Developing a modified joint for a prosthetic arm based on joints found on full leg prosthetics

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All tables, graphics, charts, graphs, data displays, and other media were designed and produced by the student researcher, unless otherwise stated.

Introduction

Current prosthetic arms can cost from 2000 to 5000 dollars just for an immovable cosmetic arm that has no replication of any motion present in regular arms joints . There are thousands of people including many veterans who have either lost or were born without an arm that can't afford one, even the cheapest option. The main focus is developing a joint, specifically an elbow joint, that can effectively replicate the movements of a regular elbow weather that be extension (straightening the arm) or flexion (bending of the arm). Also developing it in a 3d software then printing it to help with affordability. Science has proven that if you have a prosthetic limb that can mimic the movements of the regular limb then the brain recognizes the prosthetic as an extension of the body and the phantom pain troubles many amputees experience can be reduced

Research

Prior experimental and computational studies have shown that thrombin generation metrics are effective for quantitatively assessing clotting performance, yet many existing models are too complex to isolate the impact of individual factors. Previous models, specifically the Wajima (intrinsic+extrinsic clotting pathways) and Hockin-Mann models (ODE Kinetics), have been ethically limited and parametrically isolated in their testing. A unified simulation, specifically one that could model hemostatic interventions, is not only the most accurate next step but is also crucial in the treatment of bleeding disorders. In parallel, several classes of bioengineered hemostatic molecules—such as factor replacement therapies, FIX-mimetic agents, and thrombin amplification enhancers—have been developed to compensate for clotting deficiencies, motivating the need for simplified modeling frameworks that can evaluate their mechanisms in a disease-specific context.

Image 1: Reference of prosthetic hinge elbow

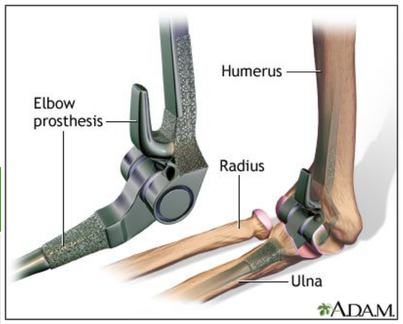


Image collected from medlineplus.gov

Objectives

The goals of this project is to fully replicate the degrees of flexion and extension of a regular elbow in a prosthetic elbow. However this is not the only reason that I am doing this project I also want to be able to prove that you can make a prosthetic joint like this for a fraction of the price compared to regular prosthetic joints on the market right now to do this I will need to use a 3D printing software.

Goals and expectations

Of course the goal of this project is to replicate both the degrees of flexion and extension in the elbow. but there is Going to be some expected trial and error I don't want to perfectly print this on the first try I want to print something to the best of my ability but then improve it. Also when I say I wanted to match the degrees of flexion and extension of an elbow I meant that but I want to broaden it to separate age groups for both genders so that I can find a specified age group and gender that this matches with as well

Procedure

- After a 3d model is designed, fit the pieces together and glue if needed
- After which two smaller wooden dowels can be cut to the length of the humorous and the radius bones
- Spray Paint both dowels black
- Glue the shorter dowel to the mannequin hand to make the "forearm"
- Glue it to the bottom of the joint and glue the longer dowel to the top of the joint to form the whole arm
- To test the prosthetic first gather the degrees of flexion and extension for 3 different age groups (Child, Adult, Senior)
- Then find those degrees for both genders
- Then measure the degrees of extension and flexion in the prosthetic and compare them to the age groups in both genders

Photos

Photo 1: Finished Prosthetic

Photo 2: Forearm of the Prosthetic

Photo 1: Finished Prosthetic

Photo 4: Each 3d printed part of the elbow

Photo 5: Fully assembled elbow joint

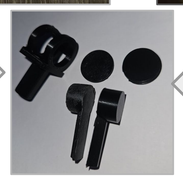
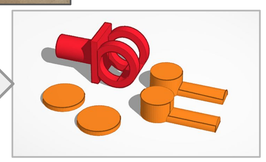
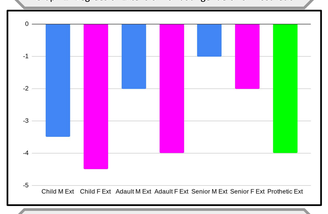


Image 2: 3d rendering of separate joint pieces

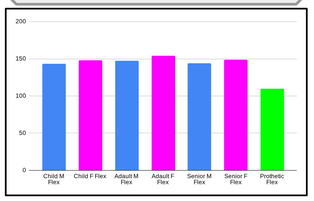


Data/Graphs

Graph 1: Degrees of Extension for both genders Vs. Prosthetic



Graph 2: Degrees of Flexion for both genders Vs. Prosthetic



Data Analysis

- The testing posed some concerns, the main one being the flexion of the joint.
- The flexion of the elbow prosthetic is nowhere near any of the average degrees of flexion that the regular elbows give so there will need to be some corrections made.
- The solution for the issue isn't that difficult, I just need to cut out part of the stopper on the top of the joint to allow for further Flexion.
- One of the good parts of this testing is the extension, which resembles that of a healthy adult female
- in my goals I didn't specify a gender that I wanted to match the prosthetic to but since this matches with an adult female
- One change could make would be to either sand down or go back into the 3d printing software and shorten the resistor on the top of the elbow joint
- This would allow me to match the degree of flexion in the joint to that of a adult female so the prosthetic fully matches but a partial match is still in my opinion a success

Results

The results were partially finished compared to the original intent which was to fully match both degrees of extension and flexion. So far I was only able to match the degree of extension in this model. However the results were not a fail because technically in the beginning I said that I wanted to prove you could make a affordable alternative to current prosthetics and these results prove that you can. I realize now that there were a few other tests that I could have done for this project but the original problem and expectations didn't really need it. however I do want to talk about these ideas in case I want to take this project somewhere in the future. what are the tests being a durability test because the original problem was replicating the degrees of extension and flexion but that is not the only part of a prosthetic arm one of the main reasons that Prosthetics nowadays are so expensive is because they are made out of expensive materials such as metal and carbon fiber. a durability test could prove that an alternative to metal and carbon fiber can be used to make a prosthetic arm or joint specifically for a lot less cost. of course a more durable expensive filament would need to be used it would still prove to be a lot more cost-effective than the prosthetic joints on the market. Another test that I think would work for this would kind of be piggybacking off of the durability test with the filaments, I think that I could make this same design specifically tailored to a gender and age group but use different filaments in the 3D printer to find which one is the well-rounded cost efficient and durable filament.

Conclusion

The whole project as a whole I see as a success because originally the intent of course was to prove that a cost-effective alternative can be made and I made one. there are adjustments of course that were mentioned and the results that I can make and I probably will in the future that would help match it to all three of the age groups for both genders instead of just an adult female, of course I would need to fully adjust it to match an adult female first before I move on to any other gender is her age groups. The filament that I use for this project was PLA or polylactic acid which is commonly found in library 3D printers and school 3D printers because it is cost-effective lightweight and doesn't have that much of an odor, it can also be printed and used with a lower amount of heat which would mean that it can be printed using a cheaper 3D printer. To achieve a true success to this project I think that I can use a more durable filament because in my opinion I don't really care about smell that much, and it would match a lot more to the highly durable materials that current hospitals use to make their prosthetic legs and arms.

Future plans

I definitely want to continue this project in the future because as I said in the conclusion I feel like this whole project was slightly incomplete. I really want to find a Prosthetics place that is able to use thicker and more durable filaments so that I could print a joint that matches those used in current medicine. A great location that I found for just Prosthetics in general is called Hanger Prosthetics and Orthotics I worked with them last year on a project of a similar Prosthetics theme and I hope that they would be able to work with me on this however I do not think they have a 3D printer that prints out the Prosthetics because of course they make prosthetics for hospitals so they will use carbon fiber and Metal but they could definitely give me some good insight and ideas for future testing if I decide to do this next year for a research class that I'm going to take. if I were going to continue this next year it would be in my research class for my research project and I would want to run these tests which I did specify earlier in the results section but I just want to ingrain it in whoever is reading this' head. first I would want to find a filament out of all of the wonderful 3D printing filaments that are on the market right now that is more durable than the rest but also is still more cost efficient then metal and carbon fiber which obviously will be but I just want to specify that. I do also want to test its durability by measuring all the different kinds of weight bearing that a regular elbow would have to undergo like the pushing motions and pulling motions of an arm because what's a prosthetic arm if you can't push or pull the things a regular on can.