

CYBERMED INC., ONDEMAND3D TECHNOLOGY INC.

# Technical Considerations of In2Guide(TM)

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White Paper

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● USA ● Republic of Korea  
[www.ondemand3d.com](http://www.ondemand3d.com)

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## 1 Introduction

Guide implant surgery using In2Guide requires new tools and equipments such as cone-beam CT, planning software, surgical template, and a surgery kit. However, these tools have their technical limitations. Although surgery with a surgical template can be convenient, it has certain restrictions compared to the conventional surgery procedure.

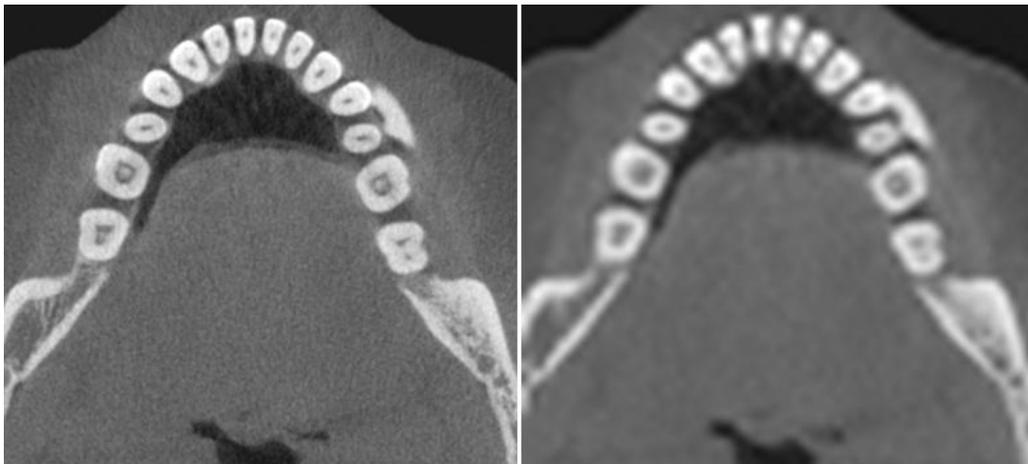
This document explains the technical limitations of In2Guide, and provides guidelines for a successful guided implant surgery.

## 2 Cone-beam CT

Cone-beam CT is the most vital equipment in surgeries using In2Guide. The following problems may occur with cone-beam CTs.

- **Low Resolution**

Cone-beam CT uses radiation to scan objects and converts them into digital images. Resolution is the capacity of how much detail can be shown. A similar concept can be seen in digital cameras as image quality from digital cameras varies on pixel settings.



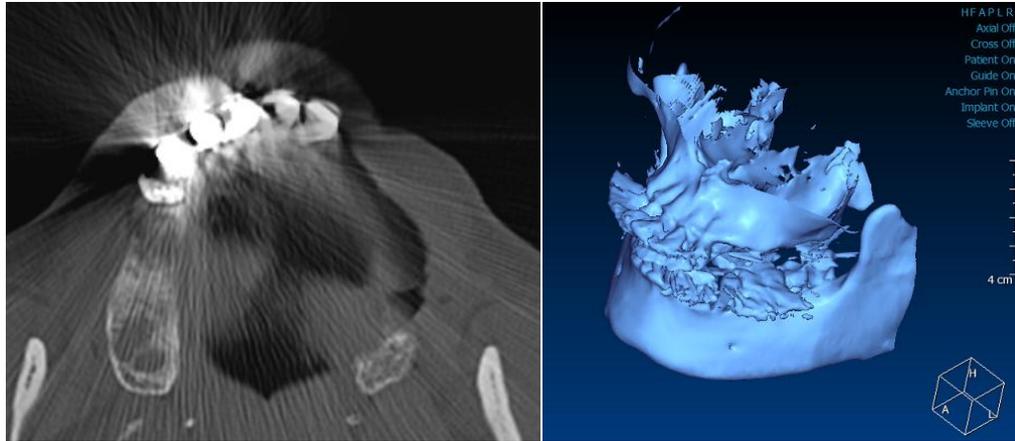
**Figure 1. High resolution image (left) and low resolution image (right)**

When scanning in low resolution, often times it can be difficult to analyze important anatomical structures. In addition, it may be difficult to see the boarder of the bones, resulting in inaccurate bone width or height measurement, making it hard to decide the correct location for the implants.

A radiographic guide extracted from such data cannot produce accurate records, and often results in undesirable fits when placed into the patient's oral cavity.

- **Metal scattering**

With patients with metal dentures, CTs may show scattered images, known as metal scattering or metal artifact. This can also occur in certain CTs when scanning denser teeth.



**Figure 1. Metal scattering**

The bright image is an indication of metal scattering in the frontal region. Such scattered areas cannot be analyzed properly.

### 3 Surgical Template Fitting

In partial edentulous cases, the surgical template comes in direct contact with the teeth. When two solid objects are in contact, even a small misfit can be critical. In case of full edentulous cases, the surgical template is placed on the soft mucosa and this situation can be avoided. The following addresses the various deciding factors of the surgical template fit.

#### 3.1 Critical Thresholds for Extraction of Radiographic Guide Surface or Stone Surface.

For fabrication of the Surgical Template, a stone-based protocol or radiographic guide-based protocol can be used. Here, explanation is done with the radiographic guide-based protocol.

Cybermed designs the Surgical Template from the stone surface. Therefore, without an accurate extraction of the stone surface, the Surgical Template will not have a satisfying fit. The following images show the relationship between threshold settings and the fitting of the Surgical Template.

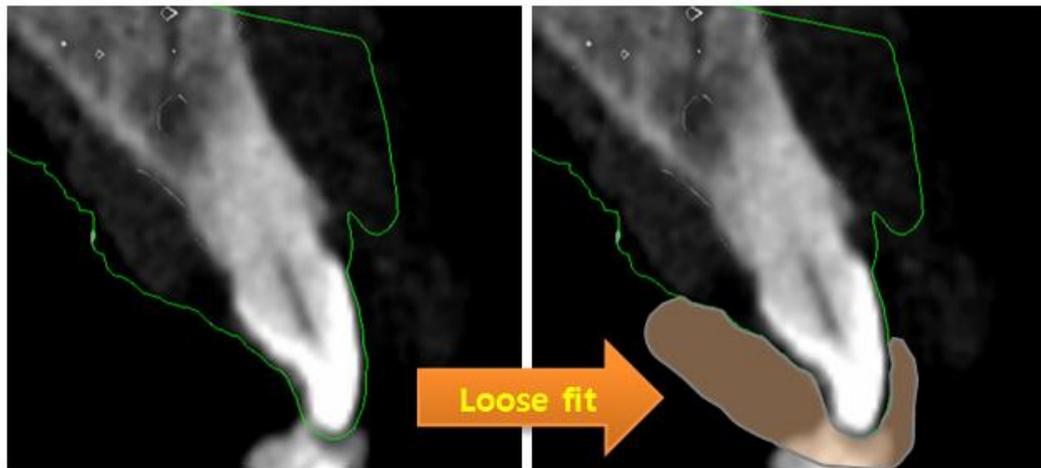


Figure 2. The green line indicates the extracted stone surface (left), and the orange line shows the surgical template to be designed (right).

When the threshold is set too low, and the stone surface is extracted too thick.

→ The Surgical Template has a loose fit.

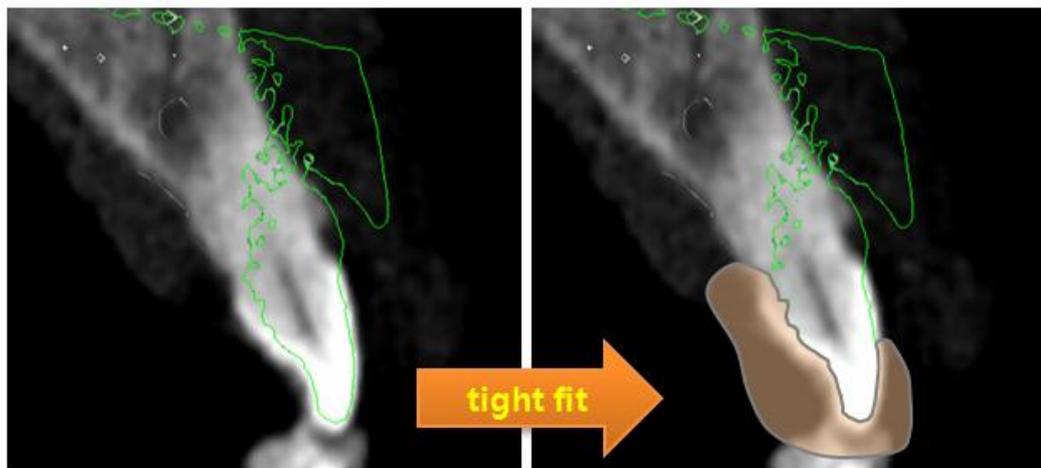


Figure 3. When the threshold is set too high and the stone surface is extracted too thin.

→ The Surgical Template becomes too tight and may not fit the patient.

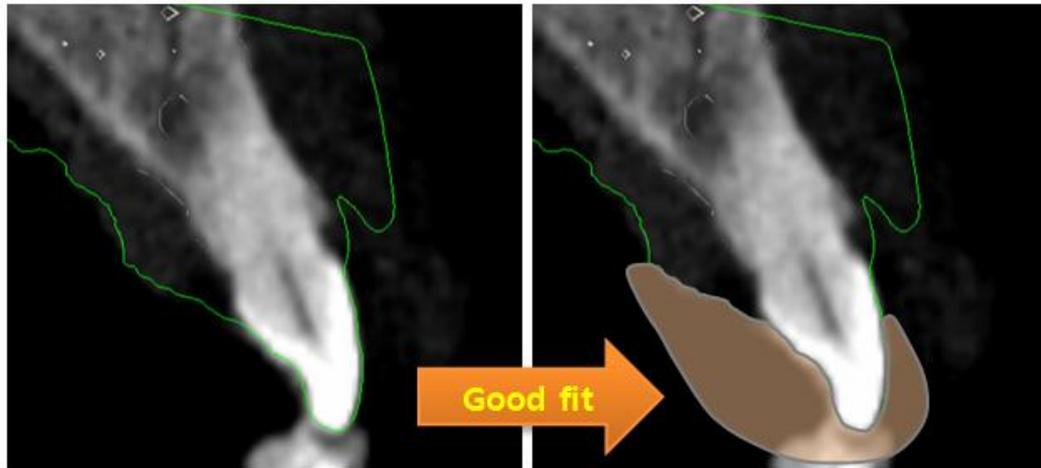
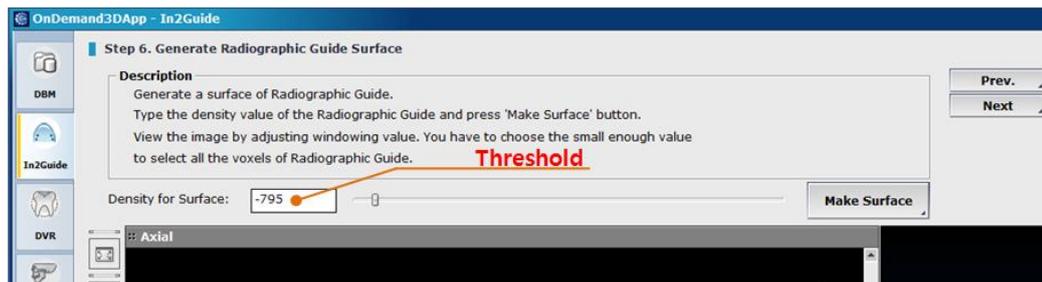


Figure 4. Correct threshold setting insures a good fit of the Surgical Template.

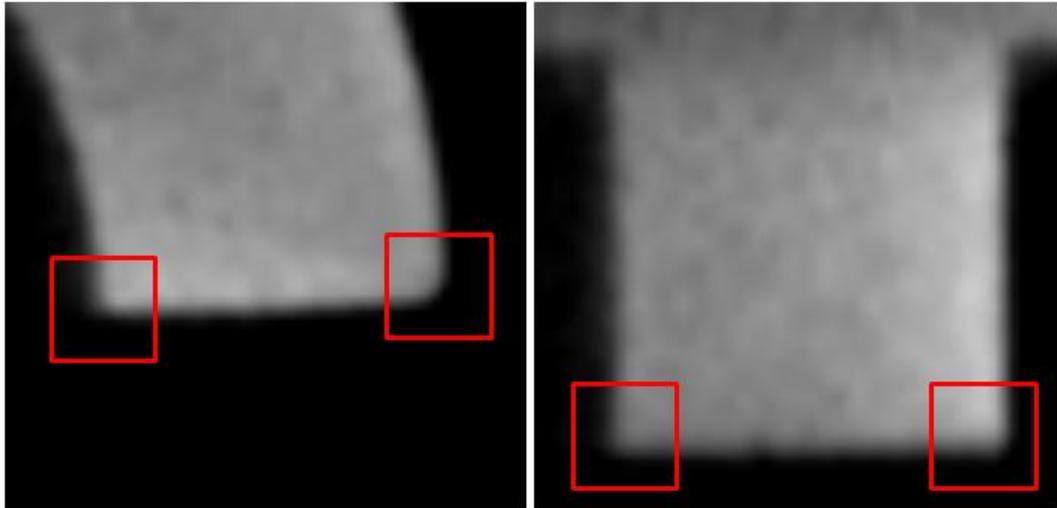
The proper threshold setting value varies on CT, scan mode, and stone material. Cybermed recommends the user to inquire about threshold settings, and not to modify such settings without prior consulting. Threshold values also need to be adjusted when the CT is recalibrated. Threshold value can be checked in OnDemand3D's In2Guide software.



### 3.2 Sharp Teeth

When CT scanning sharp teeth such as canines, images may round and smooth out around the edges. This can result in an improper fit of the Surgical Template. It is necessary to place the Surgical Template on the stone cast model after receiving it and check for any misfits. Any areas that do not fit properly should be grind or can be drilled to be used as an inspection window.

Inspection windows are used to visually check if the Surgical Template is correctly fixed in the oral cavity.



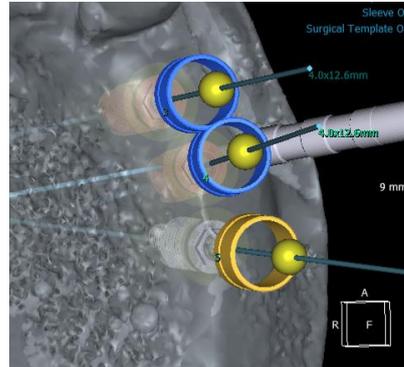
**Figure 5. When scanning a sharp-edged object as shown above, the corners become rounded and smooth. The same occurs when scanning sharp teeth.**

### **3.3 Low Resolution CT**

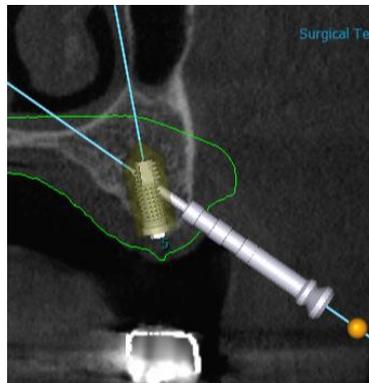
As explained above, when the CT's resolution is low, the stone cast model may not be accurate enough and a Surgical Template that is fabricated on such data may not fit the patient correctly.

## 4 Considerations in Fabrication of Surgical Template for Implant Planning.

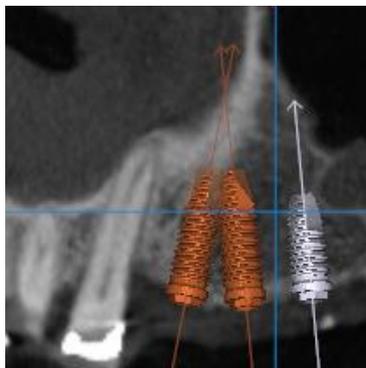
The Surgical Template contains metal objects called Sleeves. Thus, if the Sleeves collide or are in contact, the Surgical Template cannot be made. Such facts must be considered during the planning of surgery.



**Figure 6. Collision of Sleeves. In order to fabricate the Surgical Template, the Sleeves must be at least 1.0mm apart from each other.**



**Figure 7. Implant and Anchor Pin collision. The Anchor Pin should be placed between the implants.**



**Figure 9. Collision between implants.**

When the implant is too deep or the gingiva is too thick, the Sleeves in the frontal region may touch the gingiva.

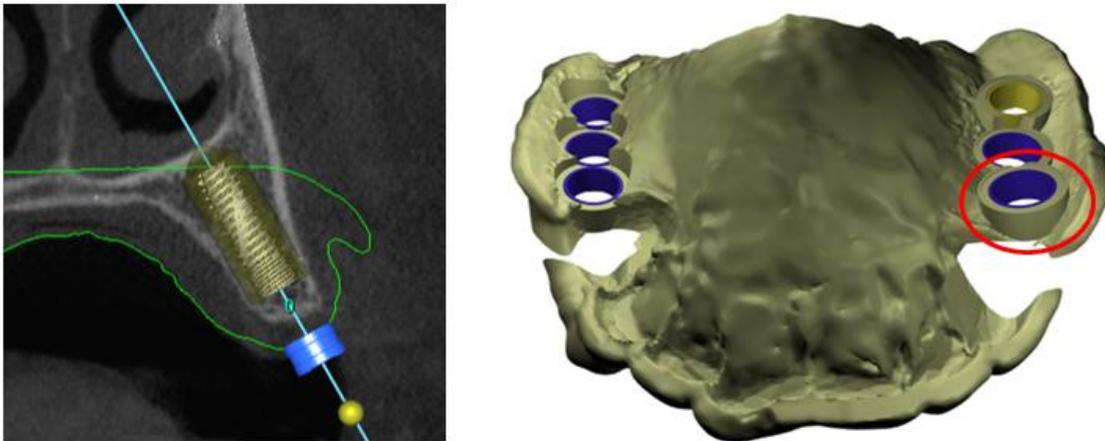


Figure 8. When the implant is placed too deep, the Sleeve touches the green line (sectional of the stone) as shown above (left). In such cases, the Surgical Template is fabricated with the Sleeve penetrates the mucosa. The user needs to grind out the part using a bur.

## 5 Range of Use for the Universal Kit

- ✓ The inner diameter of In2Guide Sleeve is 5.1mm. Therefore, implants with a platform, coronal diameter, or body larger than 5.1 cannot pass through the Sleeve. In this case, after the drilling is complete, the Surgical Template must be removed for the implant to be placed.
- ✓ In2Guide Surgical Kit is designed to support implants up to 16mm in length. Implant planning above this limit can be done with the Sleeve penetrating the mucosa.

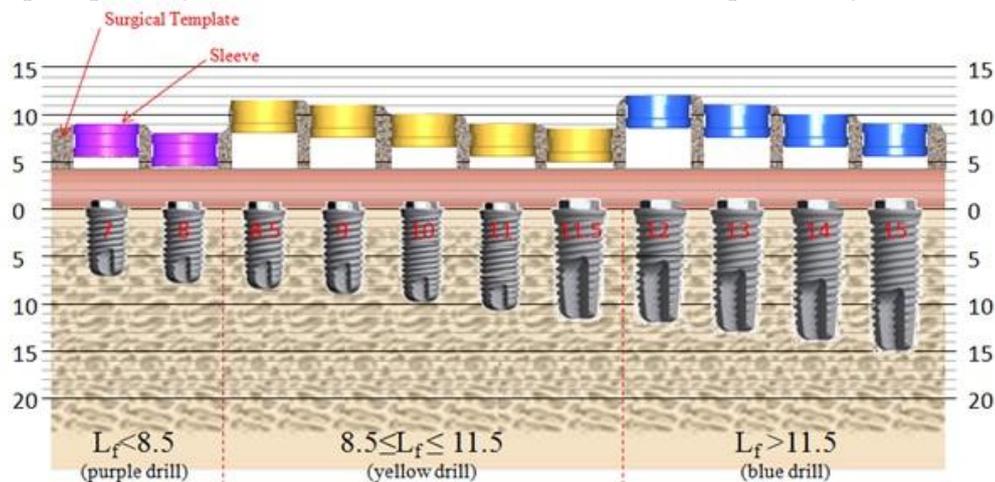


Figure 9. Sleeve height change based on implant length. For further details, refer to "Drilling depth control mechanism of In2Guide™ Universal Kit".

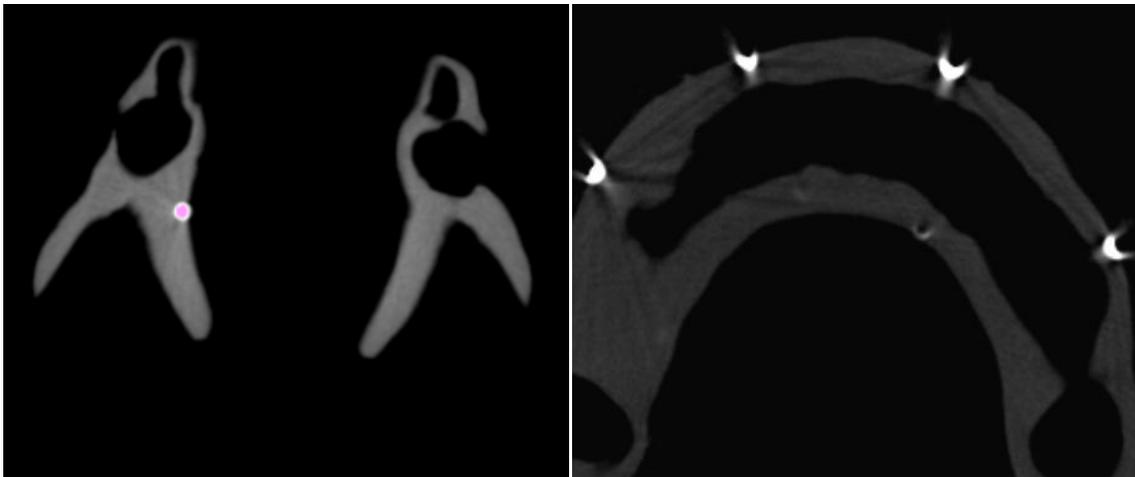
- ✓ Drills for tapered implant types are not provided.

## 6 Registration of Double Scan Data

For guided implant surgery two CT data sets, the patient's and stone (or Radiographic Guide), has to be matched. This method of matching two CT data is known as Double Scan Technique. For the matching process, distinguishable points are needed on both sides, which are called registration points or markers. Radio-opaque materials, such as gutta-percha, that can be easily distinguished in CTs are used for markers.

To summarize In2Guide partial protocol, using vacuum form on the stone cast model and placing 6 or more 1.5mm size gutta-percha points. Once this step is complete, CT scan the patient with the vacuum form on. The second scan is made with the vacuum form placed on the stone cast model. After both scans are complete, the two data sets are matched.

The gutta-percha points may appear in various forms as shown below.



**Figure 10. Well displayed gutta-percha points (Left). Donut shaped gutta-percha points due to scattering (right).**



**Figure 11. Gutta-percha points are hidden due to metal scattering (left). Severe scattering of gutta-percha points (right).**

Such CT images vary from equipment manufactures, and in certain cases, In2Guide software may not be able to make a successfully registration. The following are the settings for Automatic

## Registration.

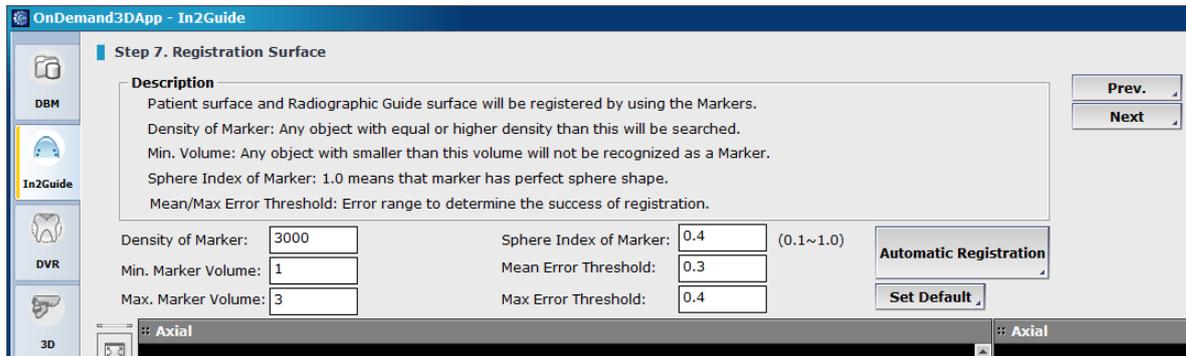


Figure 12. In2Guide Registration Screen

- **Density of Marker:** The density value is set to verify the markers. Objects above the set density value will be recognized as markers. Therefore, setting the value too low, may display other parts as markers, and setting it too high may result in difficulty verifying markers. When changing the density value, the marker area will be displayed in pink.

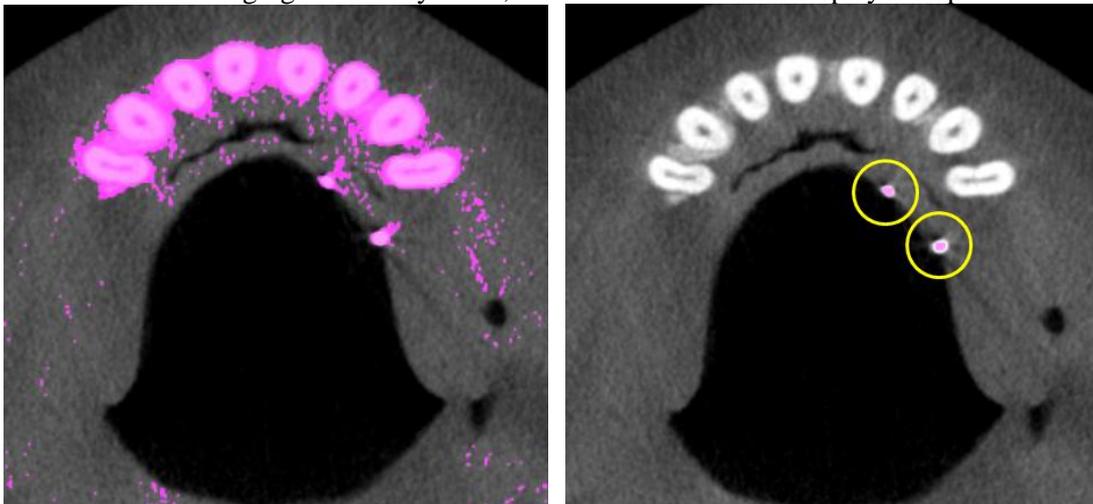
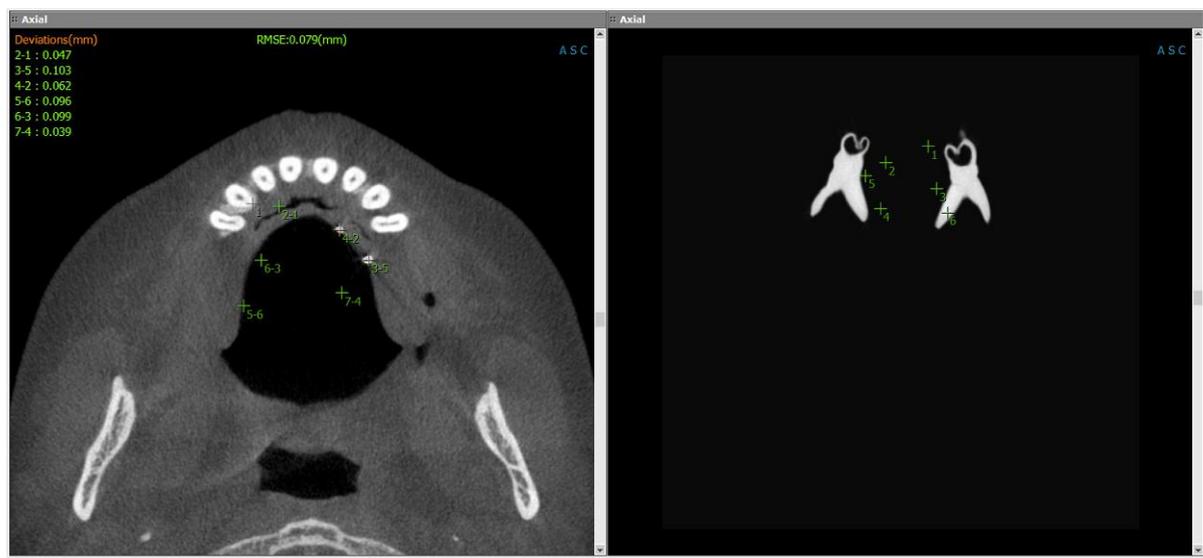


Figure 13. Threshold set too low and showing parts other than markers (Left: Threshold 0). Appropriate threshold setting, only showing the markers in pink (Right: Threshold 2500).

- **Min/Max. Marker Volume:** The extracted marker diameter must be within range to be recognized as a marker. When using a 1.5mm burr to place the gutta-percha, due to the scattering effect the gutta-percha point may appear larger. Therefore, the Marker Volume should be set slightly higher than the actual marker size.
- **Sphere Index of Marker:** Only markers that are in a spherical shape are recognized as markers. If the value is set to 1.0, only perfect spheres will be recognized as markers. As mentioned above, even with a spherical shaped gutta-percha, given the limitations of CT equipment, the marker may not always appear to be in spherical shapes. In such instances, adjusting the Sphere Index to a lower setting allows for automatic registration.

After all settings are properly configured, click "Automatic Registration" and successful matching will be done as shown below.



The green dots (+) are the extracted markers. Upon successful registration, numbers such as 6-3, 7-4 as shown above will appear. The first number represents the marker number from the patient's CT scan, and the second number represents the marker number from the stone scan. Thus, 7-4 means the 7<sup>th</sup> marker from the patient's CT scan and the 4<sup>th</sup> marker from the stone scan have been linked and successfully registered.

The green registration points will have small errors but within acceptable range. However, if the registration points are shown in red, it means that the points are linked incorrectly or a mismatch has occurred and should be canceled out. Cancellation of linked registration point can be done by right clicking the applicable point.

The RMSE value on the left side of the screen shows the average registration error, and is the measurement of error in matching. If the RMSE is high, the matching may be wrong, and needs to be reviewed. By adjusting the Mean Error Threshold and Max. Error Threshold, the acceptable error range can be changed. However, the adjust settings may affect the planning and surgery results and should be done with caution.

<b>Info.</b>	<p><b>If Automatic Registration fails.</b></p> <ol style="list-style-type: none"> <li>1. Adjust the value of the Density of Marker, check the gutta-percha points to make sure it is correctly marked in pink and retry Automatic Registration.</li> <li>2. Adjust the Max. Marker Volume to 10 or 20 and retry Automatic Registration.</li> <li>3. Adjust the Sphere Index of Marker to 0.1 and retry Automatic Registration.</li> </ol> <p>If all the above attempts fail, manual registration must be done. For further instructions on manual registration, refer to In2Guide User Manual.</p>
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Author: OhHyung Kwon



**USA**

OnDemand3D Technology Inc.  
310 Goddard Way, Suite 250, Irvine, CA 92618, United States

Phone: 949-777-5685, 8:00AM - 5:00PM PST  
Fax: 949-777-5685  
Email: [cybermed@cyberemd.co.kr](mailto:cybermed@cyberemd.co.kr)



**Republic of Korea**

Cybermed Inc.  
504, SJ Technoville 60-19, Gasan-dong, Geumcheon-gu, Seoul, Korea

Phone: 82-2-3397-3970  
Fax: 82-2-3397-3971  
Email: [cybermed@cyberemd.co.kr](mailto:cybermed@cyberemd.co.kr)