PROCESSING OF LARGE AMOUNTS OF INFORMATION FOR RECONSTRUCTIVE FACIAL SURGERY

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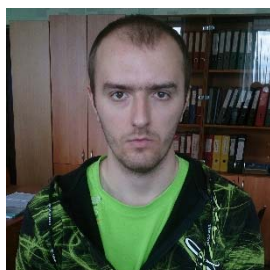

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Abstract: There is a possibility to obtain a 3-d model of the facial skull bones and a vector counter file of damaged bones based on a set of output files from an X-ray computed tomography to manufacture an individual implants.

The scientific and practical interest is in the development of technology for producing 3D models of thin, small bones and complex shaped bones of the front skull parts, based on the output files of X-ray computed tomography. The aim of research were to develop a technology to handle a large amounts of information for reconstructive facial surgery, as well as working out the technology of forming a drawing of the individual implant for bones of the eye socket. To achieve these goal it were necessary to implement the following objectives: 1) to analyze the raw data, 2) to choose the

software for obtaining and editing 3D models of the facial bones of the skull on the basis of more than 200 output files of X-ray computed tomography; 3) to develop and work out technology for the production of drawings of individual titanium implant; 4) to carry out clinical trials of individual implants.

The patent [1] describes a method of bone defects replacement. The feature of these technology is in to placing a biological container in the bone defect. These container is formed out of aponeurological patch wich is a cut from the broadest factions thigh. The container is filled with granulated porous hydroxyapatite having a pore size of 200 to 600 microns. It is a diagram illustrating the proposed technical solution on figure 1.
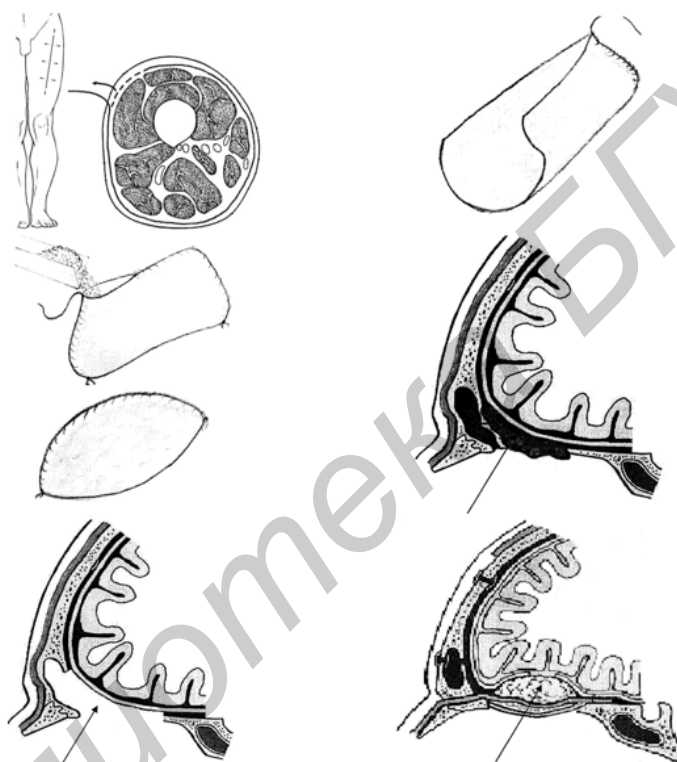

Fig. 1. Scheme of bones defects replacement [1]

B The patent [2] discloses a method for producing a bone allograft to replace bone defects of the skull. The technology of bone allograft for craniofacial plastic surgery includes: machining, degreasing, demineralization, freezing, freeze-drying, sterilization. A distinctive feature of the proposed technical solution is in specific and original selection of technological parameters of the operations mentioned above.

The authors of the patent [3] proposed changing the original design Rybal'chenko plate. The plate is intended for reconstruction of the damaged bone structures of the complex comprising the cheekbone, eye socket and upper jaw. In addition, an improved method for the reconstruction of damaged bone structures using plate. The plate is integrally formed from a flexible durable bioinert material, it includes a flat working surface perforated and perforated legs. A distinctive feature of the designed structure

is that the feet are made of at least two on each side of the plate, and the operating part is in the form of an isosceles trapezoid plate for installation into the eye-socket. The authors give 27 detailing the positions to the claims, expanding its scope, both in terms of design and in terms of technological solutions. Figure 2 is a diagram illustrating the proposed technical solution.

The authors are [4] patenting a method of making individualized precision implant to compensate for complex subtotal polyostotic eye-socket defect. The method includes: 1) the definition of bulk mathematical parameters deformed or anatomical defects and balanced them healthy tissue by sequential thin layer with uniform step up to 1mm computed tomography; 2) a comparison of paired anatomical structures; 3) obtaining a mathematical volumetric defect parameters; 4) production of the implant by obtaining difference mathematical data. A distinctive feature of the development of technology is the measurement of the skull segments, as well as the synthesis of bulk mathematical parameters of a damaged eye socket and technology training and implant installation. Figure 3 shows the reconstructed image of the patient's face when entering the clinic.
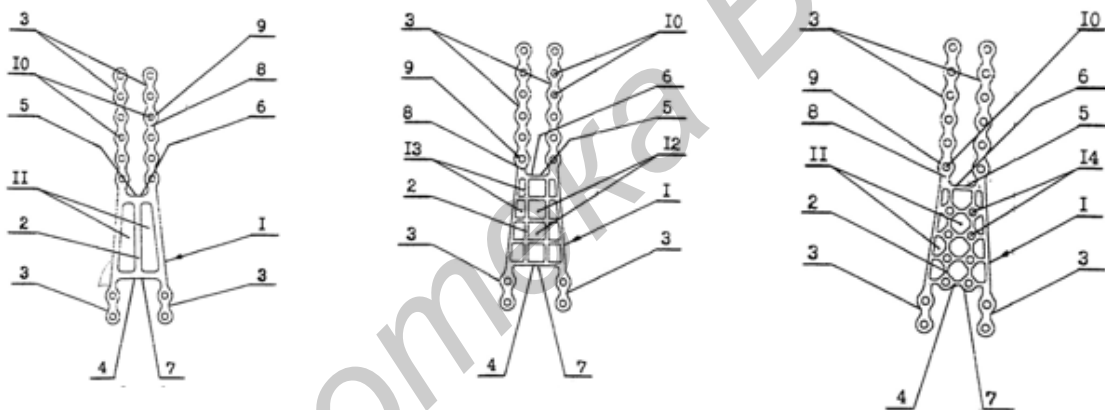

Fig. 2. Scheme of construction changes implemented to Rybalchenko's plate [3]

Fig. 3. Reconstruction of the patients' face picture

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The authors are [5] patenting a method of making stereolithographic models and bioimplants for usage in cranio-maxillofacial surgery. The classic method comprising: carrying out X-ray computed tomography; the formation of 3d computer image of the biological object; the construction of 3d plastic model of a biological object. A distinctive feature of the technical solution is proposed by the authors scaning modes during the X-ray computed tomography and the original of the final image reconstruction technique. Figure 3 shows the reconstructed image the patient's face before and after surgery.

Fig. 4. Reconstruction of the patients' face before and after operation [5]

In the patent [6] proposed a method of manufacturing implants for reconstructive surgery of the face. The implant has a base of a metal. A distinctive feature of the development: on the surface of the titanium, mesh tape is applied by plasma spraying an additional layer of titanium film thickness of 50-100 microns. As the titanium source, powder is used fineness of 40-60 microns. In addition, a layer of titanium film is coated on top of a layer of plasma sprayed bioceramics (hydroxyapatite or biosital). The latter coating is applied to the grid either on one side or on both sides, as required. Instead of titanium can be used titanium alloys (for the grid).

Basic software selection criteria for 3D models of the facial bones of the skull are:

1) the ability to import the output files to a tomographic computer software;

2) the ability to view (layers) the results of the CT scan in three planes;

3) the ability to edit the source data (files CT) before building a 3D model of the facial bones of the skull;

4) the ability to create and export 3D models facial bones. Based on the analysis and the selection criteria for the analysis software for the output files CT software 3D Slicer 4.4.0 was determined. This software meets all the above criteria.

The 3d Max software were selected to edit 3d Slicer results and to create a 3d scan models of damage facial bones of the skull. This choice were made due to disability of 3d Slicer to edit models.

When working with 3D Slicer software to display the model in 3D and to facilitate further processing is necessary to select the module «Volume Rendering», apply a function of constructing and operating the image using the slider in the «Shift» column, remove unnecessary layers. To remove unnecessary parts of the model must be chosen module «Cropvolume» and apply the function «ROIvisibility» to display the lines cutting the 3D model. When you drag these lines performed removal of unnecessary portions of the model. Manipulating lines, on which the removal is required to ensure that remains an essential part of the model (it is more convenient to manipulate the control points using a line constructed 3D figure). To remove you need to hold down the left mouse button on one of the colored balls (depending on which part you want to remove) and pull it in one direction or another. Using function «Crop!» carried out the removal of unnecessary domain model. Pressing the "eye" next to «ROIvisibility», the guide lines will be removed. The red, yellow and green areas of the software reflect the image, in accordance with the manipulation of the work done to remove unwanted parts. For further work is required to return to the «VolumeRendering» menu and disable the display of the 3D model.

To edit the model used «Editor» module (you must select «Apply»). To increase the accuracy of a pattern editing is carried out in two or three planes. It depends on what kind of facial bones broken. In the «Editor» window to isolate tissue model that you want to build a 3D model, you must press to turn function 1 and 2. With the help of these functions is used to select the type of tissue that will be allocated for building the 3D model. In the menu that appears 3 is given the name of the tissue. Requires highlight skull, so ask the name of «skull». When the slider 4 is an allocation of the necessary sections of the skull, this requires validation of the selection (the selection is not applied image will flash). After the release, you must use the «Apply» function. To build the model is required to choose a module "Build a model", click on the function «Apply» and wait for the end of the model building process.

The constructed model is stored in the .stl format for further work with it in the 3D editor, or send to the printer. To do this, use the «SAVE». In the window that appears, you only need to select the model built «skull», select the .stl format for saving and click «Save» function.

To open the model, use the "File" menu and select the function "Import" and open the desired file .STL. In the window «Import STl File» you need to set model parametres. Transition in the Perspective mode by key combination «Alt + W». To edit a model, you need to convert it by calling the submenu, right-click on the model and in the «Convert To» select «Convert to Editable Mesh». To edit a model, you must select the part of the model, and then, select the edit mode. Highlight the desired clamping faces carried «CTRL» key and select the desired face. Feature «Bride» provides an opportunity to connect the two sides.

The following operations are carried out for the creation and modification of geometric parameters of billets.

1) The movement of the workpiece is carried out of its isolation by clicking the left mouse button. Go to the "Move" mode by pressing the «W» keys. A more precise movement caused by pressing «F12» (numerical values of the workpiece position window appears in the space). The left side of the «Absolute: World» set the parameters for moving axes. On the right side «Offset: World» to increase or decrease the existing parameters by increasing or decreasing the values by a certain amount.

2) To change the surface of the workpiece must be in the list of «Modifier List» select the function «FFD (box)».

3) Edit the workpiece takes place by moving the control points along certain axes. To do this, go to the checkpoint mode, this mode is selecting by pressing the right key on the blank and select «Control Points» function. 4) Increase the number of checkpoints performed SELECT function «Set Number of Points», and then specify the number of nodes in the right plane.

To form the scanning pattern should be used modifiers «Unwrap UVMap» (creates a sweep plane model) «Unwrap UVW» (displays the result of the scanning model). The result is the creation of the sweep must be saved in .jpg format (used modifiers software does not allow you to save vector files).

The resulting .jpg file must be imported into the software Corel Draw for making vector image of damage facial bones contour. You must use the "Tracing object" function to transfer a bitmap to vector. To create a scan contour in the menu "Sort", you must select the "Convert outline to object." After the removal of unnecessary objects must be left vector image outline to scale and sweep it in accordance with the actual size of the damage model. Next, vector image can be used for editing and preparation of drawings of the implant.

Thus, the technology of producing 3D models of the facial bones of the skull, based on the output files of X-ray computed tomography and manufacturing implants for these lesions consists of the following blocks of operations (Figure 5).

1   Import the output files of X-ray computed tomography (DICOM) The 3D Slicer.

2   Layered editing slices facial bones.

3   Creating a 3D model of the skull and facial bones of a 3D model of damage facial bones.

4   Export the created models in .stl.

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5   importing files of damage facial bones 3D models in 3D Max.

6   Create a pattern scan 3D models of damage to the facial bones of the skull (.jpg).

7   Export the drawing scan in .jpg.

8   Import sweep pattern in Corel Draw.

9   Create contour scanning pattern.

10   Edit drawing sweep contour.

11   Save the edit results in the vector files in .dxf and .cdr. Figure 6 is a diagram of the technology reconstruction of damaged bones of the eye socket of the skull.
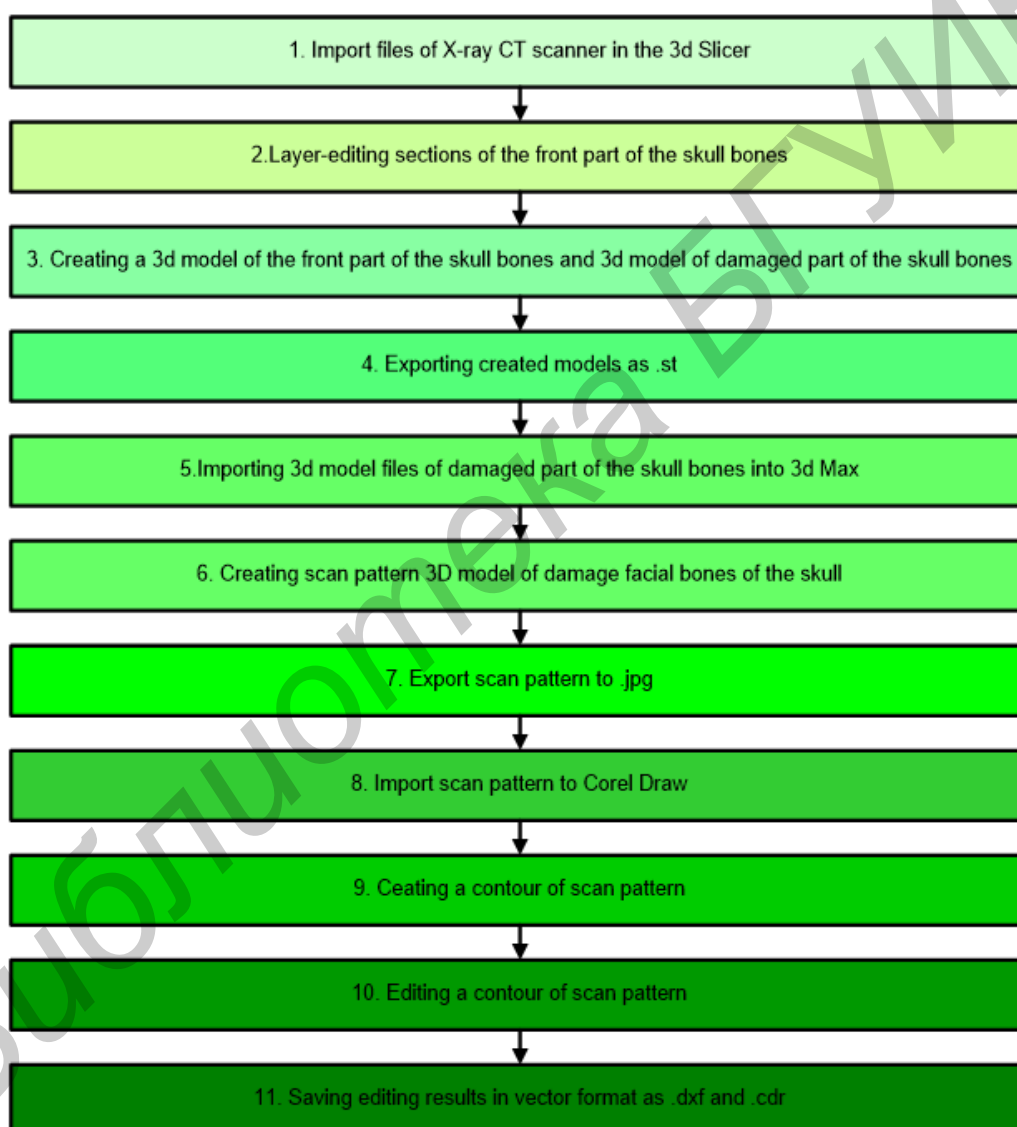

Fig. 5. Technology of receiving 3d model of the front part of the skull bones

The result of the process files are 3D model of the skull bones of the face, ready to be printed on a 3D printer, as well as a vector contour file of damage bone. Made 3D model of the facial bones of the skull is used in preparation for surgery to verify the manufacture of the implant. Vector file of damage facial bones of the skull contour

is used to manufacture the implant. After validation of the technology to print patterns of the facial bones of the skull can be avoided due to the accuracy of the preparation for the manufacture the implant for damage contour.
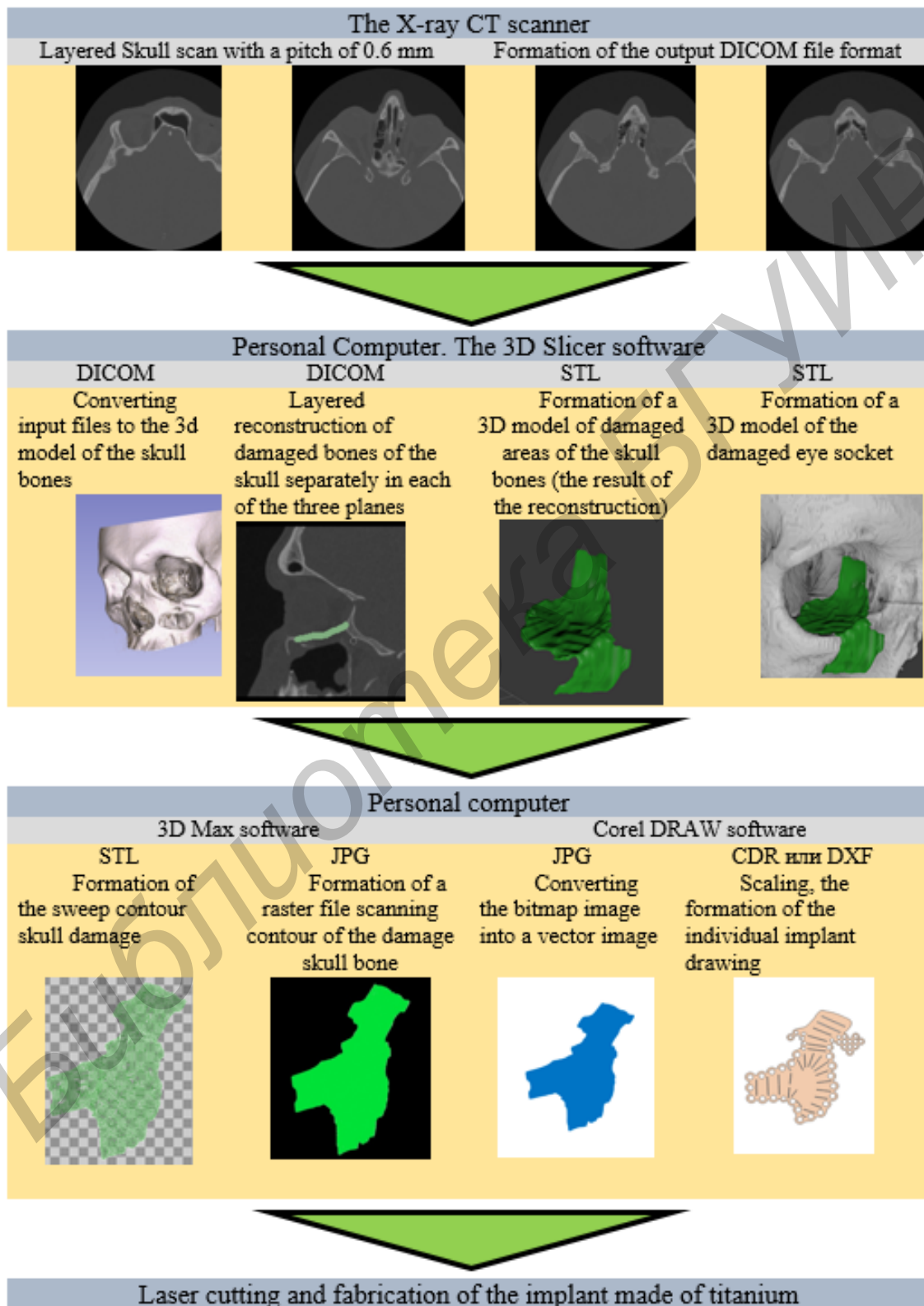

Fig. 6. Technology of reconstructing damaged eye socket of the skull bones

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