RESEARCH ARTICLE OPEN ACCESS

"Computer Aided 3-D Modeling and Design of Human Elbow Joint"

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ABSTRACT
Man-made elbow or simulated elbow or built elbow is in the long run utilized when organic elbow can't work further. Such conditions are crack, contamination, joint pain, separation and tendonitis. In one of these conditions man-made elbow is supplanted with natural elbow by surgery.This paper introduces a much stronger design with CAD models and its analysis. CAD model is made in CATIA V5 and analysis has been performed in ANSYS simulation software. It also compares the maximum principle stress, equivalent Von-Mises stress and total deformation of different materials such as stainless steel, titanium and its alloys. This design of man-made elbow is a stronger design compare to current man-made elbow used in elbow replacement.
Key Words: Simulated elbow, Built elbow, Design, Organic elbow, Humerus, Ulna

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I. INTRODUCTION

The progression of prosthetics is a long and storied history, from its crude beginnings to its mind-boggling present, to the empowering dreams without limits. As in the headway of whatever other field, a couple of contemplations and manifestations have worked and been produced, for instance, man-influenced elbow or fake to elbow, while others have fallen by the wayside or get the chance to be unmistakably outdated. There have been various refinements to the fundamental peg legs and hand catches that have incited to the significantly individualized fitting and tossing of the present contraptions.[2]The man-made elbow is the arrangement in a circumstance when the organic elbow isn't working normally. Since the rise of the mankind we have discovered the one or different approaches to take care of the issue. The quick advancement had occurred in the zone of orthopedics after industrialization began in the Europe. It has lead us to the actualizes of gadgets or devices of metals and hardware in the human body to supplant organic parts. The elbow is one of those part. The organic elbow is supplanted by the man-made elbow when there is a crack, disease, joint pain, separation and tendonitis. Fake elbow is usually a pivot joint which joins two bones, humerus(upper) and ulna(lower). Diverse joints are having distinctive quality. The quality likewise relies upon the material of the manufactured elbow joint. From the earliest starting point of stainless steel is being utilized as a material of the elbow yet now daily's titanium and its combinations are expressed being utilized.[5]

II. DESIGN

The plan of manufactured elbow comprises of humerus part, ulna section. Measurements of this joint relies upon the patients since all individuals have distinctive size of hands. The manufactured elbows are composed independently relying upon the span of the patients.[5]

III. MATERIALS USED AND ITS PROPERTIES

Since the beginning stainless steel has been used as a replacement of joints but during last 10 years, titanium and its alloys have replaced the stainless steel due to their advantages.Titanium grade 1and2are pure titanium.[2]

Material	Density (g/cm^3)	Yield Strength (MPa)	Ultimate Strength (MPa)	Young Modulus (GPa)	Poisson's Ratio
Stainless Steel 316L type	8.0	485	170	193	0.265
Titanium G1	4.51	220	345	103	0.34
Titanium G2	4.51	350	485	103	0.34

IV. ANALYSIS

Two kinds of materials will be connected in the examination, stainless steel, titanium and titanium composite. For a specific measure of load, impact of load on the elbow will investigate. There are two sort of stacking condition we will apply on the elbow. Amid both the stacking condition humerus and ulna is having 180^o to each other.
Loading condition 1:

In this case humerus, ulna and the load are in vertical position. Here humerus is fixed and load is applied at the end of the ulna(figure 1).

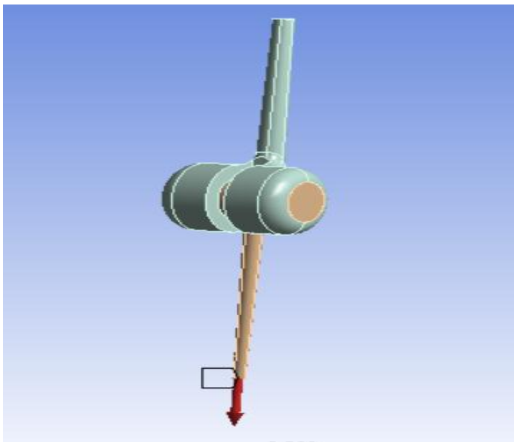

Figure 1 loading condition 1

Loading condition 2:

In this case humerus and ulna are in horizontal position and the load is applied at the end of the ulna which is vertical. In the simple understanding we can say this the case of cantilever beam loading condition. Here humerus is fixed(figure 2).

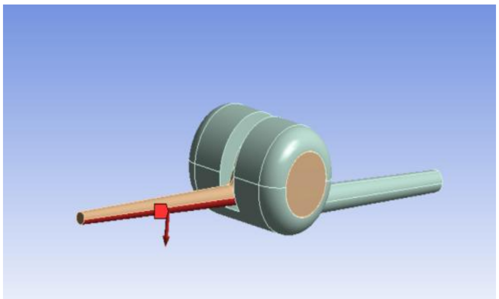

Figure 2 loading condition 2

10lb and 15lbnumber of loadsare applied in both the loading condition.

For the analysis of this joint, Ansys is used as a simulation tool. For a certain number of load the behavior of the joint or elbow with different material is analyzed. For a certain number of load maximum principle stress, equivalent Von-mises stress and factor of safety is found.[6]

10lb and 15lb loadsare applied to all the materials and these four parameters are found. The change in both the stress for all materials is not significant but the behavior of factor of safety is very surprising. [2]

Factor of Safety can be explained as the load carrying capacity of a system beyond the expected load or actual load. Generally, systems are designed by taking factor of safety 3. In the analysis, stainless steel 316L gives 2.0567 for 10lb load on loading condition 1. For the same load, we are getting much more factor of safety for other materials such as titanium and its alloys. Best result is getting from grade 1&2.

V. CIRCULAR CROSS SECTION

Load (lb)	Material	Maximum Principle Stress (Psi) (MPa)	Equivalent Von Mises Stress (Psi) (MPa)	Factor of Safety (FOS)	Total Deformation (mm)
10	Steel 316L	680.15,4.6895	674.68,4.6518	2.0567	0.004
	Titanium G1	680.22,4.6899	674.53,4.6508	2.158	0.0078
	Titanium G2	680.22,4.6899	674.53,4.6508	2.158	0.0078
15	Steel 316L	1012,7.0342	1020.2,6.9777	1.693	0.00645
	Titanium G1	1020.3,7.9761	1011.8,6.9761	1.0687	0.01767
	Titanium G2	1020.3,7.9761	1011.8,6.9761	1.0687	0.01767

VI. CIRCULAR CROSS SECTION

Load (lb)	Material	Maximum Principle Stress (Psi) (MPa)	Equivalent Von Mises Stress (Psi) (MPa)	Factor of Safety (FOS)	Total Deformation (mm)
10	Steel 316L	23513,162.12	16175,111.52	1.5244	0.76672
	Titanium G1	26367,181.79	15109,104.17	2.1119	1.4185
	Titanium G2	26367,181.79	15109,104.17	2.1119	1.4185
15	Steel 316L	35270,243.18	24263,167.28	1.0162	1.1501
	Titanium G1	39551,272.69	22663,156.26	1.4079	2.1278
	Titanium G2	39551,272.69	22663,156.26	1.4079	2.1278

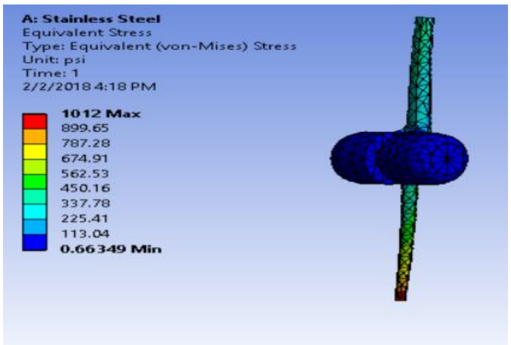

Figure 3 Equivalent (von-Mises) Stress for Stainless Steel 316L for load type 1

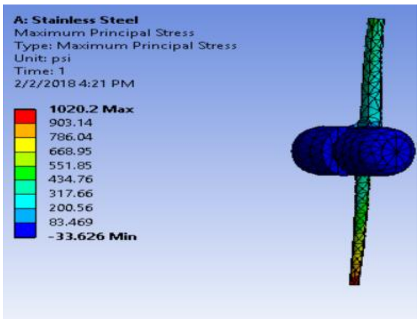

Figure 4 Maximum Principle Stress for Stainless Steel 316L for load type 1

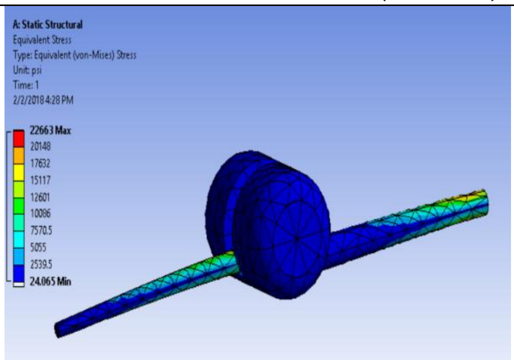

Figure 5 Equivalent (von-Mises) Stress for Stainless Steel 316L for load type 2

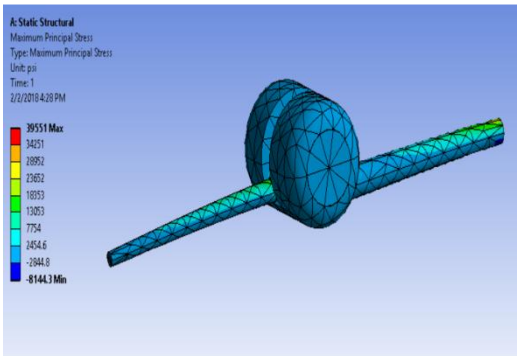

Figure 6 Maximum Principle Stress for Stainless Steel 316L for load type 2

VII. CONCLUSION

From this examination, it is presumed that titanium is the best metal for the elbow substitution. Within the sight of titanium and its composites, stainless steel isn't worth to utilize. Either pure titanium or titanium alloys can be utilized for the substitution. Considering the investigation of planned elbow, titanium review G1 and G2 are the best regarding quality.

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