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# Polyetheretherketone (PEEK) for making bone implants in maxillofacial reconstruction surgery

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***Abstract*—** Polyetheretherketone (P.EEK) has been used as a bone implant because it has the nature of a biocompatible, strong, non-corrosive, stable and not affected by high temperatures. PEEK is potential for use as an implant material. Applications in maxillofacial reconstruction surgery is very beneficial in terms of time and cost.Model-making mandible obtained from data on patients affected by tumor ameloblstoma. The data have been taken by a CT-scan in the form of DICOM (Digital Imaging and Communication in Medicine) is amended by Catya into STL files (stereolithography). STL file is then printed with 3D-printers and Computer Numerical Control (CNC) machines.Printouts based models have been created for the reconstruction implants in maxillofacial surgery.

***Keywords*—** Polyetheretherketone, implants, reconstructive surgery, maxillofacial, mandible.

## I. INTRODUCTION

The use of metal material has been 4 decades used to make implants that are integrated in the bone damaged by a tumor or by other causes. Search other materials instead of metal materials have long sought. Lately through various studies have found polyetheretherketon material (PEEK) which is a semi-crystalline material that has properties of biocompatibility. PEEK in a foreign country has been used as an implant maker which is directly implanted in the body.

PEEK has a composition that is very compact unaffected high heat, has excellent strength and has elasticity similar to human bone.

PEEK is very advantageous in its use, because it has no risk when used as implant replaces the damaged bone portion. This material has properties that are very stable, non-corrosive and without affecting the mechanical strength. The disadvantage is that PEEK after being implanted in the body can not be detected by X-ray or magnetic resonance imaging (MRI).

At the end of 1970, the material has been used in the industry because of its unique properties. PEEK can be used in medical because it has excellent mechanical properties, does not cause toxicity as well as biocompatible (1).

In recent years PEEK has been used in patients in a very large number of mainly home-major hospitals in developed countries (2). Besides, PEEK has the advantage of being compatible properties, when used in implants such as orthopedic surgery to replace metallic (3). To support the design clinic PEEK implant devices have become very important (4).

In 1990, the PEEK material has been developed to address the various problems that arise as a featured ingredient that can replace titanium is used as excellent of the implant (5).

Now it PEEK has become part of biocomposite that are able to meet in future implants (6) Due to the nature of the composite contained in the PEEK material is also compatible with the diagnostic properties compared with the implant material using metallic materials (7). PEEK also is not contaminated by toxic gases. Thus PEEK as the material does not affect the substance that is organic and inorganic both in liquid form, or solid (8). Titanium and stainless steel material known for use on patients in the clinic but along with the development of PEEK biomaterials will be able to replace these materials (9). In order to support research into biomaterials has been growing rapidly, especially in order to generate innovations, as the prosthesis or artificial spinal implant material (10). In the laboratory of Biomedical Technology wherewith some draft PEEK is used in patients with tumors to replace mandibular bone, but some improvements have been made for improvement in order to optimize the use of materials to replace the damaged bone manbular. (11,12). Therefore in this discussion will be developed several models using the PEEK material with reference to the superior properties including to utilize biomaterials will be designed in materials artificial implant.

## II. METHODS AND MATERIALS

### *A. PEEK materials*

PEEK material has the properties very stable in use as implant materials. The chemical composition of PEEK like (-C6H4-O-C6H4-O-C6H4-CO-) n, the power level of the PEEK material used can be compared with metallic materials and bones for the modulus of each of these follows

TABLE I
COMPARISON BETWEEN TITANIUM, BONE, AND PEEK

| Type | Titanium | Bone | PEEK |
|---|---|---|---|
| Modulus of elasticity (GPa) | 110 | 1-30 | 4.1 to 4.6 |
| Strength (MPa) | 530 | 115 | 113 |

Other properties PEEK is also very important is that the PEEK material deserted in a wet media (such as blood), and was not affected by high temperatures.

### *B. Modelling repair the damage.*

Laboratory of Biomedical Technology, in collaboration with researchers at the Department of Surgery Oral RSCM-FKUI and Oral Surgery Department of the Faculty of Dentistry, Universitas Indonesia ( FKG-UI), has been getting the data with tumors ameloblastoma. By an oral surgeon has recorded patients affected by tumor with Computed Tomobgraphy (CT). This data is then inserted into the file DICOM (Digital Imaging and Communication in Medicine) as medical data, then the resulting image through software Catya converted into STL files (Stereolithography) as follows in figure.1.

**Figure 1**. Modelling techniques for reconstructions material.

The results of the proficiency level can be seen in Figure 2. With respect to the original image modeling (1A) can identification damaged section to be repaired. Modeling can be seen in Figure 2 and Figure 3 below. To perform corrective measures against damage caused to a patient, based on the model created. Reconstruction of 3D prints can be sorted according to the modeling that has been made. In figure 2 and figure 3, we can see the damage experienced by patients affected by tumors.

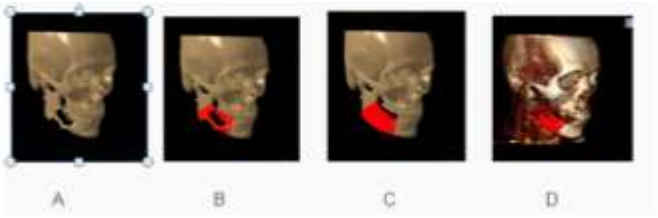


**Figure 2.** A reconstruction of the image (A), an original image, whereas (B-D) a model shows in a section of the mandible was broken. Shape so that the right and left alike, to make the damaged parts used techniques mirror (mirror reflection of the mandible intact).

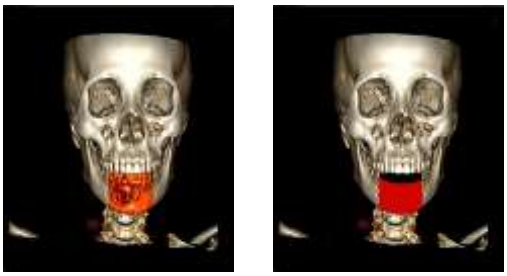

**Figure. 3.** Reconstruction of the model with positions in damage of the front teeth.

The layout of the damaged section on the lower jaw can be different as shown in Figures 2 and 3. For the reconstruction of the 3D printer uses material Acrylonitryle Butadyene Styrene (ABS), a polymer material with a melting point (melting point) of about 200oC. This material is not biocompatible and therefore can not use for implant material.

Machine Computer Numerical Control (CNC) is a machine that can be used to print a model of imagery derived from DICOM files. Data were taken from patient ameloblastoma tumors. Mandible damaged parts can be identified and then through a program created file Catya STL (stereolithography) and printed with 3D

printers and CNC machines. PEEK a solid material so loud that need a CNC machine to print them. For use as an implant should match the shape and size are very accurate and precise as it has been patterned based on the damage suffered by the patient. To embed techniques as implant material requires a different technique that remains to be studied. .One Models reconstructed using CNC machines can be seen in figure 4.

**Figure 4.** Reconstruction of the mandibular model of PEEK material using a machine Computer Numerirical Control (CNC).

**Figure 5.** Reconstruction of the mandible cross section by 3-D printing use material Acrylonitrile Butadyene Styrene (ABS) a type of plastic polymer.

## III. MODELING RESULT AND DISCUSSION

The results of the modeling has been reconstructed using 3-D printer and CNC machines. The results of this modeling has been developed to determine the position of the damaged in patients with tumors, whereas the model mandibular teeth intact and can be seen in Figure 5. To fix the damaged position can be seen in Figure 6. Model mandible printed with CNC, is not equipped with a gear, can be seen in Figure 7. this model uses the PEEK material that will be developed as an implant material that will be made in accordance with the results of the scan CT-scan. Analysis of the use of material PEEK implant should use by surgeons, including stiffness properties owned PEEK, in order not to cause pain experienced by patients receiving implants. Another important factor that must be considered is the nature of its biocompatibility, mechanical strength, degradation that may arise, as well as the fatigue properties of PEEK material. With such analysis PEEK material will be featured as ingredients that are safe for users, especially in patients with ameloblastoma tumor.

**Figure 6.**Mandibular model with 3-D printer are made of ABS.

**Figure. 7.** Reconstruction of PEEK mandibular cross section can be used as implants to replace parts damaged by the tumor.

## IV. CONCLUSION

With the success of modeling for the manufacture of implants from PEEK material, can be summarized as follows.

1) PEEK as implant materials have different properties compared with titanium and stainless steel. No changes in the nature of the use and resistant to temperature changes, and does not cause contamination, has a low modulus of elasticity than metal.
2) PEEK highly profitable as a biomaterial used in medical implants. PEEK material has properties similar to the properties of bone. To be used as implant materials is possible because the material is not changed in the blood fluid.
3) The model is printed with a 3D-printer can be used by the oral surgeon and reconstruction only as a reference material in maxillofacial reconstructive surgery.
4) Model of PEEK material for implant materials can be reconstructed primarily to the CNC machine.

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