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FABRICATION AND ANALYSIS OF MANDIBLE FRACTURE PLATE BY USING CASTING METHOD

B.kalyan[1] , Dr.Y.Rameswara Reddy[2]
1. M.Tech scholar, Mechanical Engineering Department, JNTUA College of Engineering, Pulivendula, A.P, INDIA
2. Assistant professor, Mechanical Engineering Department, JNTUA College of Engineering, Pulivendula, A.P,INDIA

***Abstract:* - The skeletal injury could be a severe bone fracture because of accidents and fragility of the bones at a definite age. To heal the fracture, some locking plates are used to hold the bones in a line in the original position. The fracture is healed by using temporary, permanent, and biodegradable fracture plates. Fabrication of mandible locking plates by using 3D printing and casting process. The drawing and analysis of locking plates are performed by CATIA and UTM (universal testing machine) machine on the manufactured material and also software analysis is carried out in Ansys software. Zamak is suitable for making casting. Based on study it is suitable for medical implants it is safe for using as interior fixation in research is going on this the 3D-CAD data was sent to an fused deposition machine (3D printing) to generate a master pattern using PLA(Polylactic acid). A melt ZAMAK alloy was poured directly into the moulds, and left it until completely hardened. The produced part is then making the surface finish. 3point bending test was performed on the prototype plate using universal testing machine. The main objective is to decrease production time and change the material and making a method.**

Keywords: Mandible plates, Casting, 3D-printing.

1. INTRODUCTION

Most of the facial fractures are occurred by fighting, sports, natural disasters and road accidents and sometimes bones are breaking due to weaken or losing calcium in the bones.

In facial injuries or facial fractures are commonly having nosed fractures (nasal), skull fracture, cheekbones fractures (zygoma), upper jaws and lower jaws (mandible).The facial injuries are leads sometimes to deaf, blindness. Implant failure has been reported to be greater in the poor bone. In the body most of the bones are split into an external cortical and an inside spongiosa. Newly zinc and their alloys are planned as the new addition to the list of degradable metals and as a replacement to magnesium and iron.

Nowadays the essential for biomaterials in the bone osteosynthesis application are very high. Zinc alloy is also a biocompatible material for bone osteosynthesis. It is having good mechanical properties, biocompatibility and degradation. Magnesium has drawn great interest in biodegradable metallic substance and its bio applications characteristics have been studied since the beginning of the 20th century [1].

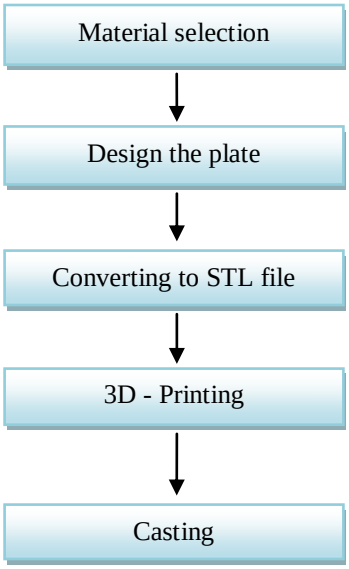
By using mandible bone we can also identify the sex by using mandibulometer. To identify the sex there should be collect around 22 characteristics of the mandible [2]. Now a day's zinc alloy has become a propitious as the biodegradable material for internal fixation system. Zinc is one of the main elements in our body. Pure zinc is having less mechanical properties when adding other elements it improved its mechanical properties. The intake of magnesium is about 300-400 mg/day and intake of zinc is about8-15mg/day. Copper is a stronger alloying element as it is one of the important trace elements for a person. [3]

In recent years, zinc alloy has become a promising metal for a novel biodegradable material for internal fixation systems since Zinc is an essential trace element in the human body. Pure zinc is Soft and brittle and possesses poor mechanical properties however Zinc alloys have improved mechanical properties by adding other metals. The finding of the in vitro cytotoxity study indicate that Zn-3Cu-xMg alloy are biocompatible, meaning good cell level alloy are biocompatible , meaning good cell level alloy biosafety. Through increasing the amount of Mg. cell viability is increased [4].

In the case of Zn-1Mg (wt. %) binary alloy, a maximum strength of 150MPa was achieved. Zn-Mg alloy corrosion rates were found to be significantly lower than pure Mg [6].

The lowest degradation level (0.08±0.01mm/year) was observed in Zn based alloys containing 0.5wt percent Mg. This can be due to the addition of magnesium in the insoluble corrosion material. This can serve as a shield film to avoid further penetration of the reactive solution into the alloy layer [7].

2. METHODOLOGY



2.1. MATERIAL

PLA means Poly-lactic Acid is used to create a 3D-printed model of the product. The printed model is used to create mould.PLA material is having a melting point around 1500c-1800c. PLA material is a thermoplastic and it is not an acid.

Zamak metal is used to create a masterpiece. Zamak is a zinc alloy. Zamak is combination of zinc, copper, aluminium, and magnesium. Zamak alloy is a part of zinc aluminium alloy family.

2.2. EQUIPMENT

To make the specimen by using PLA material with the help of 3D- Printer. I used JULIA+ desktop 3D-Printer. 3D-Printer is a rapid prototyping technology. This is one of the additive manufacturing processes. 3D-Printing is a fused deposition modeling process. In this, the PLA material is deposited layer by layer in order as in the design. By using 3D- printer we make the pattern for making a mould.

3D printing also defined as additive manufacturing refers to techniques used to produce a three dimensional structure in which under computer control successive layers of material creates a component. Structure can be of almost any shape or structure and are generated from electronic design data of the 3D model.

Fig.1:3D- Printer

2.3. EXPERIMENT

2.3.1. DESIGN

The plate is designed in the CATIA V5R20 software. CATIA – computer aided three dimensional interactive applications. CATIA is multi-platform commercial software. The software is written in c++ programming language. This is used in aeronautical, automobile, shipbuilding and other industries. The design dimensions are assumed by studying through papers and the collection of data through the internet.

The design part file is converted into STL file because of the fracktory software studies only STL files. The saved STL file is opened in fracktory software. Then the software saves the file in a memory as gcode files. The files are saved in memory card as gcode files because the 3D-Printer software is only read gcode files.

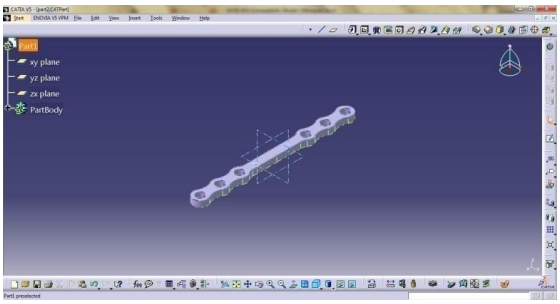


Fig. 2: CATIA design

The memory card is inserted in the 3D-Printer machine. The setting is done as print from memory card. From the card it reads and starts printing.

The printed plate piece is used to create a mould to create a masterpiece with metal by using casting.

Fig.3:3D- Printing

2.3.2. CASTING

Casting is a method of manufacturing in which molten material is traditionally poured into a mould consists of a hollow cavity of the desired shape and then solidified. Materials for casting are generally used metals or components that recover after combining of two or more components.

The printed piece is taken and makes the mould with sand to make a masterpiece. Zamak metal is melted in the furnace and poured in the mould to make masterpiece Casting is made in natural process with sand. The melted metal is poured in the mould then it keeps for some time until it cools then removes the sand around the mould and takes the plate piece out.

Remove the unwanted material and do surface finishing. There are having some limitations in the product

Fig.4: Casting

3. FLEXURAL TEST

The test is also called a three-point bent test. It defined as the ability of the material to resist deformation when bending the flexural strength is a maximum amount of bending it can withstand. This method measures the behaviour of the materials subjected to a simple beam loading. In this method, it measures the flexural strength, flexural modulus, stress-strain behaviour of Mandibular fracture plates are measured by using INSTRON-3369 UNIVERSAL TESTING MACHINE with maintaining a crosshead speed of 1 mm/min. The specimen dimensions are in mm. The four samples are tested and the results are plotted.

UTM machine is used to find the tensile and compression stress. It is also called as versatile.

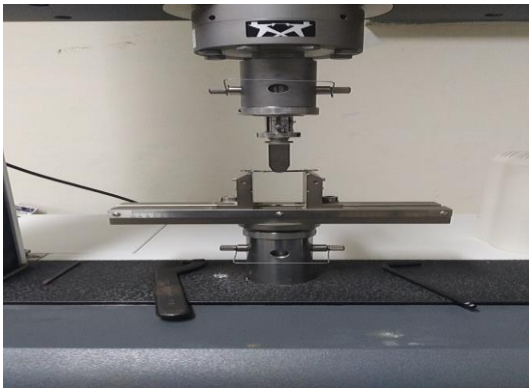


Fig.5: Testing specimen in UTM machine

4. RESULT AND DISCUSSION

In total four specimens of Mandibular fracture plates are prepared with Zamak alloy with casting method. The length of the each specimen is 50mm up to center of the circles at both ends. The bending test is a mechanical test. The test is done in INSTRON-3369 UNIVERSAL TESTING MACHINE for all specimens. The output of the manual testing in UTM machine is Maximum load applied on the specimen is around 110N. The max stress withstand by the specimen is around 187.56MPa.

Specimen	Max load (kN)	Max stress (MPa)	Flex modulus(MPa)
Zn	0.11	187.56	24968.87

The result of ANSYS analysis is indicated in the maximum result is described by red region while the blue region describes the minimum result.

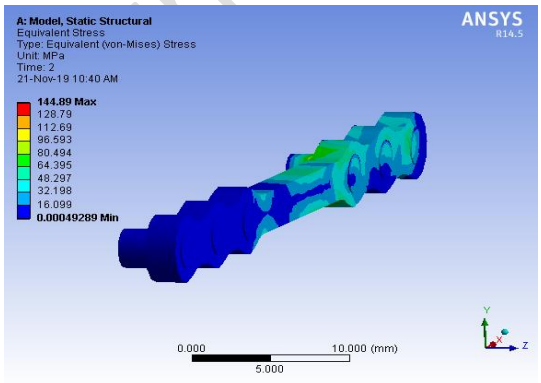


Fig.6: Stress analysis in ANSYS

This analysis is carried based on real time approach to test the specimen. When a load of 110N applied on the specimen as variable distribution load the maximum stress is 144.89MPa. When compared with material strength it will be less. So the specimen can withstand to certain extent limit of load also.

5. CONCLUSION

In this, the specimen plate is designed with 6 holes and the design is anatomically compactable which is designed in CATIA software. The fracture plate is made in 3D printing technology based on fused deposition modeling which is one type of additive manufacturing method.

From this, manufacturing of a mandibular fracture plate in osteosynthesis can be made by using an indirect additive manufacturing method. For manufacturing it takes less cost than producing by EBM machine for small parts.

So that the cost of fabrication is reduced when compared to rapid manufacturing method and also the cost of material is also less when compared with other metals which are using for bone fixation.

Zinc and its alloys are used in medical purpose but not for internal fixation (or) osteosynthesis. Nowadays research is doing for finding biodegradable materials in metals. Zinc and Magnesium are close to biodegradable properties because they are present in bodies. So that the zinc alloys can be used for osteosynthesis but in limit composition required for the body.

Zinc can be combining with titanium or stainless steel in manufacturing process.

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