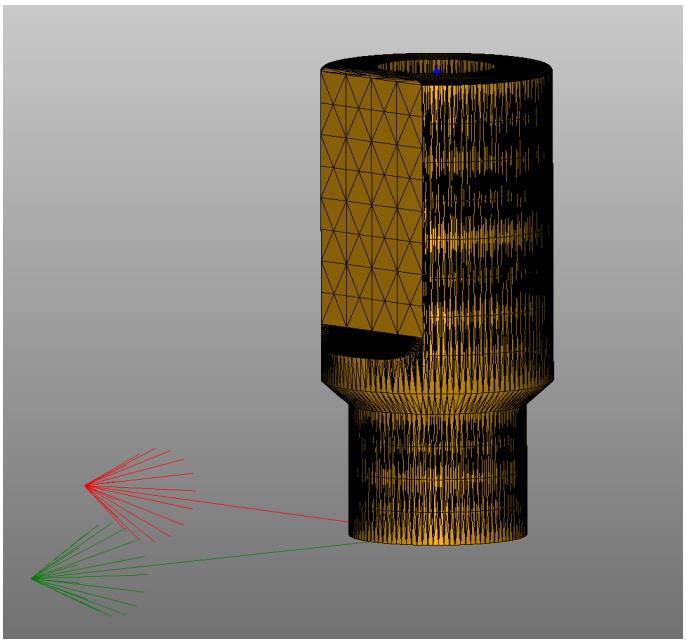
exocad

[Pushing Dental CAD to New Heights]

Instruction Manual

Creating Implant Geometries for exocad



CONFIDENTIAL INFORMATION – NOT FOR END USERS

In your own interest, please do not leak this documentation to end users. Having end users tamper with implant libraries themselves may cause additional support overhead.

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1 About this document

This document helps you to generate implant data suitable for integration with exocad DentalCAD. Please note that this document only covers aspects regarding the required technical representation of the mesh data.

- This document does *not* cover any aspects related to mechanical or medical requirements.
- This document does *not* cover any commercial aspects, such as: Licensing conditions for implant data, how to protect your data from 3rd party usage (e.g. by dongle-specific unlocking of libraries), etc.

1.1 Target audience, prerequisites

This document is targeted at experienced CAD operators, who can work confidently with industrial 3D CAD software and have a deep understanding of the terminology and technology involved. This includes knowing the difference between a solid and a surface, and understanding the effects of mesh export settings on the final output.

You will need a professional CAD software package to draw the implant geometries. We highly recommend to use a Hybrid Modeler, such as SolidWorks, Inventor, hyperCAD, or WorkNC HM. Additionally, the free software MeshLab can be helpful when postprocessing or analyzing output files.

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2 Parts of an implant library entry

In exocad DentalCAD, an implant library entry consists of several parts. Parts which are used in the matching and design process are *required,* while parts which are only used for visualization are *optional*. For an implant library to be usable, it must at least contain all the parts marked as "required" in table 1, while optional parts can be omitted.

Each part must be provided in its own STL mesh file. All parts have to be in the same coordinate system (correctly positioned relative to each other). The center of the implant geometry / titanium base must be aligned with one of the axis (X/Y/Z, at your option, but Z is highly recommended).

Part Type	Requirement	Description
Scan abutment	Required	Outer shell of scan abutment. Parts which are not well visible to scanners like the inside of the screw channel, implant connection and parts which are hidden by the gingiva should be removed. However, it should contain a hole there where the physical part has a hole. See figure 5.
Connection geometry	Required	This geometry will be used as the bottom part of the designed abutment. For direct screw retained abutments: Abutment-to-implant contact geometry with screw channel. The screw channel length defines the minimum abutment height. See figure 1. For cemented abutments with titanium base: outer shell of titanium base with cement gap, tool diameter compensation and screw hole cut out. See figure 4.
Implant	Optional	Implant or lab analog geometry. There are no special requirements for this geometry as it is used for display only.
Screw	Optional	Screw geometry. There are no special requirements for this geometry as it is used for display only.
Titanium base	Optional	The titanium base/interface geometry (for cemented abutments). There are no special requirements for this geometry as it is used for display only.

Table 1: Parts of an implant

2.1 Examples

The following figures illustrate the expected shapes of the meshes:

2.1.1 Connection geometry examples

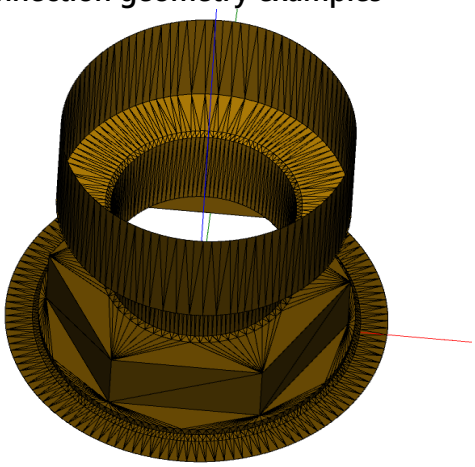

Fig. 1: Connection geometry for a popular implant system (internal hex)

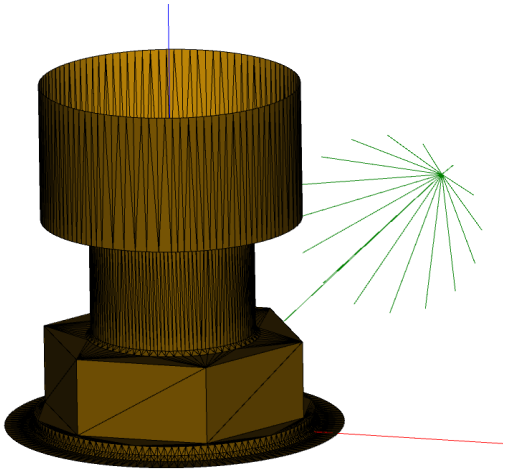

Fig. 2: Another view (showing screw channel shape)

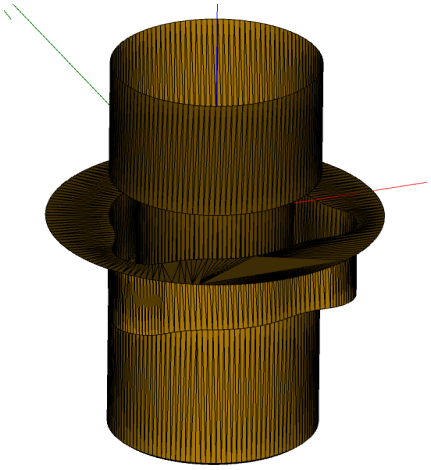

Fig. 3: Sample image for another popular implant system

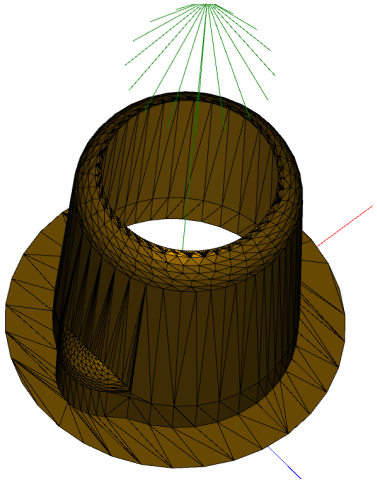

Fig. 4: Sample geometry for usage of titanium base with rotation lock

2.1.2 Scan abutment examples

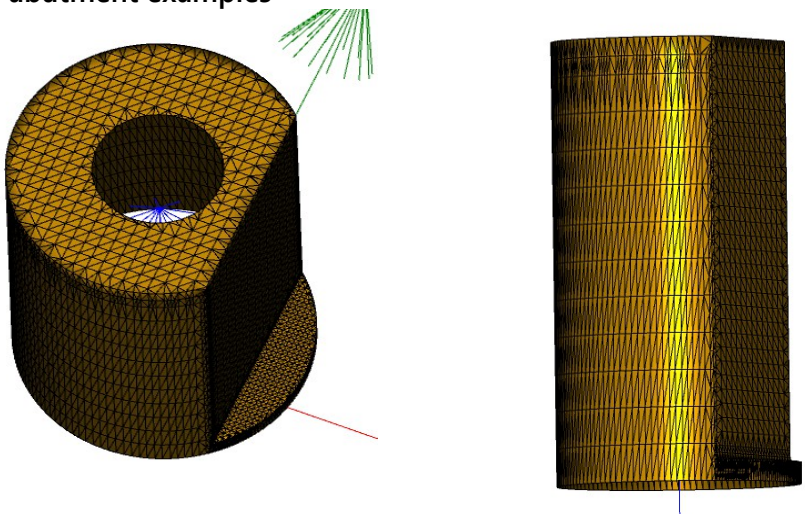

Fig. 5: Two different views of a sample scan abutment shape (outer shell). Note how the inner screw channel and the implant contact parts not visible to scanners have been removed.

3 Requirements for implant geometry

In order to be usable by exocad, implant parts must meet special requirements:

Part Type	Req. ID	Description
Connection geometry	SB01	The mesh must be fully interconnected. That means no open edges within the mesh (see figures 12 and 6), except for the two boundaries: upper boundary (at the end of the screw channel/hole) and lower boundary (near the abutment-to-implant contact area).
	SB02	The mesh has euler characteristic of 0
	SB03	The mesh is two-manifold
	SB04	Consistent orientation of triangle normals
	SB05	No overlapping surfaces. No double surfaces.
	SB06	Must be single surface (one connected component), not solid
	SB07	Reasonable triangle count (**Minimum**: ~1000 triangles. **Recommended**: 2000 triangles. **Maximum**: ~5000 triangles). Using higher mesh resolution will not improve quality of the output, and may cause slowdown of both CAD and CAM, as well as other problems.
	SB08	For direct screw retained abutments: the length of the screw channel should be as long as the screw head height. This defines the minimum abutment height and ensures that the screw does not protrude from the abutment.
	SB09	For cemented abutments with titanium base: screw hole must be cut out
Scan abutment	SA01	Only the outer shell of the scan abutment should be provided. Connection geometry, screw channel, etc should be cut out. The hole on top of the scan abutment should not be closed.
	SA02	Triangles should not be too long (< 0.8 mm). Please see figure 5 above for a reasonable triangle size. Do not use long, thin triangles that reach all the way from top to bottom of the scan abutment.
All parts	AP01	All parts have to be within the same coordinate system, correctly positioned to each other.
	AP02	All part centers have to be consistently aligned with one of the axis (X/Y/Z, at your option but Z is highly recommended)
	AP03	Don't use brand, trade or property names not owned by you in file and folder names as well as in implant names and descriptions.

Table 2: Requirements for implant library parts

4 Example for “good” triangulation

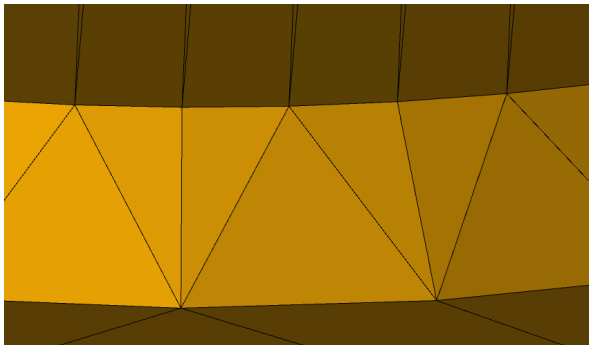

Fig. 6: "Good" triangulation. Mesh is fully interconnected, no open edges inside.

For an example for a 'bad' triangulation, please see Fig. 12.

5 Recommended procedure

In order to meet requirements SB01-SB06, we recommend to draw the connection geometry with screw channel as a solid first, and then cut away superfluous surfaces to create a surface.

The following video shows how to draw a suitable geometry using freeware applications:
http://www.exocad.com/a3c368e82b36/ExocadImplantGeometryCreation/

Make sure you watch the video in full screen, so that you can see the subtitles.

Tip: You can look at the DentalCADApp\library\implant directory for more samples. You can load .sdfa files in exoviewer (just drag&drop the file onto exoviewer3d.exe) or the DentalCAD application (using the „Load Jaw“ feature) to look at the sample files, and design your own geometries in a similar way.

5.1 Verifying Requirements SB01-SB06 using free software (no need for exocad dongle)

You can use MeshLab [http://meshlab.sourceforge.net/] to verify if your connection geometry mesh meets requirements SB01-SB06. Open your file and select the following menu: `Filters ► Quality Measures And Computations ► Compute Topological Measures`. Now open the result window with `View ► Show Layer Dialog`. If your mesh meets the requirements, you will see the following output:

```
Mesh is composed by 1 connected component(s)
Mesh has is two-manifold
Mesh has 2 holes
Genus is 0
```

6 Questions

Please contact info@exocad.com if you have questions. **We kindly asked you to check your data for common problems (see Section 7) before sending it to us.**

7 Avoid common problems

The following graphics illustrate the expected shapes of the meshes:

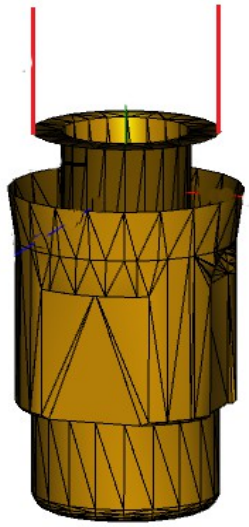

Fig. 7

WRONG:

A) Screw channel too short

- Must go as high as the actual screw head goes (see red markings above)

B) Too low resolution mesh (SB07)

- causes bad fitting / surface finish

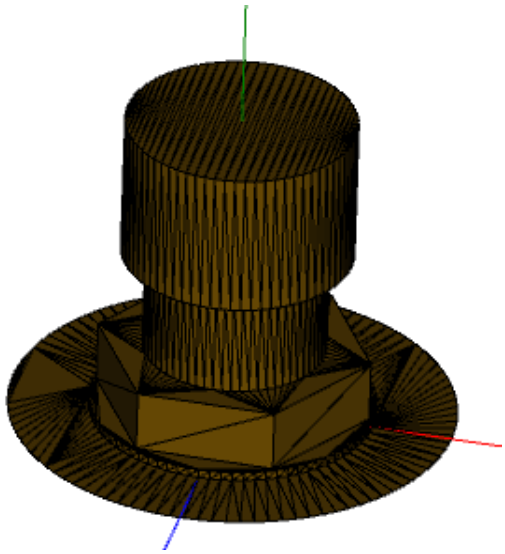

Fig. 8

WRONG:

C) Screw channel is closed on top

- This is easy to fix, just cut away the upper surface in your CAD software.

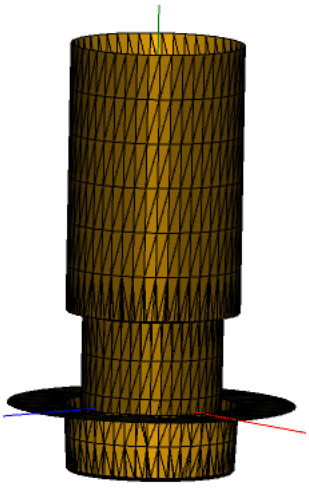

Fig. 9

WRONG:

D) Screw channel too long

- exocad Software will enforce minimum height of design according to height of geometry. A too long screw channel results in unreasonable constrains with regard to mimimum design height.

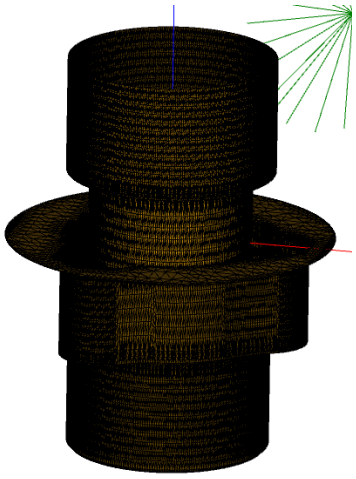

Fig. 10

WRONG:

E) Too fine triangulation (SB07)

- Does not improve accuracy, and causes slowdown and problems
- You can control this in your CAD program's STL export settings

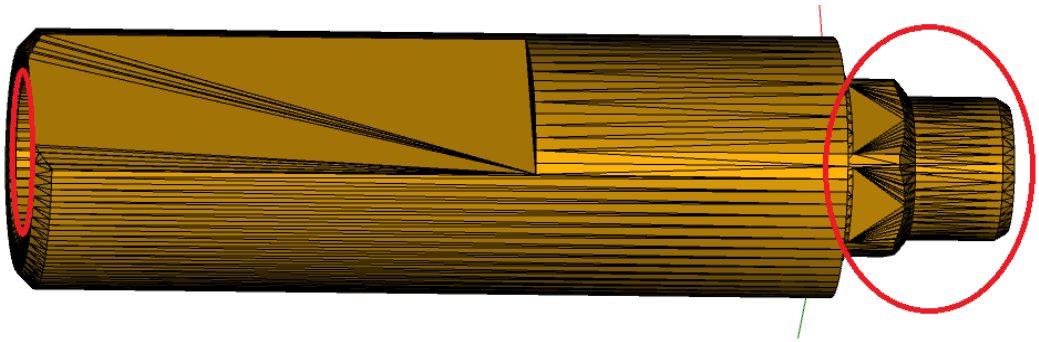

Fig. 11

WRONG:

F) Scan abutment mesh contains parts invisible to scanner (circled in red - SA01)

- It should not contain connection to implant, or inside of screw channel. However, it should contain a hole there where the physical part has a hole.

G) Scan abutment contains too long triangles (SA02)

- see Fig. 5 for an example how it should look. This can be fixed easily in MeshLab [http://meshlab.sourceforge.net/] using the `Filters ▶ Remeshing ▶ Subdivide – Midpoint` feature.

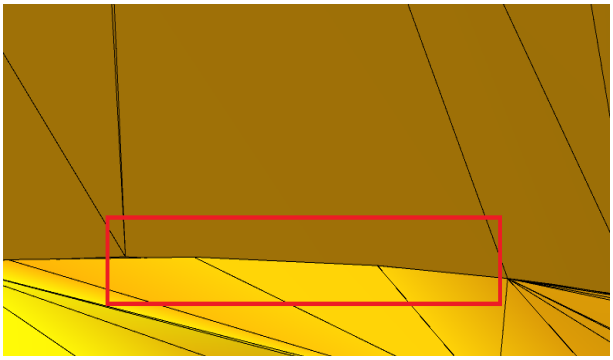

Fig. 12. Please see Fig. 6 as an example how it *should* look instead.

WRONG:

H) Mesh is not fully interconnected (marked by red square - SB01)

- The most common reason for this is that it was attempted to build a geometry by putting together several surfaces, instead of drawing it as a solid and then cutting away superfluous surfaces.
- Some CAD applications may generate single open edges during STL export. CAD applications known to export proper STL files – if used correctly – include SolidWorks, Inventor, WorkNC HM, and FreeCAD.

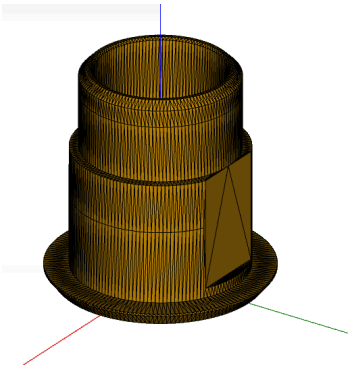

Fig. 13.

WRONG (as connection geometry):

I) Mesh is a a solid, not a surface

- Only the outer shell of the connection geometry should be present, no inner surfaces

J) Connection geometry *for usage with TI base* lacks tool diameter compensation

- Tool diameter compensation and cement gap (typically, 30µm) should be applied to connection geometry. Please look at Fig. 4 or an existing implant library for examples on how it should look.

Note: For direct-to-implant geometries, no tool diameter compensation should be applied.

As a "visualization mesh" of the Ti base, the above mesh would be suitable – but a connection geometry is still required.