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3D scanning systems for monitoring the size of mesh implants

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Abstract. The work is devoted to 3D scanning capabilities investigation for controlling the geometric dimensions of cervical spinal implants. Models of cervical implants were modeled in the CAD program "SolidWorks" and were made on rapid prototyping installations RS 6000 and ProJet 1200. Polymer models of implants were used for casting on consumable patterns at the casting unit Inducast. Scanning of polymer models and metal castings was performed using the 3D scanning system Activity 850. The resulting parametric 3D model had a lot of defects and inaccuracies. However, the use of non-contact optical scanning methods greatly simplifies the measurement of the control dimensions of complex profile mesh implants.

Introduction

A rachial implant (Cage) is a special device implanted into the spine of an artificial device of various shapes and sizes that serves as a stabilizer, corrector of the direction and height of the spine, the replacement of individual elements of the spinal column, when they are removed and replaced. These implants should be as close as possible to the spine. At the moment, the greatest number of implants are made using castings [1,2,3,4].

In the process of manufacturing a cage, there are various processes that affect the geometry of the implant. Distortion of the geometry of the device by more than 1 mm leads to rejection of the product. Standard measurement methods are not suitable for obtaining sufficiently accurate implant sizes. The presence of a complex geometric shape makes it difficult to measure the reference dimensions and determine its exact geometry, so the purpose of this work was to explore the possibilities of 3D scanning, the accuracy of the 3D scanner measurement, the comparison of sample geometry after manufacturing on a 3D printer and casting [5,6,7].

Main part

To analyze the scanning capabilities, dental scanner Smart Optics Activity 875 is selected.

Smart Optics Activity 875 is a desktop optical 3D scanner with enhanced performance. The device is designed to produce high-precision digital models used in dental prosthetics. In accordance with its purpose, the scanner has a high resolution, reaching 0.01 mm. The scanning process is fully automated and takes from one to three minutes depending on the size of the object. The received data is exported as STL files.

This scanner does not need to be calibrated when the scan object is changed, and the scanning process itself is automated. Activity 875 is designed for scanning objects with a diameter of up to 85 mm, which is very suitable for us, since the maximum size of the cage does not exceed this value. The main functional elements of the device are the camera and the light source, which structures it in a special way and directs it to the object being scanned. The essence of structured light technology lies in projecting light pattern onto an object and fixing it, analyzing its deformation. The light flux is projected onto a subject by several kinds of light sources: LCD, video projector, diodes, halogen lamps. In this case, Activity 875 uses the LED and camera. [1]

To simulate the cage, the program "SolidWorks" was used (Fig. 1). The walls of the body are a mesh structure, which reduces the weight of the implant. After 3D-cage modeling, the manufacturing process begins.

Two rapid prototyping installations have been chosen for the cage making: RS 600 and ProJet 1200.

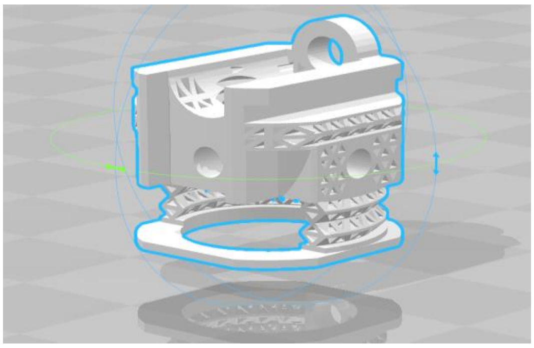

Figure 1 - 3D-model of cage.

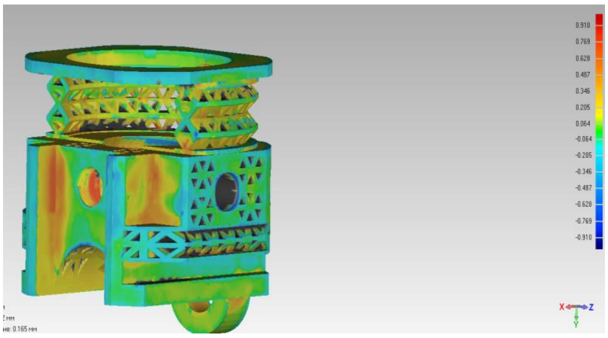

Figure 2 - Analysis of the geometry of implant number 1 in the program "Geomagic Studio".

UnionTech RS 6000 is an industrial installation for three-dimensional printing using laser stereolithography (SLA). The device is equipped with a working chamber of a large size, allowing you to create models up to 600x600x400mm.

3D ProJet 1200 model printer uses the patented 3D Systems Micro-SLA technology. This technology exactly coincides with the technology of stereolithography (SLA), which is characterized by the highest accuracy of printing. Micro-SLA differs from it only in that the product is created layer by layer from top to bottom, that is, "set", and not in a cell with light-sensitive resin. Resin in this case is applied from the cartridge layer by layer. Since such a method is possible only in conditions of a small working chamber, it was called Micro-SLA.

After the prototyping of the cages, these products were scanned on the Optical 3D Scanner Activity 875. To analyze the geometry of the digital cage model manufactured with the RS 6000 and compare the reference dimensions with the 3D model modeled with the SolidWorks program. Geometry comparison took place in the program "Geomagic Studio". The data of this analysis can be seen in Figure 2.

When scanning implants, difficulties arose with holes and threaded elements. The implant has a shiny surface, so it needs to be processed by the developer, to give a matte surface. In this work, the developer "Sherwin D-100" was used. The influence of the developer on the measurement error is insignificant from 0.01 to 0.1mm. The conditions that were mentioned above could together influence the deviation of the geometry, but it is insignificant, since the maximum value is 0.9 mm, the average is 0.14 mm. The smallest deviation occurred precisely when scanning this implant, from which it can be concluded that the accuracy of manufacturing the RS 6000 is higher than that of the ProJet 1200.

The next geometry comparison takes place between the digital implant model made on the ProJet 1200 rapid prototyping unit and the 3D model modeled with the SolidWorks software. The physical model of the implant has not only a shiny surface, but also a dark green color. All these parameters have a poor effect on the quality of the scan. To improve the scanning process, it is also necessary, as in the first experiment, to process the surface with the developer "Sherwin D-100". Geometry analysis was also carried out in the "Geomagic Studio" program. The results are similar to the first experiment (Figure 3). The maximum deviation is 0.9 mm, the average deviation is 0.14 mm.

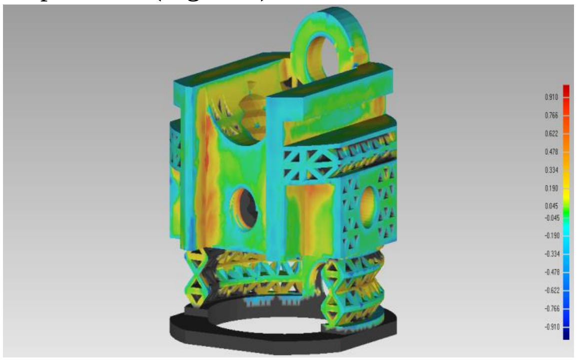

Figure 3 - Analysis of implant geometry number 2 in the program "Geomagic Studio".

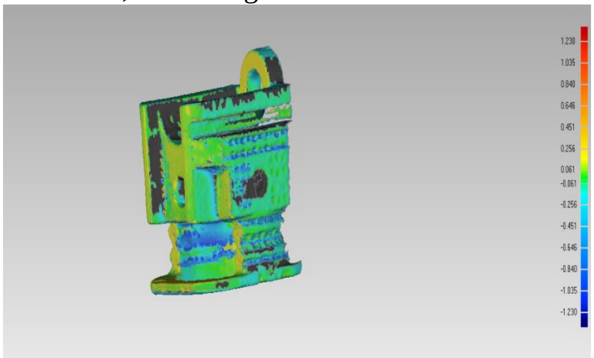

Figure 4 – Digital model of cast.

Consumable patterns, created on stereolithographic equipment, replace the traditional wax models. The use of SLA technology makes it possible to quickly produce the most accurate casting products from metal with the best surface quality in comparison with other technologies.

The printed prototypes are coated with a high-temperature suspension in several layers to create a shell shape. Further, the models are burned out at high temperature and molten metal is poured. After curing the metal, the sheath is removed and the casting is polished. Casting cage, in contrast to the implant, manufactured on the RS 6000, has unevenness. Cutouts located on the main part of the implant turned out to be inaccurate. As a result, the surface does not have through cutouts, since the metal completely filled the holes during the casting of the casting.

The metal casting as well as the previous two prototypes was scanned using Activity 850. Then the resulting point clone was processed in the "Geomagic Studio" program for obtaining a polygonal model and comparing the casting with the prototypes, and for quality control. Analysis of the scanned cast showed small deviations, an average of 0.2 mm (Figure 4).

The maximum deviation was 1.3 mm. Such a large deviation is due to the unavailability of the 3D scanner to handle holes and small threaded elements. The minimum deviation was 0.02 mm.

Conclusion

As a result of the work, it was shown the possibility of improving the casting technology, using a consumable pattern, digital scanning with structured light and 3D printing. The equipment and software used influence the quality of the burned-out model. In those cases where it is required to transfer small parts, it is necessary to use equipment and software with the appropriate characteristics.

Shape comparison, surface quality comparison of the consumable pattern and the cast part showed that the surface of the casting has the greatest distortion among all the implants used in this article. Investment casting does not make it possible to obtain mesh structures in implants.

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