Development and Testing of a Novel 3D Printed Hip Replacement as an Alternative to Traditional Medical Implants

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Orthopaedic implants are widely available in a large range of different materials, however what if a hip implant could be printed in a lighter material for the patient with the same mechanical properties? What if these implants could be manufactured with a method that allows for them to be created as and when they're needed for a lower cost?

Design:

To create a hip implant design that could be 3D printed required knowledge of both hip implants and 3D printing. The design needed each aspect of the implant to be defined and fit for purpose, also this design also needed to be able to translate smoothly to a 3D printed environment.

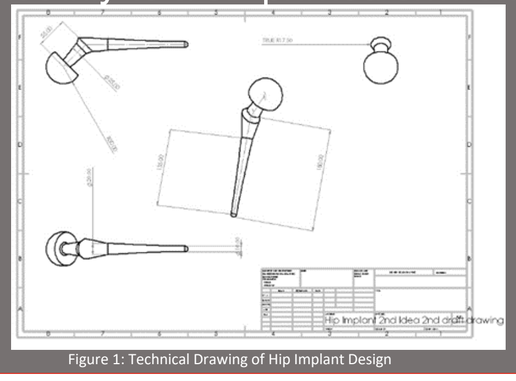

Figure 1: Technical Drawing of Hip Implant Design

Figure 2: Typical Design of Hip Implant

Existing implant models were used to determine the dimensions of the designs. They informed the decision of the overall length, the offset of the femoral neck, the size of the femoral head and many other dimensions.

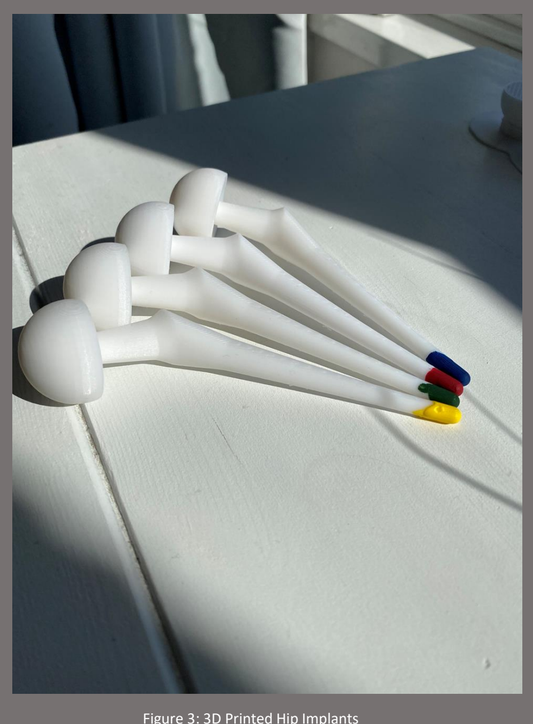

Figure 3: 3D Printed Hip Implants

The design of the implant had a conical shape to give a more rounded and smoother surface. This was also done to reflect the shape of current implants. The design translated well to a 3D printed model and gave high detail and a quality finish.

Price:

To judge the feasibility of the hip implants as a potential replacement to traditional, widely available implants a price comparison table was made. This table compares the material cost of different infill types against retail prices for current widely available implants

3D printed Implants	Widely Available implants
Rectangular Infill Implant - £175.73	Cemented polyethylene cup with metal cup - £1557
Triangular Infill Implant - £175.03	Cement less metal cup with polyethylene liner plus a metal head (cementless stem) - £3016
Hexagonal Infill Implant - £171.26	Cementless metal Cup with a ceramic liner plus a ceramic head (cementless Stem) - £3869
Solid Infill Implant - £181.15	Hybrid cementless metal cup with a polyethylene liner plus a metal head (cemented stem) - £2650

Figure 4: Cost Comparison of 3D Printed Part against Widely Available Implants

FEA:

An FEA Study was carried out on the hip implant to determine how the implant would perform under test circumstances relatable to the real world.

The test simulated a load of 2.3kN on the femoral head of the implant while the stem was static.

The material properties were calculated using AutoDesk Helius to simulate the 30% Onyx and Carbon fibre Filament mix.

There were three different results measured. Von Mises Stress, displacement and Strain.

FEA Study	Onyx Carbon mix Results:	Titanium Results:
Displacement	0.71mm	0.112mm
Von Mises Stress	57.65 MPa	56.15 MPa
Z Axis Strain	Max – 5.645x10^-4 Min – -6.891x10^4	Max – 1.424 x10^-4 Min – -1.17x10^-4

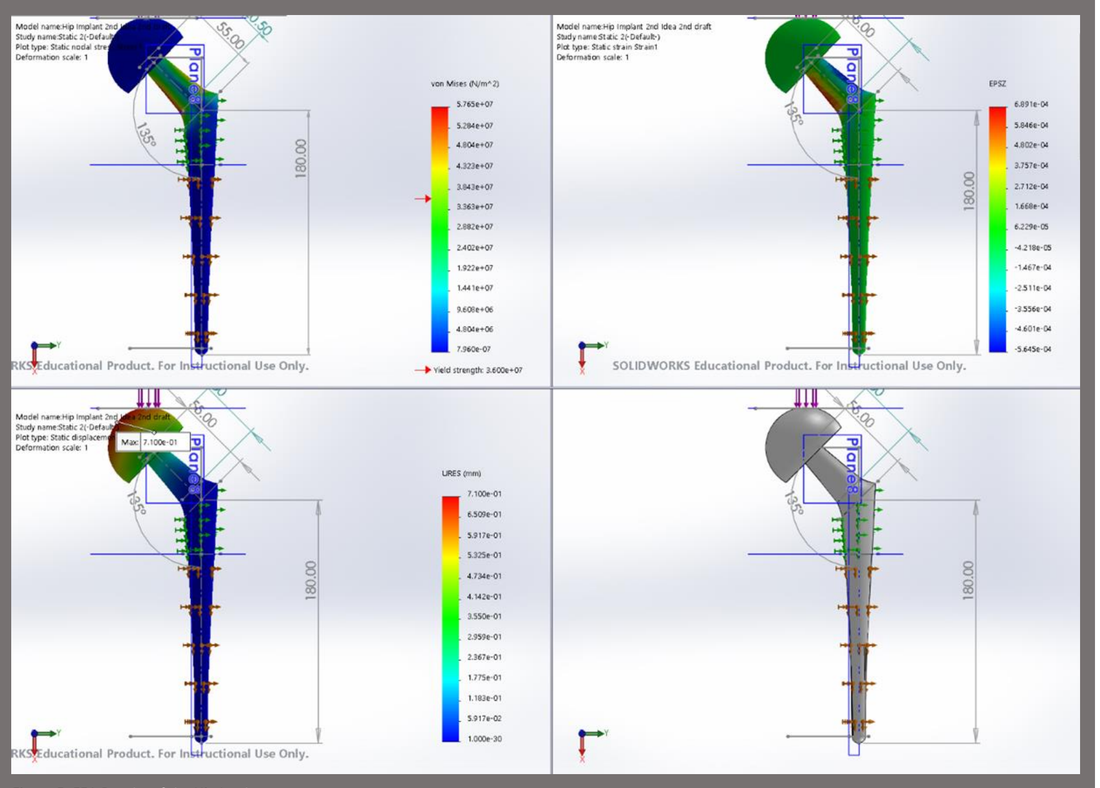

Figure 5: FEA Results of the Hip Implants

Figure 6: Comparison of FEA results of the 3D Printed Material and the Widely Used Materials

In conclusion a 3D printed Carbon Fibre reinforced hip implants can be described as feasible for real world application through the evidence gained throughout this study. When comparing the price of the 3D printed component to that of widely available implants they are more than 17 times less expensive. The FEA study shows that both materials have a very small displacement and very similar stresses. However, to fully identify the components potential, real world tests need to be carried out to determine yield strengths of the material.