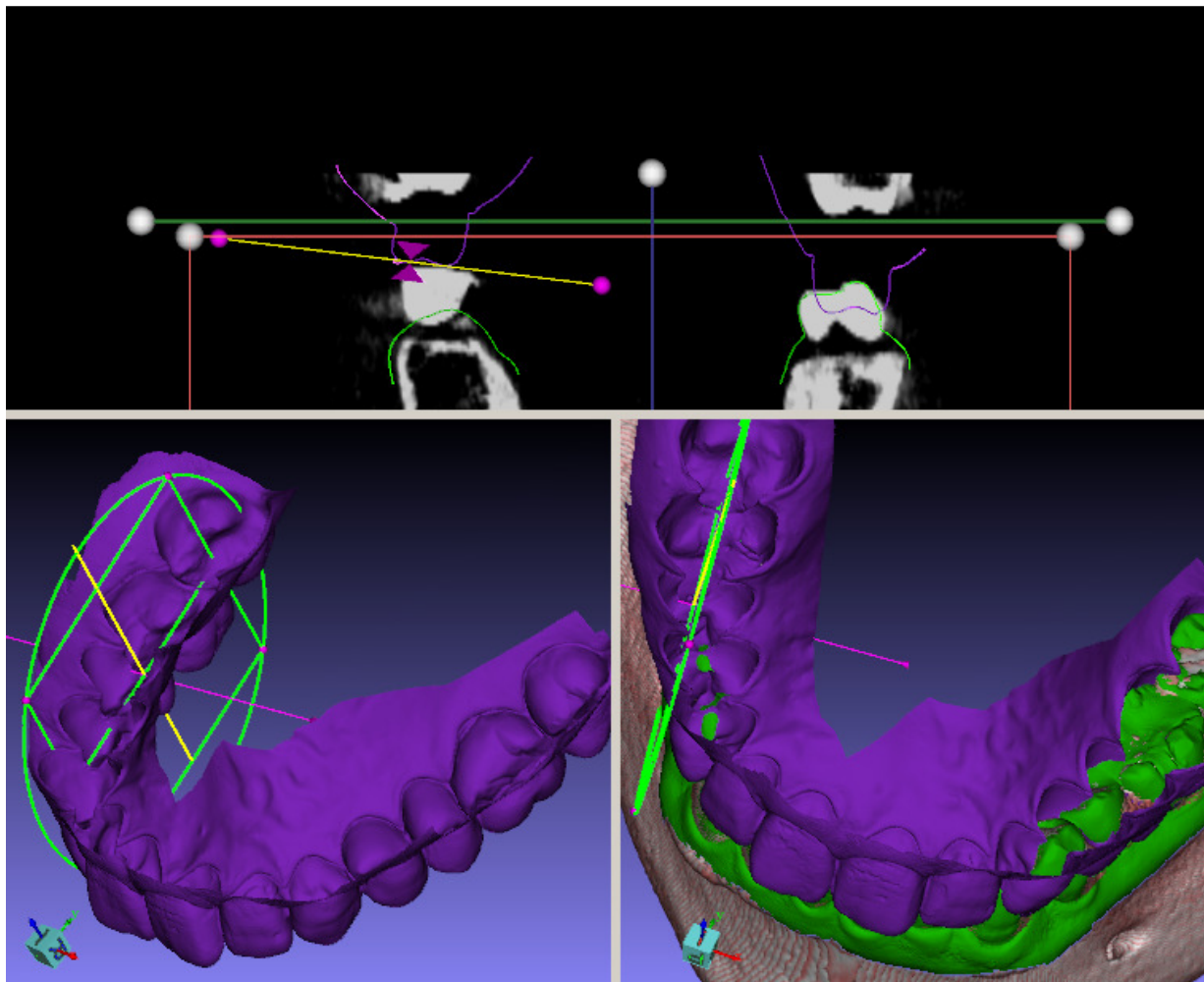
Step 11. Load antagonist model/scan. Use menu item References/Add Additional Reference. The antagonist model is registered to the bone model automatically by inheriting the transformation from the stone model. The model is assigned a placement widget, and the 2D cross section views also show the models.



2D placement widget

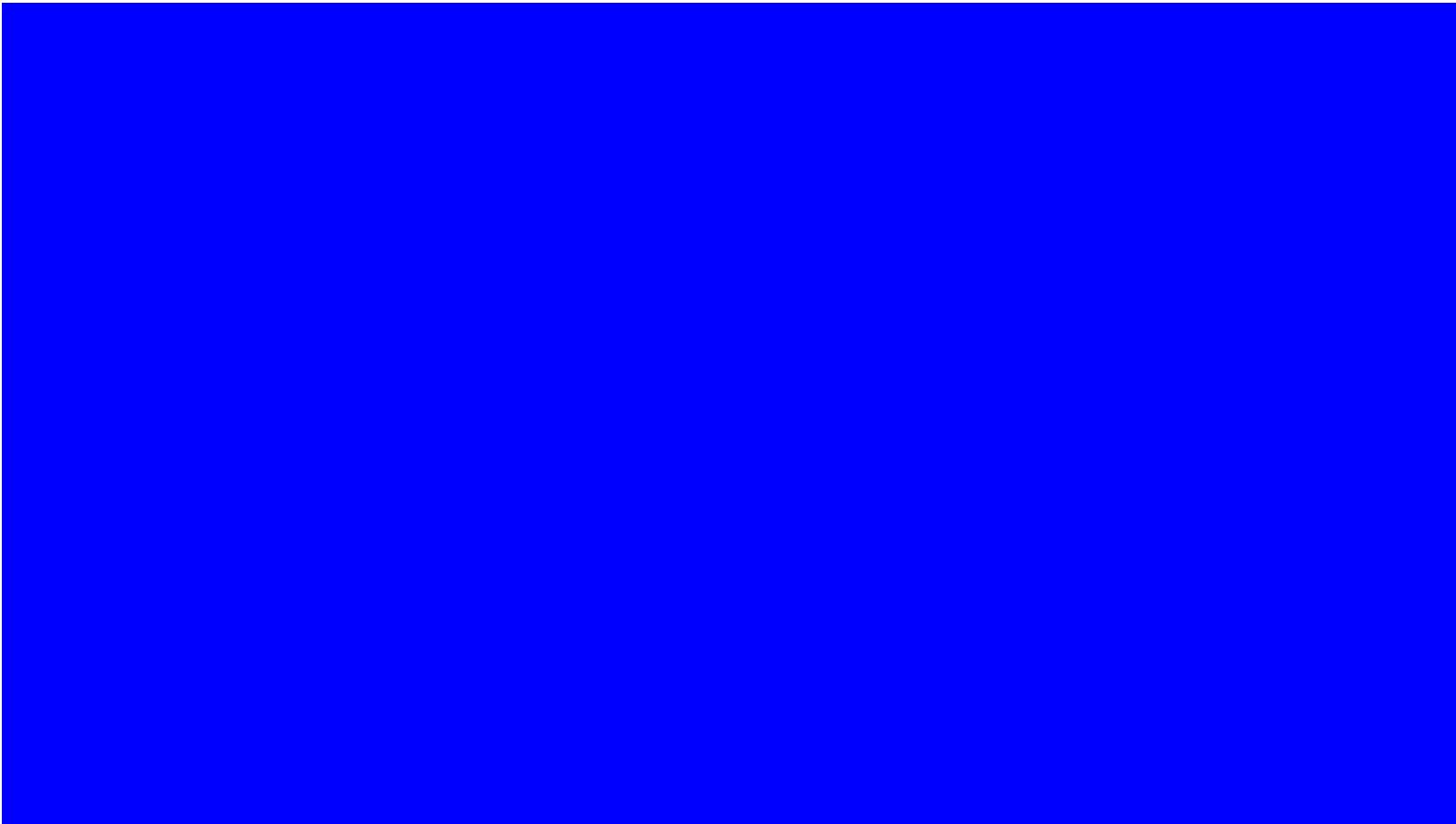


Placement widget is moved to another location by drag and drop one of the two triangles by MB2.

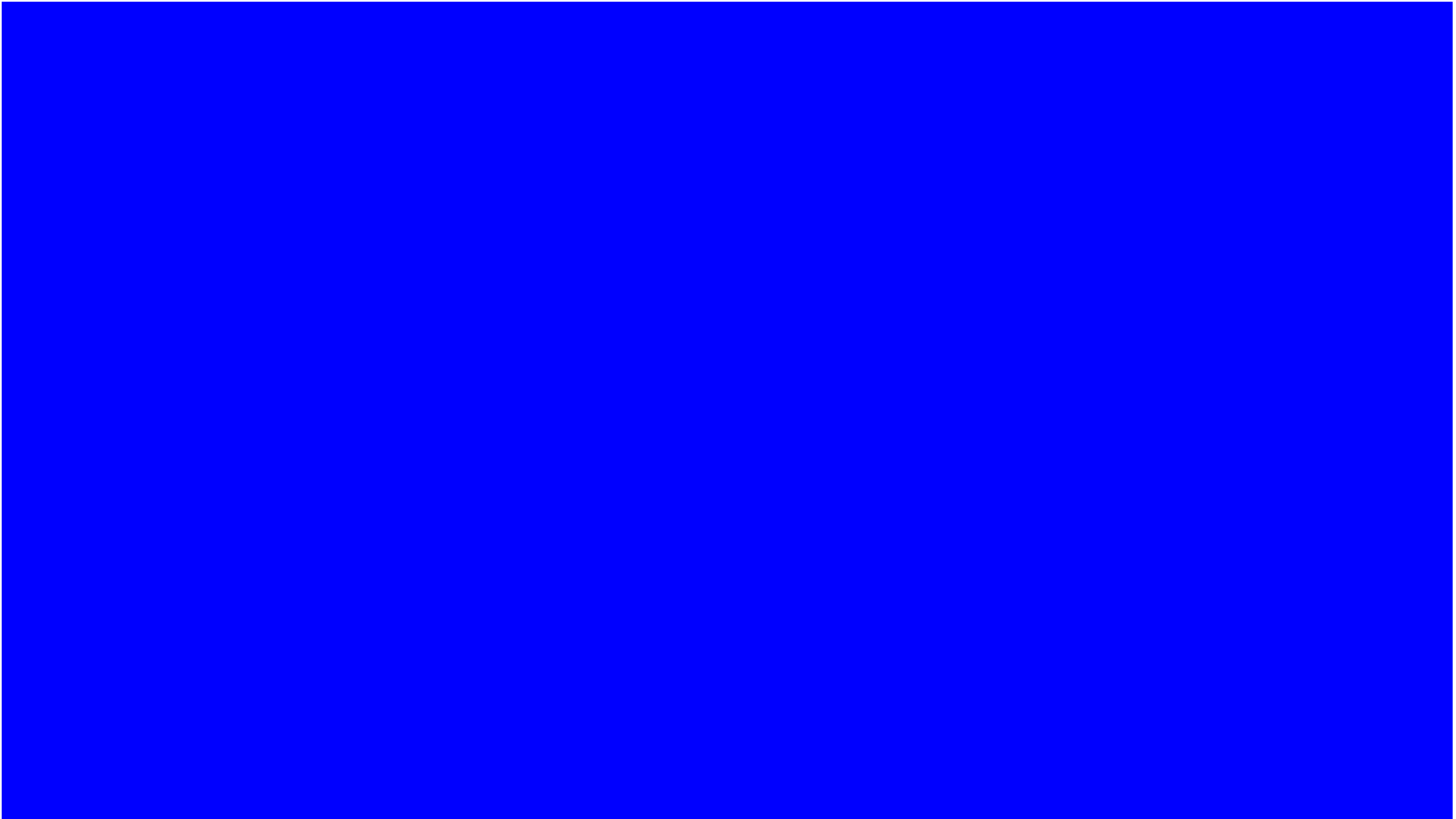


2D and 3D manipulation of the widgets are similar to those of implants, except that in 2D views the rotation is always around the center of the widgets.

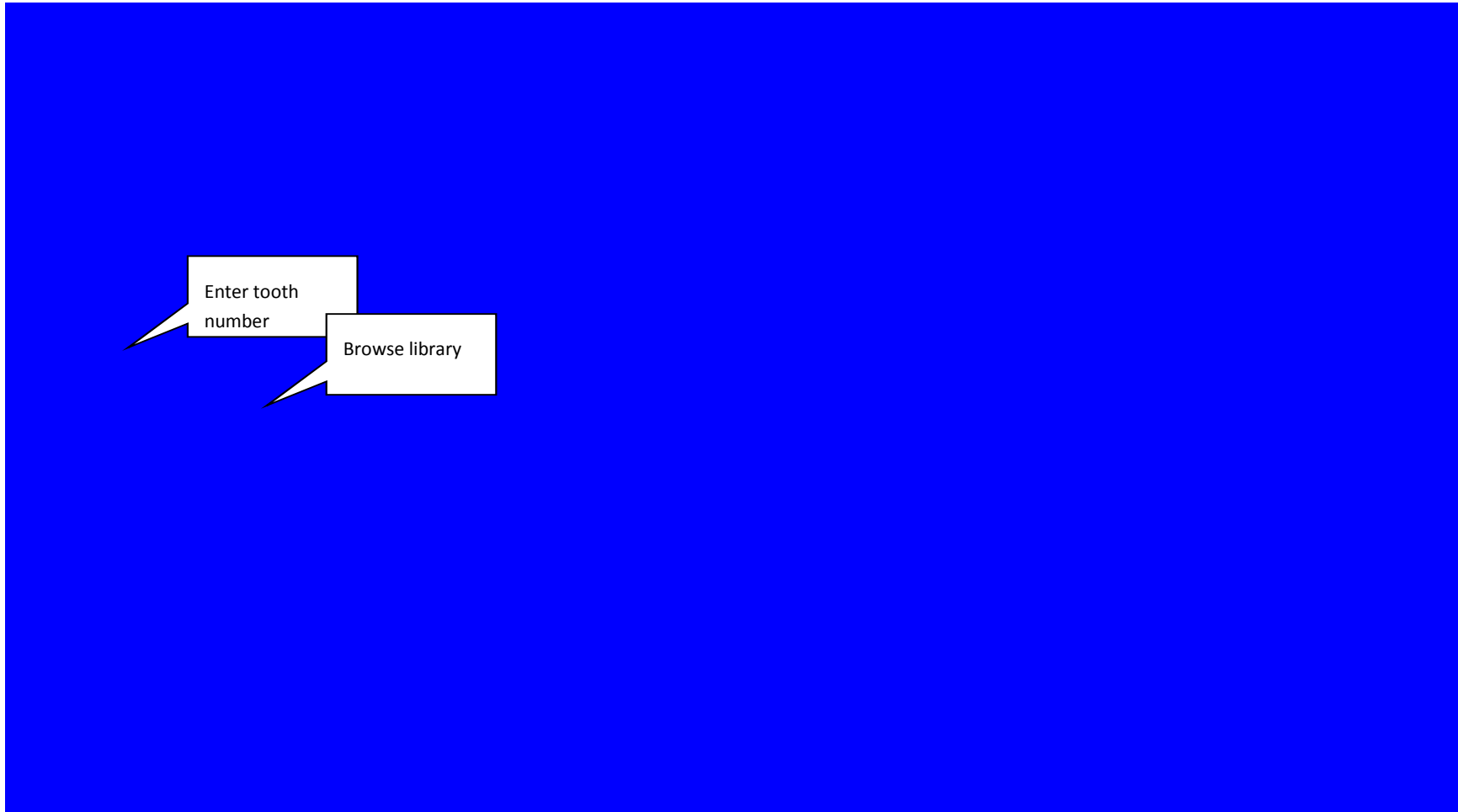
Step 12. Relocate placement widget and adjust model locations.



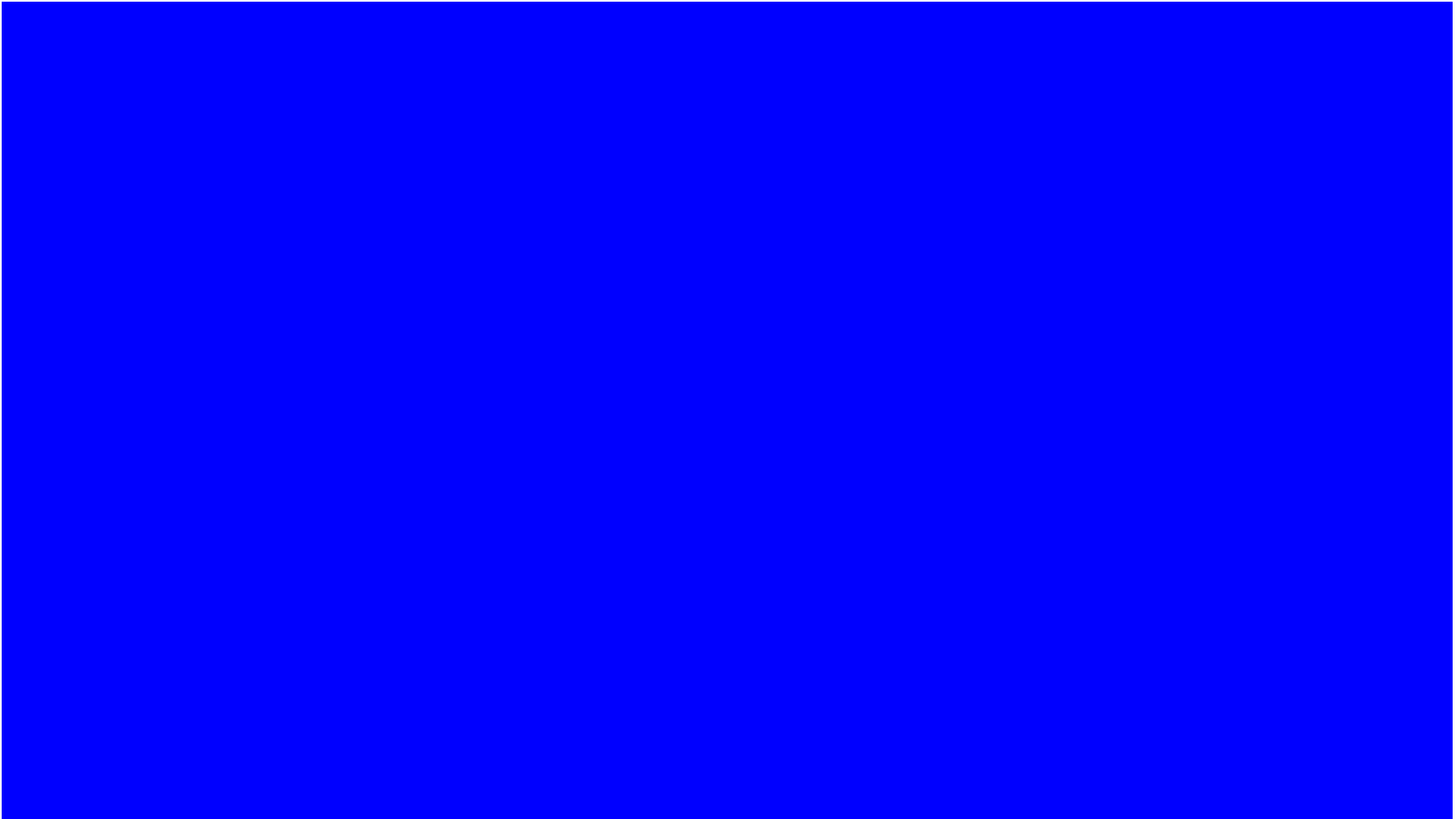
Step 13. Create nerve drawing. Adjust the arch curve and 2D thresholds, and enter nerve channel definition. In the "Draw Nerve" section there are two buttons, one for left channel, one for right. Click to start a channel, and again to finish. Once you start, in the panoramic view MB1 to place a point, MB3 to finish, mouse wheel to scroll through slices. The nerve model is automatically updated in all the views.



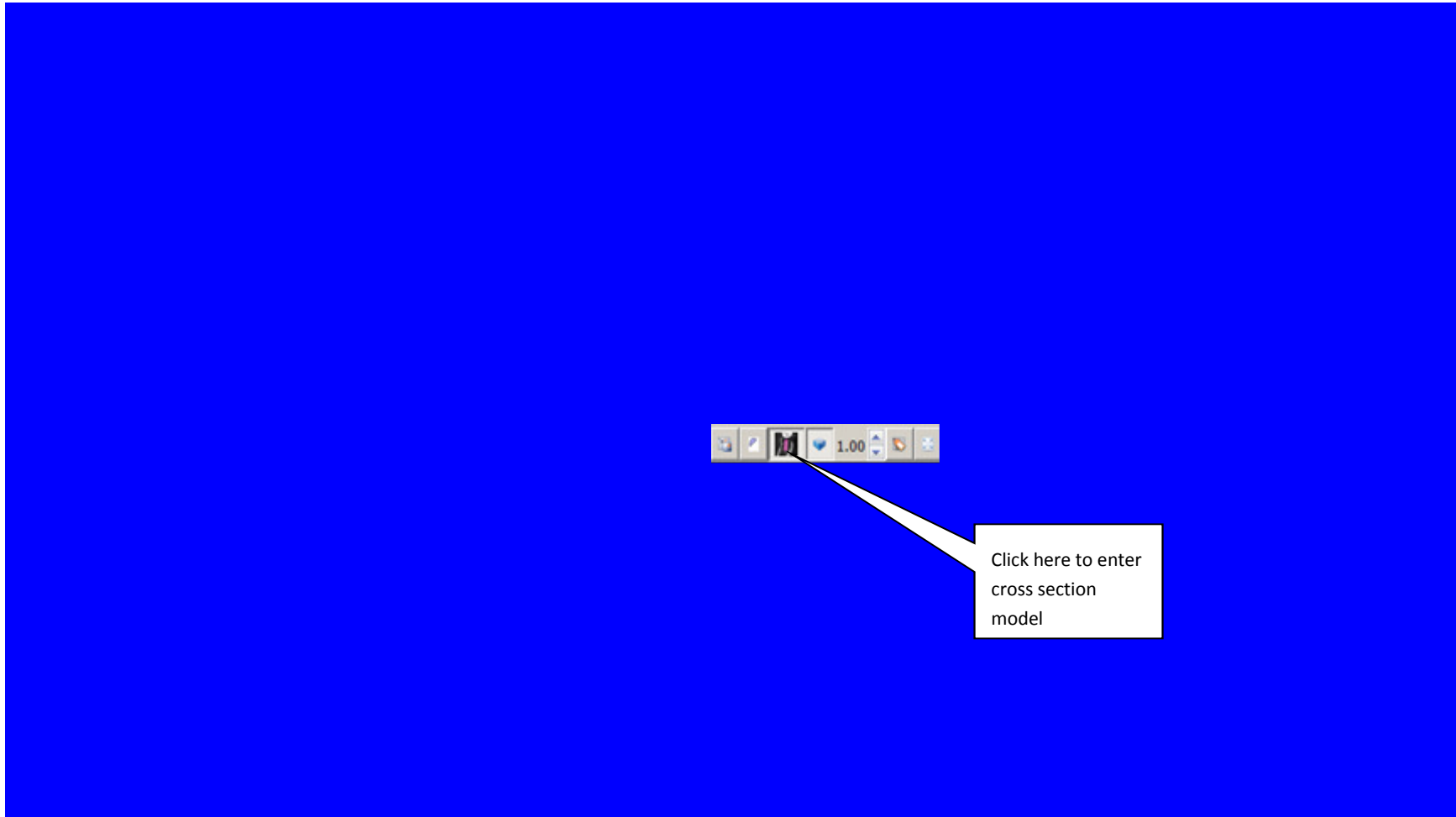
Step 14. The both sides have been created.



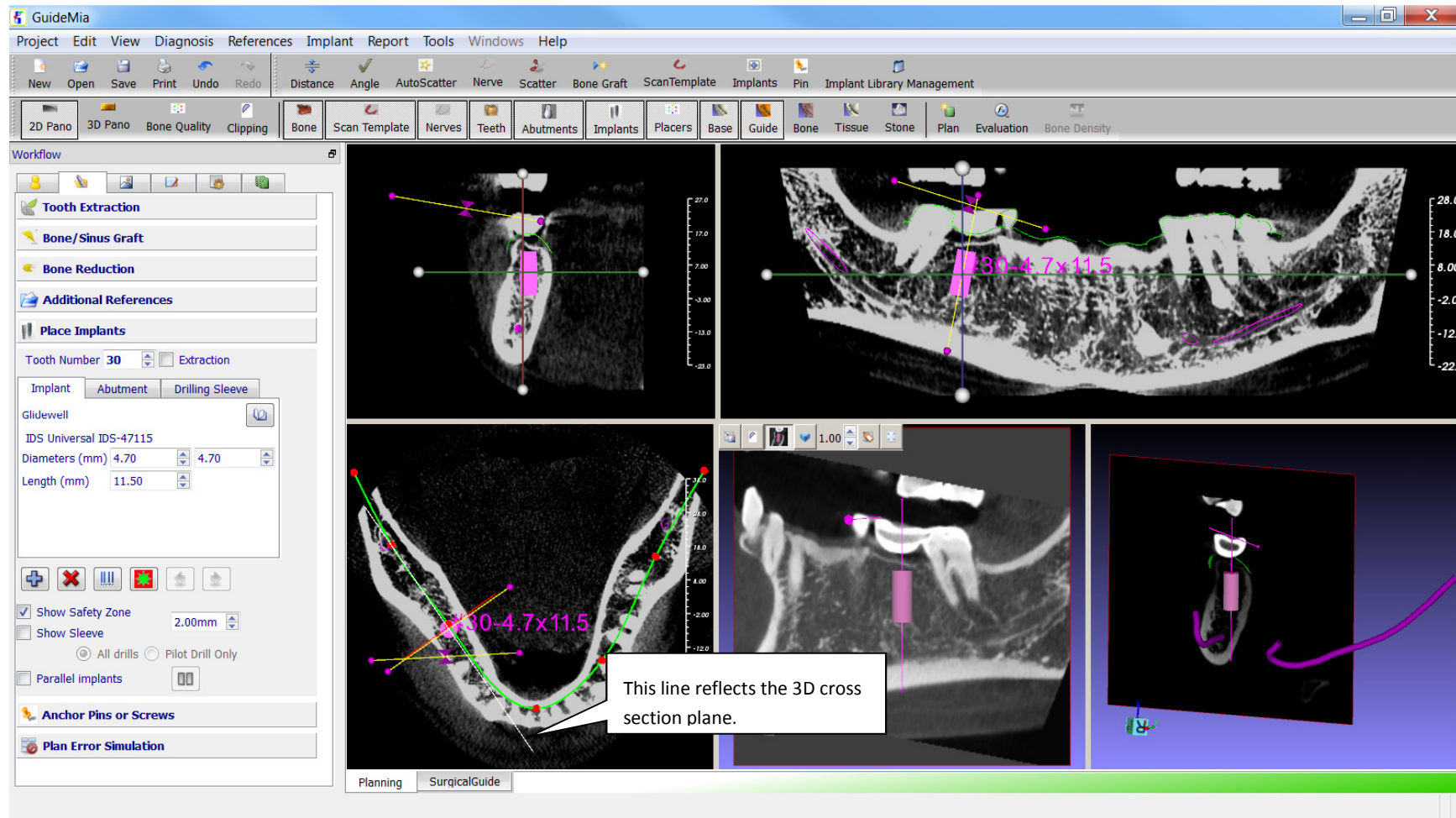
Step 15. Plan implants. Enter into implant placement and select implant from the library.



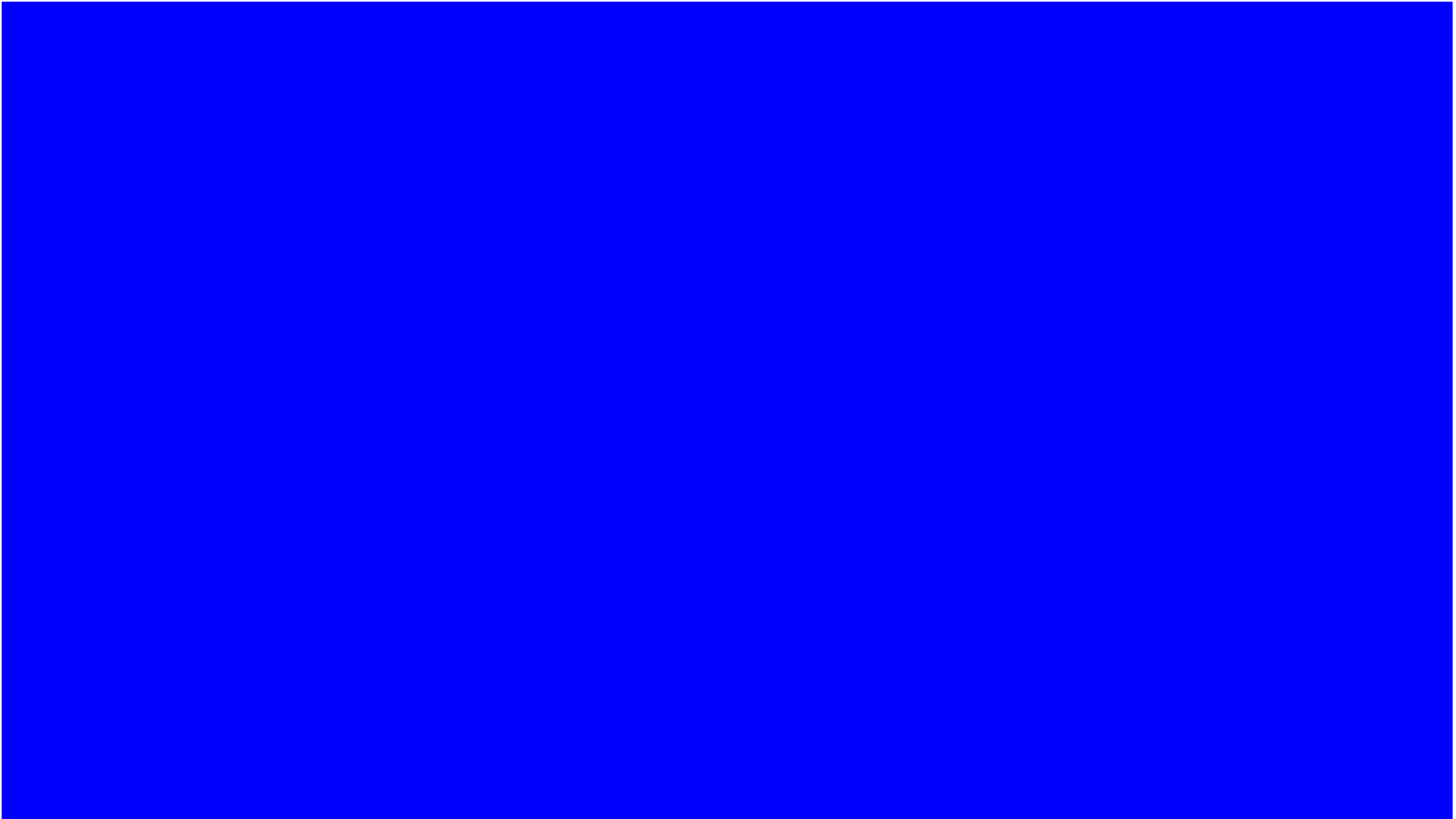
Step 16. Place the implant and adjust implant by placement widgets. See chapter 5 for more details.



Step 17. Enter cross section mode in the current object view, and also assembly view.



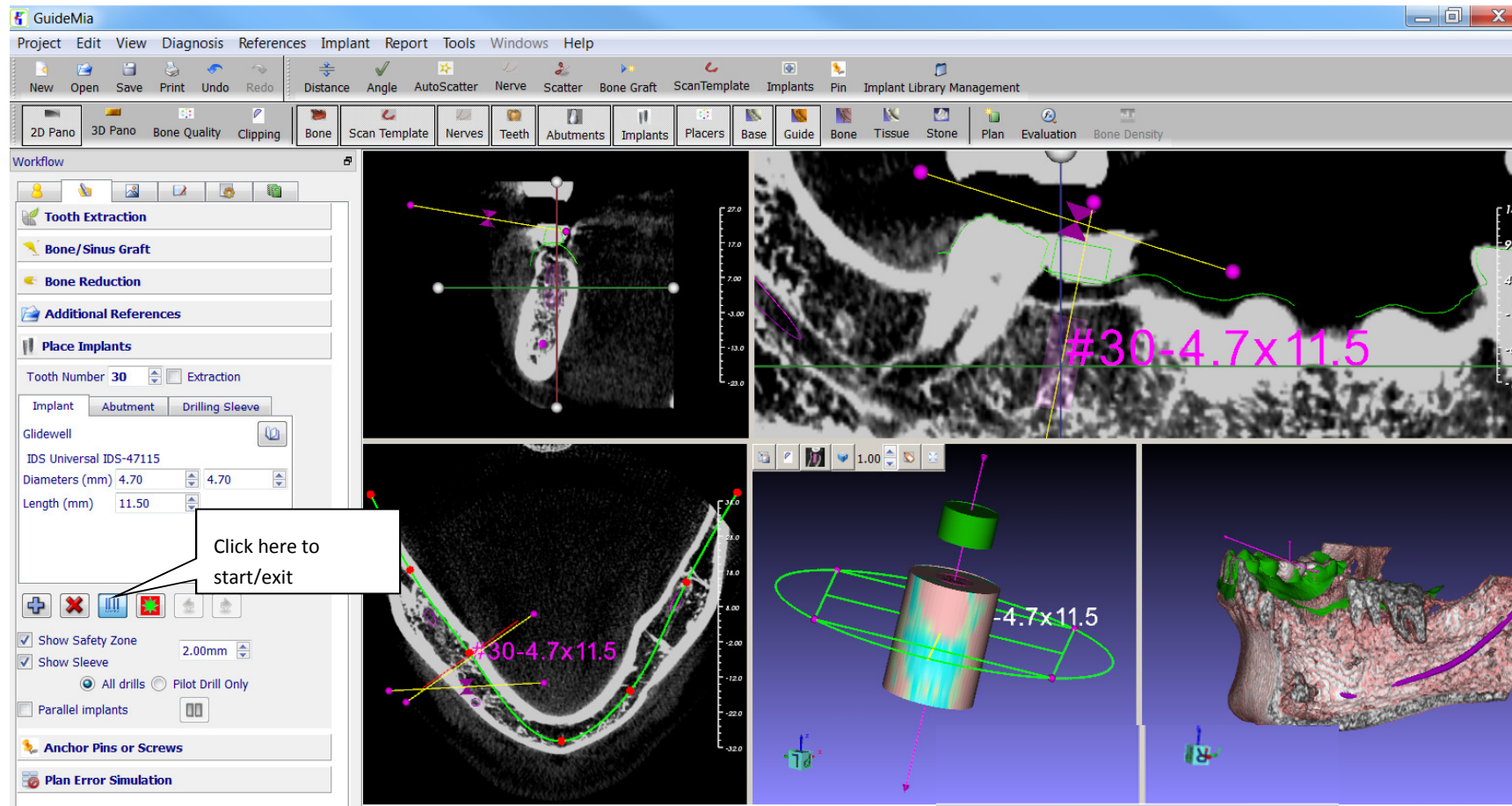
Step 18. Adjust the cross section mode. MB3 to adjust thresholds on the cross section plane, and mouse wheel to adjust the sectioning direction.



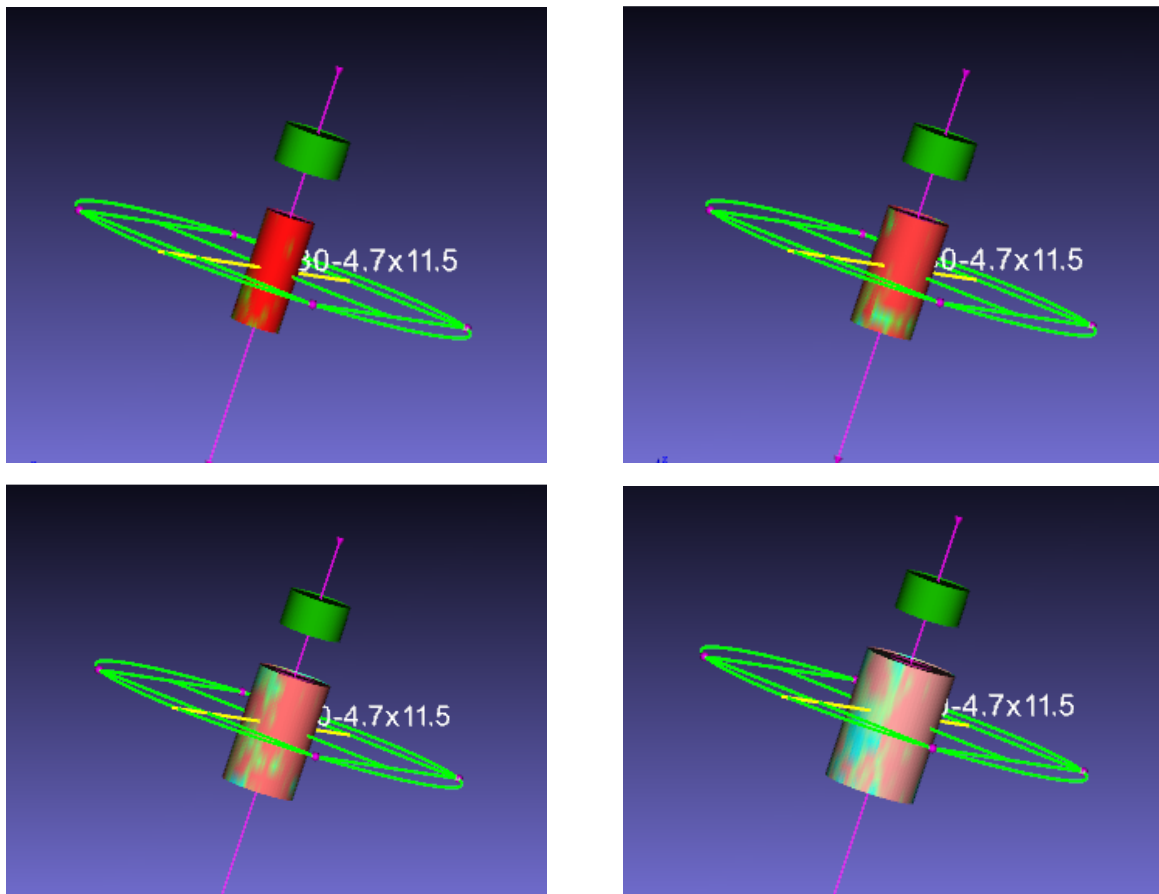
Step 19. Inspect implant drill sleeve. Turn on/off the "Show Safety Zone" and "Show Sleeve" to see the effects of this function on the 2D and 3D views.



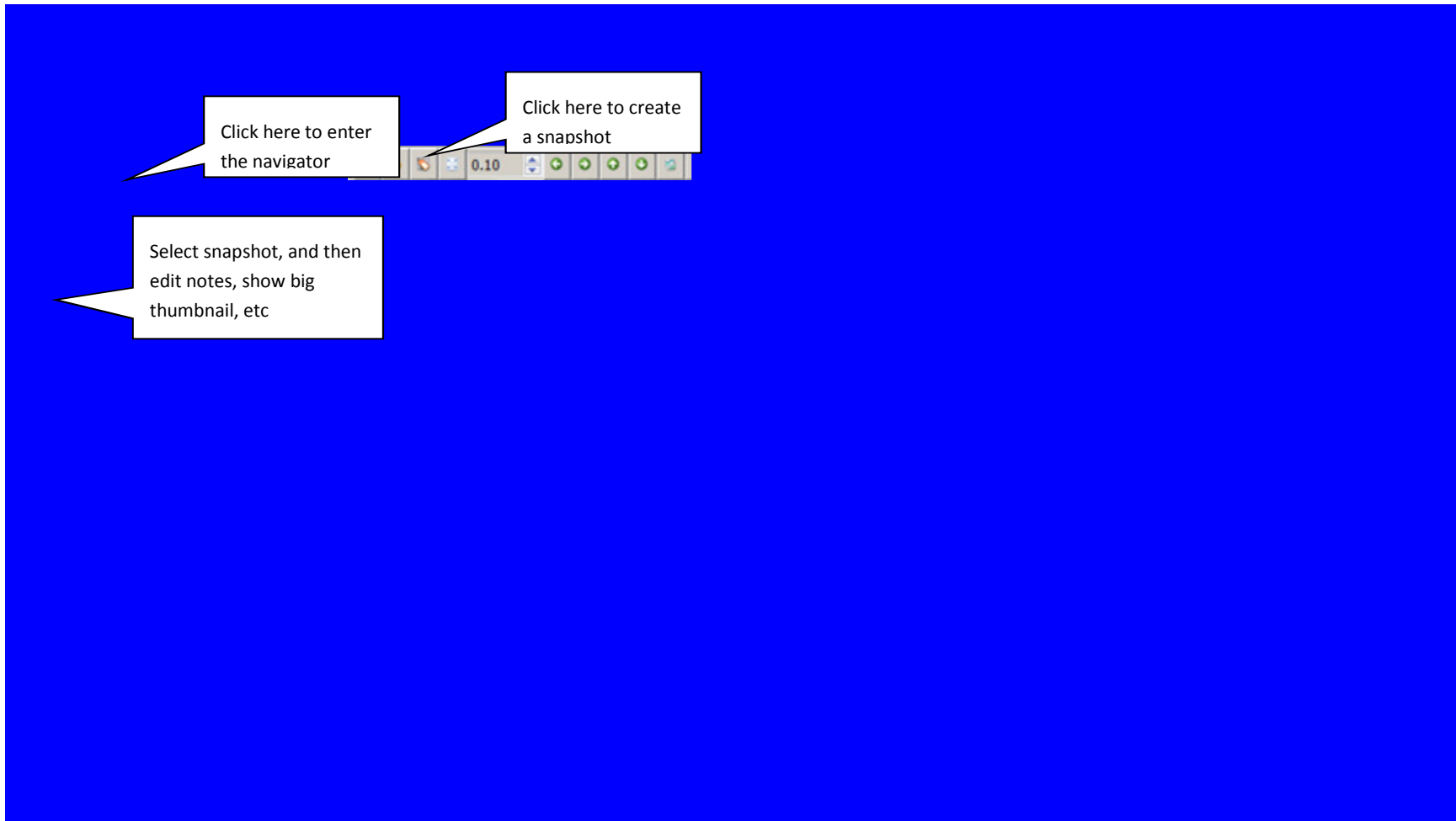
Step 20. Perform plan error simulation



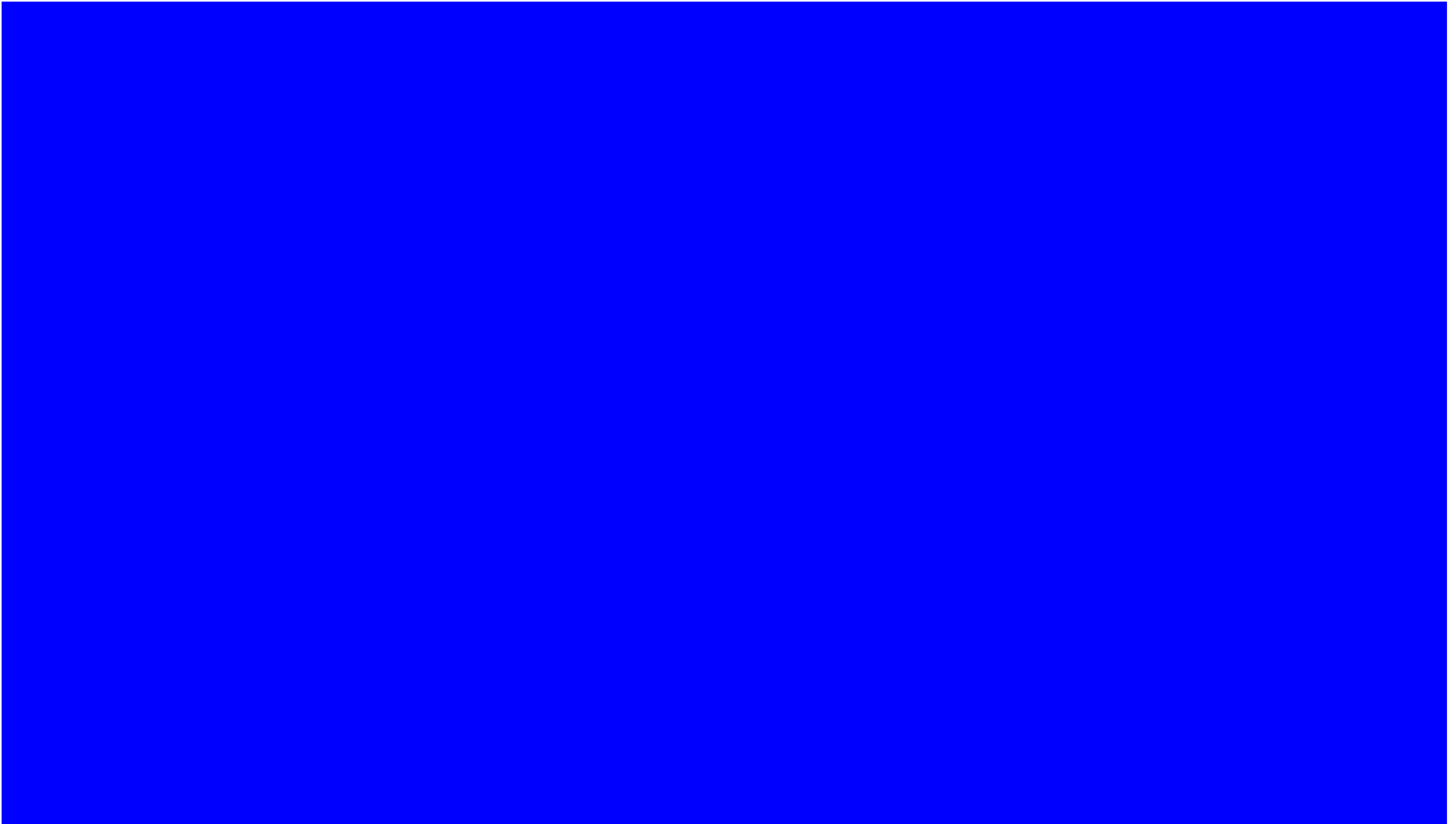
Step 21. Inspect implant neighborhood. There are two modes to perform neighborhood inspection. The button in the place implant tool box is for the "current implant mode", the menu item "Diagnosis/Neighborhood Viewer" will perform this for all the implants. In "current implant mode", move your mouse into the 3D current object view see how this function scroll through a neighborhood of an implant so that you can evaluate the bone density, the status message will show you a summary of the neighborhood of the current implant. The menu item for all implants will scroll through the neighborhood for all implants automatically. It is necessary to exit one mode before you enter into another.



Neighborhood viewer, individual implant. Use mouse wheel to change.



Step 22. Create snapshots and view them in the navigator

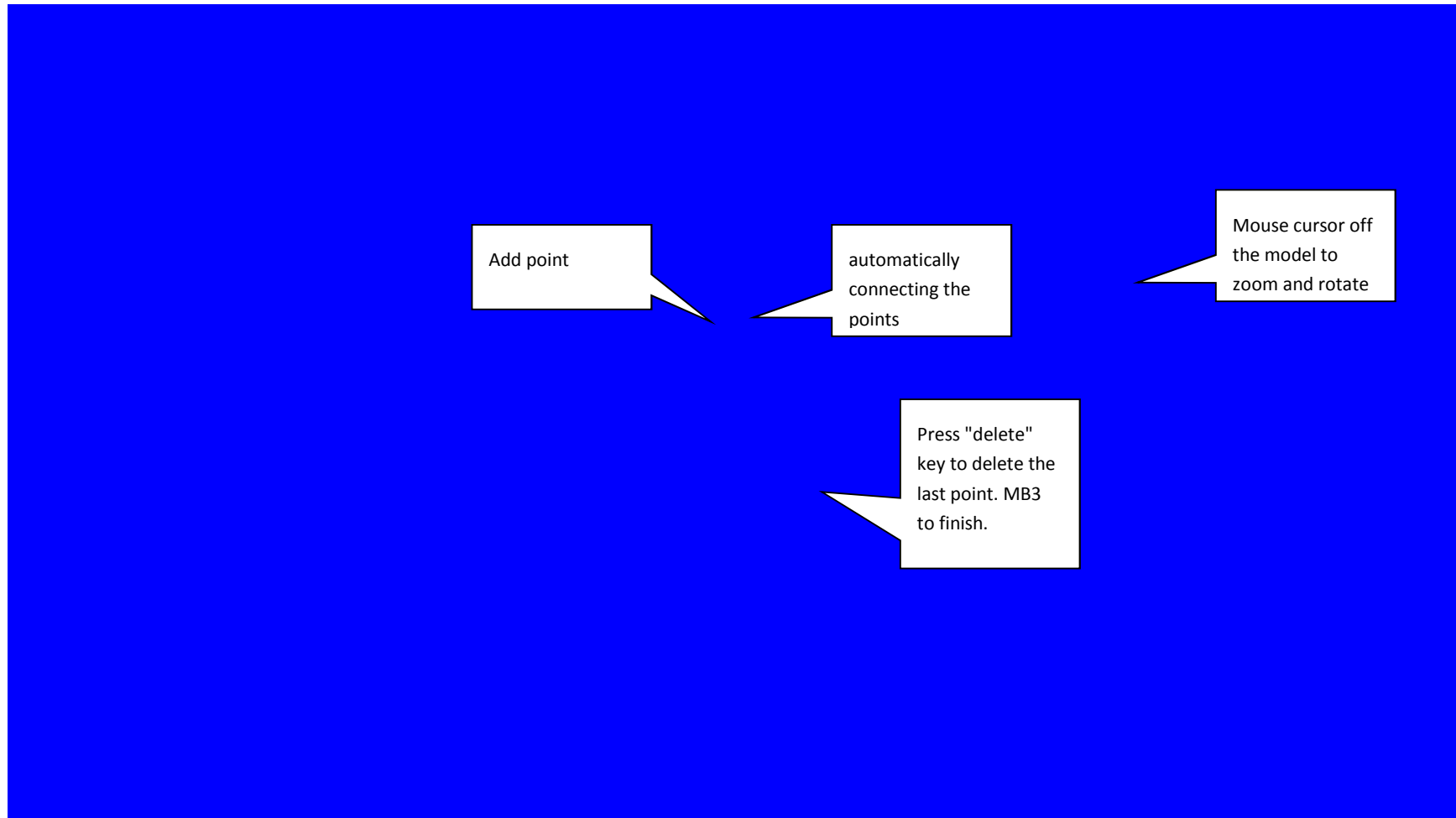


Step 23. View object navigator and pop up window in 3D views

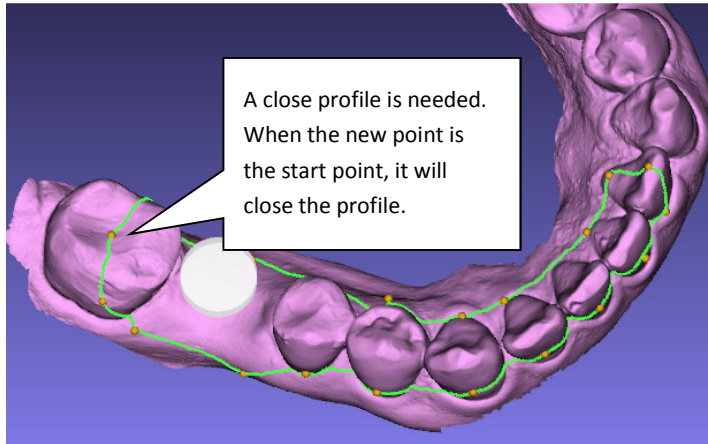
Save project



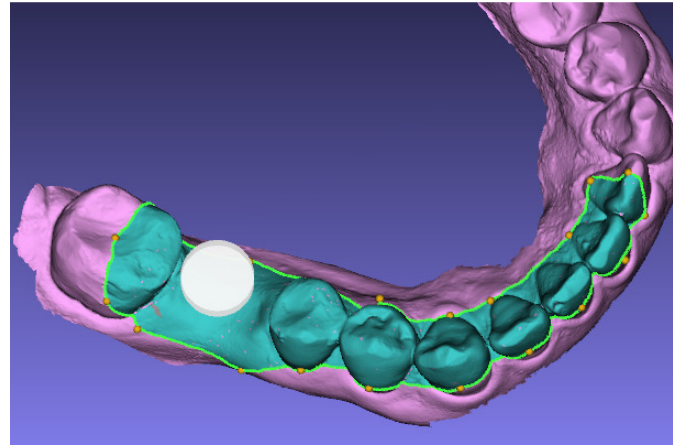
Step 24. Enter surgical guide design



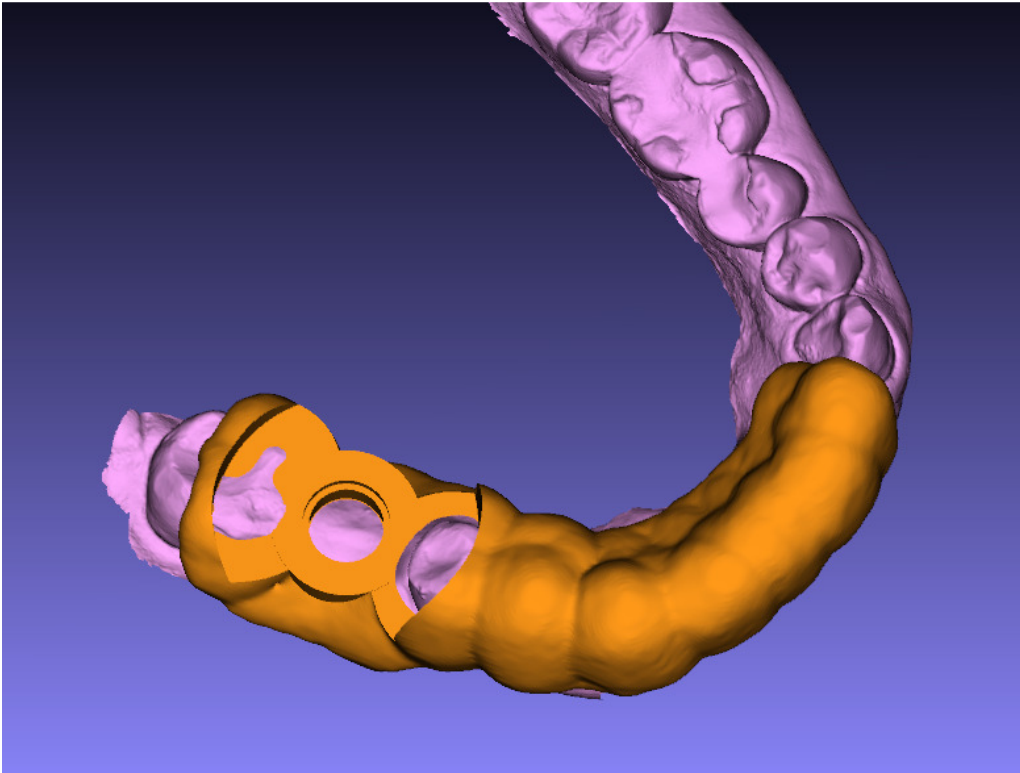
Step 25. Design the boundary of the base model by placing points on the intra-oral scan and tracking the boundary.



Closed boundary



Trim the boundary model by clicking the "Cut" button, and restart by clicking on "reset" button.



Step 26. Generate surgical guide, export STL file, etc. Press the "Generate/Update surgical guide" button to generate the guide model. See chapter 6 for additional operations.



Step 27. Review surgical guide in planning views. Go back to planning view, right mouse click on the surgical guide model, and choose from the pop-up menu to show the surgical guide with "Fit analysis". Also inspect the cross sections in 2D views.



Step 28. Generate report.

9 . MEASUREMENT AND PLANNING ERRORS AND HANDLING

9.1 ERROR FACTORS

As designed in the treatment plan error simulation module, the ultimate error of a surgical guide, or, its implants, come from the following area:

- Image Processing Errors, including registration errors and segmentation errors. Behind the two factors is the actual accuracy of the DICOM files from the CT scanners. Because of this, we do not recommend planning cases with slice thickness bigger than 1mm. Thickness of 0.25mm or lower is preferred.
- Surgical guide manufacturing errors, including:
 - Guide dimension errors,
 - Hole position linear errors,
 - Hole position angular errors,
 - Linear deformation of the guide, and
 - Angular deformation of the guide
- The positioning error of surgical guide at the treatment time, or the implant placement errors with respect to the planned position and orientation.

Among the various error sources, the image processing errors will affect the design of surgical guides, and the manufacturing errors and positioning errors will affect the deployment of treatment plans.

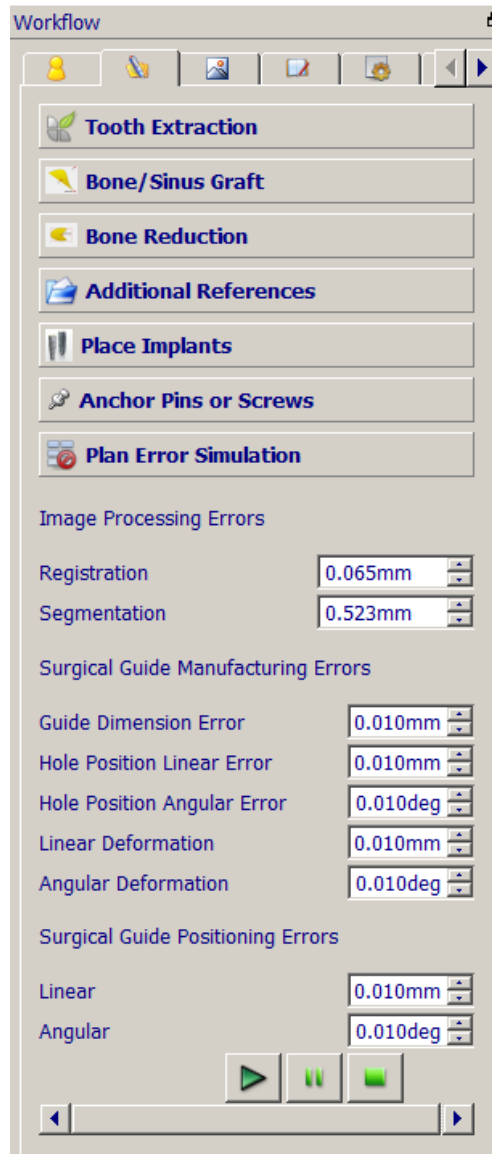
9.2 ERROR SIMULATION

This section gives an outline about how the error simulation is implemented. More details can be found in our corresponding US patent application [5].

The data representation of a treatment plan includes the coordinates of apex centers and the orientation vectors of all the implants. A plan is visualized in 2D and/or 3D views. Along with the bone structure, or even soft tissue models, users can visually evaluate a plan.

Error simulation is done by continuously applying different deviations to the implant parameters and updating the plan display accordingly. First, error sources are identified. A few examples are errors of stone models, manufacturing errors and deformations of radiographic guides, errors of radiographic guide placements, errors of CT image processing, etc. Secondly, each error factor is translated into the possible deviations of implant locations and orientations. Maximum deviation values are set for each of the factors. Next, a statistic distribution of the errors is assumed, and a series of deviation values are generated. For each deviation value, the display of a treatment plan is updated. With continuous update of the display, a real time visual feedback is given to the users so that they can evaluate the plan and possible error conditions. Such error simulation is coupled with techniques such as bone quality visualization to enable better treatment plan evaluation.

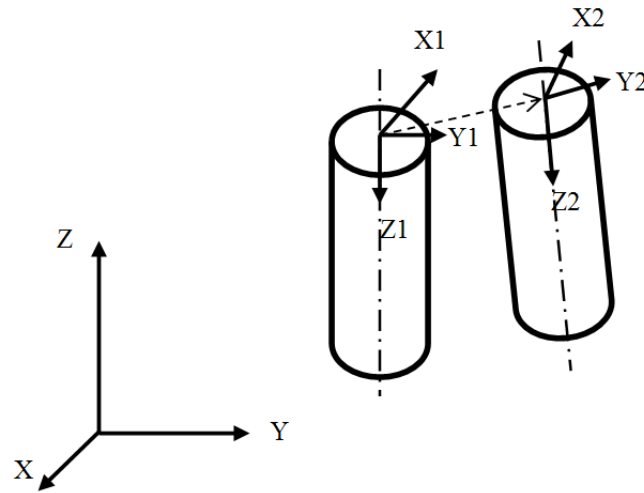
The software component to simulate the error conditions includes the following logical components: an interface object (the dialog) to designate the error factors and their distributions, a module to combine the error factors and generate a series of positions and orientations for each of the implants, a module to display treatment plan and update the display with the series of implant positions and orientations, and a module to control the error simulation.



Error Simulation Dialog

An error source is first translated into the deviations of implant positions and orientations, or simply, the deviations. The following figure shows an implant and its deviation. A linear error means the shifts of X, Y and Z coordinates, notated as (dx, dy, dz). An Angular error means the deviation of the implant orientation. An angular deviation can be a combination of rotations about X, Y and Z axis. Normally the rotation about Z axis does not really change implant position, hence the rotations about the X and Y axis are considered and represented by two

angles: angle_x, angle_y. The deviation between two implant positions has therefore 5 components and is represented as (dx, dy, dz, angle_x, angle_y). These 5 components define a 5D space, namely, error space.



Implant Deviation

The error simulation will generate a series of model deviations before simulating the display. The module generates possible deviations according to the error source definition and statistic distributions, and applies them to the treatment plan. Each component of the deviation, for example the dx component, will have a series values: -maximum_dx, $-(N-1) \cdot \text{maximum_dx} / N$, ..., $-\text{maximum_dx} / N$, 0, $\text{maximum_dx} / N$, ..., $(N-1) \cdot \text{maximum_dx} / N$, maximum_dx. The combinations (linear sum) of the series values of each component together make up the sampling space of the implant deviations. The “Plan Deviation” module may generate all the combinations in one run, or individually upon request.

This module then applies the deviations to a treatment plan by transforming the geometric models of the implants. For each implant and a specific deviation value (dx, dy, dz, angle_x, angle_y), it (1) stores the coordinates (x, y, z) of the implant apex, (2) translates the implant model by (-x, -y, -z) so that the apex is positioned at the origin, (3) rotates the implant model by angle_x about X axis, (4) rotates the implant model by angle_y about Y axis, (5) and finally translates the implant model by (x+dx, y+dy, z+dz).

The display module will then receive the deviated plans from “Plan Deviation” and update the display by using transformed implant models. The minimum of the display contents include bone and implants. There are at least two kinds of display windows, ie., the 3D views and 2D views.

9.3 DIMENSION AND ANGLE ACCURACY

The measurement features, dimension and angle, are guarantee to have error smaller than 0.01mm or 0.05degree, however, all the measurements are subject to the accuracy of the input datasets. Please refer to the specs of your CT and optical scanners.

9.4 MINIMIZE THE TREATMENT PLAN ERROR

9.4.1 DEVICE CALIBRATION

The users who make surgical guides themselves should be advised that device calibration is critical to have a satisfactory treatment plan and outcome. The devices involved include CT scanners (or CBCT scanners), CNC machines if surgical guides will be milled, or 3D printers or SLA machines if surgical guides will be made by SLA or printing technology.

As a general practice, the device operators should calibrate their equipments regularly. For the purpose of error simulation in GuideMia, users are advised to acquire the equipments' scanning or manufacturing errors from the operators.

9.4.2 RADIOGRAPHIC GUIDE MODELING

It is strongly recommended that users use the segmentation threshold filter to create a radiographic model from its CT scan. When adjusting the threshold, measure the digital model displayed on the screen and the physical model to make sure the threshold is set such that the reconstructed model replicates the size and thickness of the physical model.

9.4.3 CASES WITH OPTICAL SCAN OF STONE MODELS

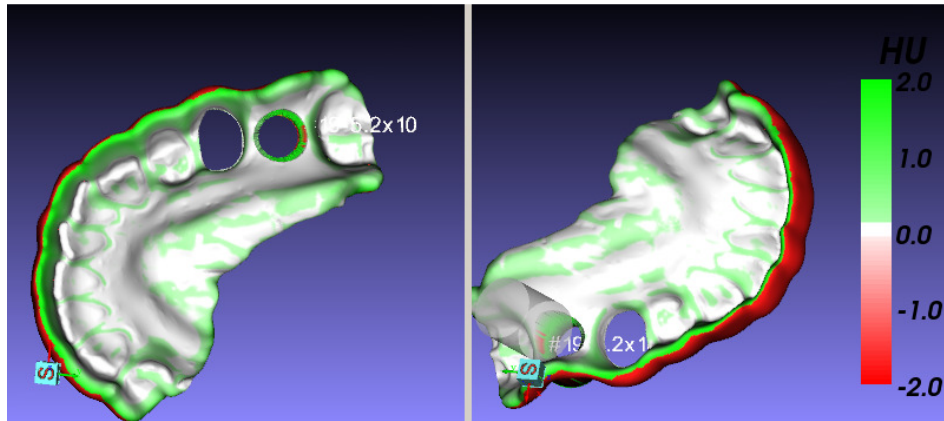
If the users prepare their cases with optical scan of stone models, or intra-oral scans, the accuracy is a very minor concern. Most of the time the surgical guide design based on an optical scan will fit on the patient anatomy very well. Therefore, optical scan is actually recommended over radiographic guide.

9.4.4 IMPROVE THE MODEL REGISTRATION

Since a surgical guide is designed based on the radiographic guide or stone model, the registration between such model and the patient's scan plays a critical role for the guide accuracy.

GuideMia has the following functions to improve registration results:

- Fine tuning tools. After registration, users can use the tool to slightly move or rotate the model so that it better matches the patient anatomy. This tool can be found in SimPlant 2011.
- Fit analysis. See Functional Specification F95. The idea is to calculate the deviations between the surgical guide and patient's anatomy, and visualize them. This provides a visual tool for the users to identify problems in model registration. The "Scalar bar" in the right side defines how the "distance" is mapped to color. The "distance" is between a point on the surgical guide and the model that is used as the base for surgical guide design, such as a stone model for tissue-based guide or bone model for bone-level surgical guide.



Surgical guide fit analysis.

10 . HOW-TO GUIDE

This chapter is a "How-to" guide, which presents some basic functions, some complex issues and solutions, some special process, and some tips. For more information and updated list, please visit our website or contact our representatives.

How to organize DICOM file folders before creating a case?

Dicom files of a scan must be placed into one folder, and there should be no other DICOM files except the series of slice data of this scan. The following file list is from an actual clinical case. Files with name "2" and "3" are "aliens" that will fail the DICOM file loading. Just remove file 1,2 and 3 to fix the problem.

Name	Date modified	Type	Size
1	2/6/2012 3:36 PM	DCM File	514 KB
2	2/6/2012 3:35 PM	DCM File	1,276 KB
3	2/6/2012 3:35 PM	DCM File	1,276 KB
4	2/6/2012 3:34 PM	DCM File	517 KB
5	2/6/2012 3:34 PM	DCM File	517 KB
6	2/6/2012 3:34 PM	DCM File	517 KB
7	2/6/2012 3:32 PM	DCM File	517 KB
8	2/6/2012 3:32 PM	DCM File	517 KB
9	2/6/2012 3:32 PM	DCM File	517 KB
10	2/6/2012 3:32 PM	DCM File	517 KB
11	2/6/2012 3:32 PM	DCM File	517 KB

Figure 8.1. A problematic folder

How to import a diagnostic model as a planning reference?

Use menu item "References/Add additional scans" to add the STL model of the file. If the model was in the same coordinate system as the stone model or intra-oral scan, and the later has been registered against the bone structure, the new model will inherit the registration information thus be automatically placed at the right position. Otherwise, you need to register this diagnostic model with the bone structure. In order to do this, you need to:

- Step 1. Go to the object navigator, select the new model on the object list, click on the icon "Select as Scan Template".
- Step 2. Go back to the first toolbox of the workflow panel, enter "Registration", and perform the necessary operation to register the new model.
- Step 3. Go back to the object navigator, select the actual "scan template", and click on the icon "Select as Scan Template" to set it back.

How to lock the position of an object?

You cannot lock the position of an implant. Use the "Placer" button on the tool bar to turn on and off the placement widgets. Once off, you cannot adjust the implant location. You can always turn them back on.

For other STL models, MB3 on the model in a 3D view, choose "Start Positioning" or "Lock Position" will turn on or off the placement widget of the model.

How to determine good threshold values for bone structure?

Unless you will design bone level guide, it is not necessary to work hard on this. If you will, the low threshold value can be in a wide range from 200 to 700 based on experience, the high threshold value should be the maximum. It is very subjective to determine the low threshold value. It is normally based on the visual assessment of the resulted model.

How to design bone level surgical guide with loose bones?

The bad news is that cases with loose bones are not good candidate for bone level guide. The good news you can use "Tissue Peeling Simulation" in GuideMia to create a good bone model for surgical guide design. See chapter 5 for tissue peeling and chapter 6 for the procedure to design the surgical guide.

Generally GuideMia does not recommend bone level guide for loose bones, or more specifically, fully edentulous cases.

How to combine GuideMia treatment planning with physical model based planning?

Use GuideMia's master model function to create study models with implant holes and additional features, and then use the master model for physical model based planning. For example, you can directly modify the master bone model in further planning.

How to inspect if a radiographic guide is properly placed and scanned?

Use the "Virtual Tissue" function (see chapter 5) to display a color map as below. If the radiographic guide was not properly placed at scanning time, the colors at the areas where guide touches the patient anatomy will be very different at the two sides.

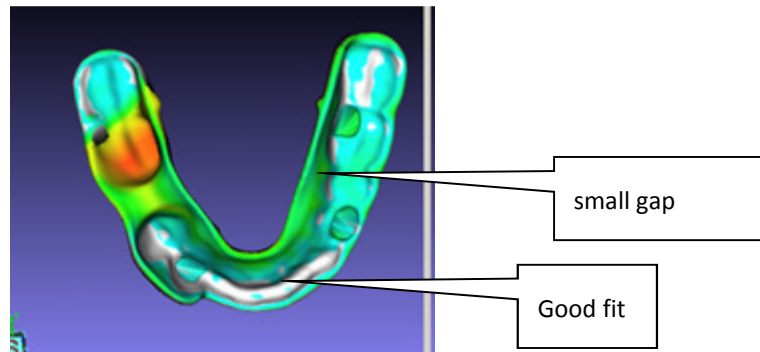


Figure 8.2 Color map of the virtual tissue model

How to determine the surgical guide insertion direction so that the undercuts can be created accordingly?

By default the system will calculate the average direction of the implants as the insertion direction. If you have virtual tissue model, the direction of the model will be used. Either way, you can rotate the surgical guide design view to a good orientation and click on the "Update" button in guide design tool box.

With certain cases, there might be excessive undercuts at certain direction, it will help have a better surgical guide design if you try to identify a direction with less undercuts by visual checking.

How to improve the surgical guide design to avoid weak spots?

Surgical guides can have insufficient materials in nearby areas of implants. The following picture is an example. Users can add acrylic materials to the weak spots after making the guides, or change the guide design. The techniques to do so include: using customized drilling parameters so that the top planer face can be higher, changing the boundary definition so that more materials can be included in those areas. using pilot drill only options so that the holes and sleeve areas are smaller.

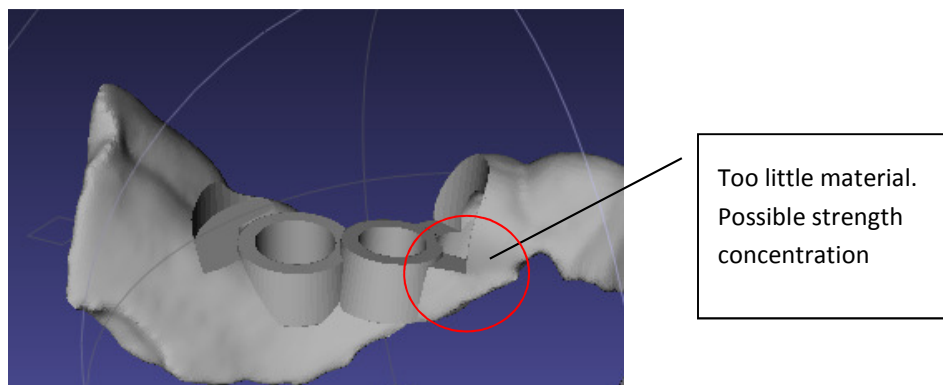


Figure 8.3 Weak spot in a guide design

How to check the fitness of a surgical guide?

After you design the surgical guide, go back to planning view by entering any other tab of the workflow panel, right click on the surgical guide model, and choose "Show Fit Analysis". Color map shown along with the images will indicate how the model fits the patient anatomy.

How to obtain best results of automatic radiographic guide registration?

Before you load the radiographic guide scan, make sure you investigate the patient scan by adjusting the thresholds. You should tell how the markers can be distinguished from the anatomy, scatters, etc. You should also adjust the region of interest to include as many markers as you can. Sometimes, the patient might have been scanned with two radiographic guides on, so you will need to make sure your region of interest does not contain the markers you don't need for the ongoing planning job.

It is important to know that even though the planning can be done with both arches, but we recommend doing one in a project.

How to specify markers for stone model registration?

Markers should be in the areas that have good and clear tooth contours, and no metal artifacts (fillings, existing implants, etc) or scatters.

How to use point of interest to associate the display of 2D views?

If you double click on any point in a 2D slice or a bone model, the point will serve as a point of interest. All 3 2D views will be set to the slices corresponding to this point.

How to browse the treatment plan reports?

A report should be brought up into a browser automatically after you create it. With some computer configurations this might not be true. You can always double click the generated HTML file from Windows Explorer to browse the reports.

How to include my logo in the plan reports?

There is a customer logo file in the GuideMia installation folder. You can simply replace that file with your logo. You are recommended not to use a logo with bigger size.

How to get better volume rendering effects?

Change the opacity to a value lower than 1 will produce better visual results. You need a graphics card as recommended to have acceptable volume rendering results.

How to determine if a system configuration is sufficient for GuideMia?

See the recommended configuration. After you load a patient scan, adjusting the thresholds, you should have instant update in the 3D views. A lagging of 3 seconds or more might indicate the system is slower than expected.

How to design surgical guides for pilot drills only?

When the size of an implant is not in the surgical kit's platforms, you will get a guide design with pilot drill only for this implant. If you want to force pilot drill only, go to the "Surgical Kits and Guide Option" tool box to turn on the corresponding option.

How to improve the system performance when changing arch curves?

Adjust the arch curve before you load any additional STL files. If you have to adjust when there are many STL files and generated surgical guides, turn off the panoramic mode (see button on toolbar), and adjust the arch curve, then go back to the panoramic mode is necessary.

How to browse and delete planning notes for bone modification, sinus grafting, etc?

Use the snapshot navigator.

How to design surgical guide if the stone model has deformed locally?

Use the "Calibration" tool. See chapter 4.

How to fix the guide so that it will not interfere with patient's anatomy?

This should only apply to cases with radiographic guide. Before you create the surgical guide, click on the "Cut" button in the guide design tool box, it will extract the adaption surface of the radiographic guide. Later on the system knows how to trim the model to avoid interference between the surgical guide and patient's anatomy.

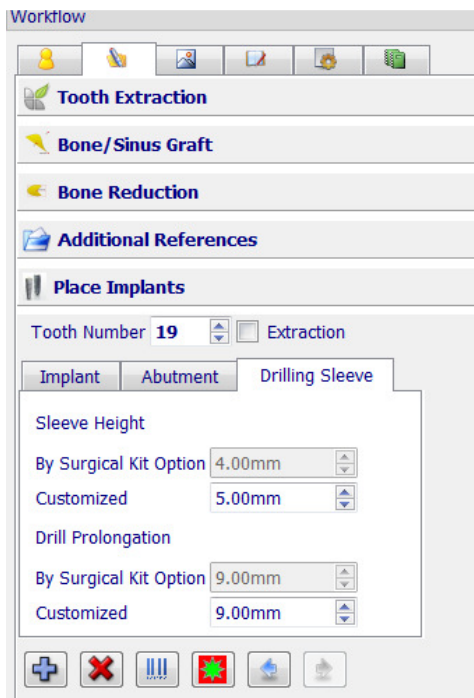
For other cases, this is automatically handled.

How to customize the drilling sequence and sleeve for some situations where drilling sleeve cannot fit into the space?

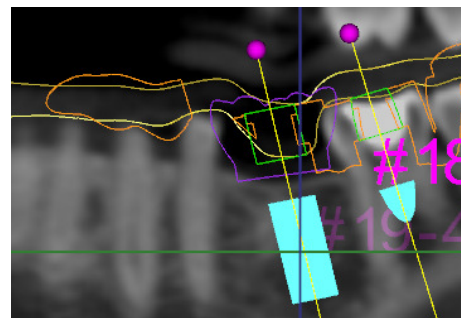
In some situations, you don't want to use the method in the last item. You can customize the height of the drilling sleeves, and the drilling prolongation value for an individual implant.

The UI is shown in the following picture (a). The second one (b) shows the sleeve by default. Notice that it interacts with the patients' anatomy because it penetrates through the radiographic guide. The picture (c) shows a customized design.

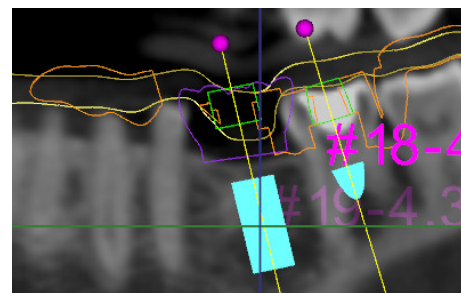
Drilling instructions in the generated reports will reflect such customizations.



(a) User interface to customize sleeve



(b) Sleeve interacts with anatomy



(b) Sleeve is moved up by changing the 'Drill prolongation'

Figure 8.3 Customize drilling sleeve

How to change implant type?

In any 2D view, double click on an implant.

How to design multiple surgical guides for a case, and why is this useful?

You can design surgical guides with different options and compare them. You can also design one surgical guide for left side of an arch, and another for the right side. In case of excessive undercuts, this strategy is very useful.

It is important that the treatment planning report is always generated with the latest surgical guide.

How to inspect the difference between two surgical guides?

Go to the object navigator, make one surgical guide as the current object, then turn of the display of all objects except the second surgical guide. Now each 3D view shows one guide. You can also change the colors and compare them.

How to register multiple STL models to the patient bone structure?

See "How to import a diagnostic model as planning reference".

How to make implants parallel?

There are three ways to make implants parallel:

- Make all implants parallel: click the "Make Parallel" button in the implant placement toolbox.
- Make new implants parallel to previous one: check on the checkbox.
- Make some implants parallel: go to object navigator select the one implant, and CTRL+select additional ones, then press the button "make selected implants parallel".

How to choose a model as the base for surgical guide design?

Go to object navigator, select the model, and click the button "Set Scan Template". When the users load for example multiple scans of stone models, this will give the user a chance to select a model that better serves as the base for surgical guide design for whatever reasons they decide.

How to trim or re-trim the base model for surgical guide design?

See chapter 7 for more details. There are two tools in the guide design toolbox. One is "Track", another "Circle". They will define a region by tracking the triangles on the model, or by define a closed profile as "cookie cutter". The "Cut" button will finish the trimming. If not happy with the results, you can use "Reset". The combination of "Circle" and "Cut" can be used multiple times. If you circle the profile clockwise, "Cut" tool will give you the areas inside the profile. Otherwise, it will make a "Hole" on the model.

How to proceed if I am getting errors when creating a surgical guide?

The system uses many Boolean operations to finish surgical guide design along with other operations. For a simple case, the surgical guide model can have hundreds of thousands of triangles, which can lead to high possibility of coincident edges, manifold topologies. Also the STL file quality of the input model can contribute to the complexity of Boolean operations. It is almost impossible to guarantee the success of Boolean operations with such models.

The system has implemented a good error handling mechanism. Many times, slightly adjusting the undercut angle or base model boundary, can fix the problems.

How to split a CT scan into two?

After loading the DICOM files, you can set the thresholds to -1024 and a value bigger than for example 10,000, adjust the region of interest, and then use menu item "Project/Export/DICOM file series".

How to set the display options in order to get a cleaner report?

This is important when you have many imported STL models or have generated many surgical guide models in the project. You may want to turn the unnecessary model off by "Show/Hide" and "Show/Hide in 2D" tools in the navigator toolbox, before you generate a report.

11 . MISCELLANEOUS

11.1 LIMITATIONS

There can be some conditions that the system will not likely support or not be able to produce good quality results. Here are some of them:

- The CT scan slice thickness is more than 1mm. This can lead to inaccurate models.
- CT scan slices are bigger than 2048x2048 pixels. In general they should be supported, but real time performance depends on hardware.
- The CT scan has too many slices. It is well expected to process 512 slice scans without problems with recommended hardware configuration, but more slices can present difficulty for the real time rendering and contouring of image data. However, the system should still be able to process large number of slices. Dataset with more than 1024 slices will generally be supported but slowly. Use the "export DICOM series" tool to create a smaller dataset for further planning.
- There are excessive scatters in the patient CT scan, which mainly are due to the metal crowns, fillings, existing implants, etc.
- When a bone level surgical guide is desired, the patient has very loose jaw bones, such that it is extremely hard to create bone models from CT scan.
- The input STL files of stone model or intra-oral scan have excessively tiny triangles, overlapped triangles, and other STL quality problems.

11.2 SYSTEM LICENCE

There are two versions of the software:

- Normal version allows the users to plan cases and design surgical guides. Surgical guide design is an optional module. STL exporting functions are only available with surgical guide license.
- Viewer version allows the users to open existing project, browse objects, and adjust implants.

- END -