

Fabrication of artificial knee bone joint by additive manufacturing process

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Abstract: The significant development of additive manufacturing in the field of medical applications. An integrated approach of scanning technology was adapted with software package and rapid prototyping ensure the human bone fabrication process. This paper present enhancement of human knee joint bone model by 3D printing technology for implementation of human bone implantation. This fabrication model provides all human knee joint bone parts such as femur, Tibia, Fibula and Patella were constructed exactly as same size with good surface finish. This knee joint bone is made of Acrylonitile butadiene styrene (ABS) and fabricated by fusion deposition modelling (FDM) technique. Hardness of fabricated scaffold knee joint bone was measured by shore durometer (ASTM D-2240 standard) and compared with human bone. We attempt to implement artificial knee bone craft to human implantation.

Keywords: Additive manufacturing, 3D printing, knee joint bone, Fabrication, Hardness test.

I-Introduction: 3D printing is one of the additive manufacturing techniques which is used to fabricating a complex shaped structures from three dimensional model data.3D printing specifically useful in the bio medical field whew by unique patent customized products are required. Additive manufacturing multi functional and multi material systems including living biological system as well as life like synthetic systems [1] Fabrication of patella using fused deposition modelling technique by ABS material. CT scan images are used to make digital file along with MINICS software and artificial bone is printed by “U print SE plus” 3D printer with layer revaluation thickness Of 0.254 mm with good surface finish. [2] Assessment of stress distribution in the femur joint during standing on both legs using MIMICS software and analyze the bigger value of stress developed in femur and tibia [3] Constituted personalized artificial bone scaffold by polyvinyl pyrrolidone using piezo-electric 3D printer through micro CT scan of humans for craft fabrication [4] d 3D printing for medical application to development of custom bone prosthesis and scaffold using additive manufacturing concept. It is also introduced quality by design (QBD) and ensures manufacturing correctly without error. Bone scaffold achieved critical quality attributes of human bone fabrication by 3D printing method s using lactic acid based polymers such as PLA and PCL are focussed to excellent mechanical and biodegradable properties.[6] Analyzed hardness of human bone in patella portion. Rockwell hardness testing procedure is adopted for measuring method and found that 7 normal patella in 20 with chondromalacia and 33

in ostenarthrosis. Finally 3D print human bone is possible by Fusion deposition modelling by Acrylonitile butadiene styrene (ABS) material and recommended to human bone implantation.

II- Experimental Details

2.1 Acrylonitile butadiene styrene (ABS)

Acrylonitile butadiene styrene (ABS) is a triblock co polymer of petro chemical origin provide good strength and toughness. ABS having 215J/m of toughness, 3.2 GPA of young's modulus, 2.4 GPa of stiffness, 43 MPa of tensile strength and 6% of elongation. It is a bio compatible material which is used to make artificial knee bone by fused deposition modelling technique (Fig 1).



Fig1 ABS material



Fig 2 Shore Durometer

2.2 3D Printer

In this work WOL 3d printer is used to make artificial bone joint, wire of ABS is fed from roller and melted by hot injector of 3D printer and scaffold is crafted layer by layer as per digital file modelling.

2.3 Shore Durometer : It is a portable hardness measuring device to find hardness of rubber and plastic material. It provided steel indenter which is used to measure hardness as per ASTM D-2240 standard (Fig 2).

III-Result and discussion

In this work involves CT Scan image, digital file and rapid prototyping, the repaired knee joint model is taken form computer tomography and then converted into digital file along with software. during printing process 0.254 mm layer thickness resolution is used to make 3D printed artificial human bone. ABS is used as raw material and all the knee bone parts such as femur, tibia, fibula and patella are printed layer by layer finally the required shape of scaffold is formed (fig 4). After fabrication of artificial knee joint bone, hardness values are measured and compared with human bone.(fig 4)



Fig 3 3D printed knee joint bone



Fig 4 Hardness measurement of SD printed bone

The hardness of artificial knee joint bone was measured by Shore durometer (ASTM D 2240) which provide 30⁰ X R0.1 Steel indenter. The pressing mass 4.5 kg is applied to indenter to 15 seconds and corresponding hardness values are measured and tabulated in table 1.

Table 1 Hardness values of 3D printed knee joint bone using ABS material

Sl.NO	Part of Knee joint	Trails					Hardness number (D scale)
		T1	T2	T3	T4	T5	
1	Femur	29	35	35	34	36	33
2	Tibia	32	30	26	31	30	30
3	Fibula	27	28	29	30	30	29
4	Patella	33	34	33	34	35	34

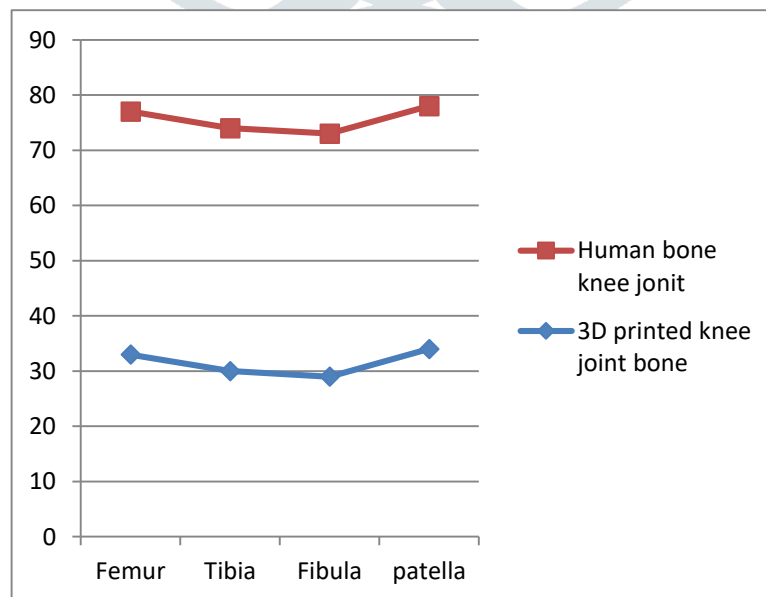


Fig 5 Hardness relation between Human bone Knee joint and 3D printed Knee joint bone

Figure 5 shows that, hardness value of 3D printed knee joint bone is more than ordinary human bone joint. Generally human Knee joint bone such as Tibia, femur, fibula and patella having hardness value are 44 (D scale). But hardness of 3D printed knees joint bone parts is nearly 34 and less than conventional bone, because of Production method, finishing process and raw material strength. Hence 3D printed ABS Knee bone has excellent mechanical and good bio de gradable property and suitable for human implantation.

VI-Conclusion

In this work, knee joint bone has been fabricated successfully from 3 D printer in fused deposition modelling (FDM) technique. The fabrication model provided all human knee joint bone parts such as femur, tibia, fibula and patella as per digital file. 3D printed scaffold bone hardness is measured by shore durometer (ASTM D-2240) standard and compared with human bone. 3D printed Acrylonitrile butadiene styrene (ABS) Knee bone has excellent mechanical and good biodegradable property and suitable for human implantation. We have attempted to implement artificial human knee joint bone fabrication technique using additive manufacturing process.

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