CHAPTER 9

CONCLUSION AND FUTURE SCOPE

9.1 CONCLUSION

The goal of this research finding was to create low-cost prosthetic and orthotic components tailored to meet the needs of the patients. Based on findings, the analysis provides quantitative evidence that the most promising medical services goods that can be manufactured using 3D printing are those that have high profitability with a single set of equipment and limitless market accessibility of hardware. Especially in medical applications, these technologies are of great interest and open up many possibilities for healthcare applications.

This thesis discusses the detailed procedure for the design, analysis, and development of various K-level human foot models. Identification and application of innovative manufacturing techniques in healthcare engineering are explored throughout this research.

- Based on the mass comparison data it is observed that the unique foot design is lighter than prior prototypes while preserving structural integrity and permitting optimal functioning according to the patient's needs. The mass of the SACH foot structure is discovered to be 309 grams and the mass of the novel foot structure after optimization is found to be 190 grams. The development efforts by considering design optimization in novel prosthetic foot structures show that there is a weight reduction of approximately 61.5 % in comparison with the SACH foot structure.
- Based on the literature and analysis carried out in this research, it is revealed that the most recent advancement is a novel single-unit prosthetic foot that can absorb shocks during ambulation while also effectively transferring energy between heel strike and toe-off and enhancing stability.
- Based on the experimental evaluation and analysis, it is observed that an amputee can adapt their foot to uneven ground and effortlessly mount and descend ramps. By pasting the sole treaded on the bottom side of the prosthetic foot, an amputee can walk/ambulate without a foot shell and participate in water activities such as beach/swimming.

- Based on the design optimization process, it is established that the current innovation concerns a prosthetic foot that has a hollow rectangular lightweight top component that is a vital component of the new single-unit prosthetic foot development. Another advantage of having an adjustable prosthetic foot is the option to select a range of medial-lateral rotation and varus-valgus movement to adapt to uneven terrain, comparable to the natural subtalar joint.
- Based on the patient requirement and the survey data, flexibility is incorporated in the foot structure model related to die preparation. It can be reduced to a smaller foot size based on the patient's foot. Attempts may be made in the die for a thicker shaft and blade for ultra-heavy amputee patients, where nations such as the United States have heavy patients weighing 400 to 500 lbs (the same will be utilized with filler for routine amputee patients with a weight limit of up to 120kg).
- Based on the market survey and the analysis data, it is recognized that prosthetic foot made of various materials provides additional benefits, including carbon fiber composite for heavy load circumstances and other polymer materials like UHMW-PE/nylon/delrin that are lightweight and have low production costs.
- Parametric analysis is conducted on the foot structure model for material optimization. Based on the simulation, the result shows the natural frequency (1363 Hz) of model 2 is the maximum for UHMW-PE material. So for the preparation of the foot structure, this material may be selected for the best performance of the prosthetic foot model. Based on the simulation, it is established that the 1st natural frequency for all phase analyses of prosthetic foot models (midstance /heel strike / toe-off) is very large compared to the average human walking frequency of 2-3 Hz.
- Based on the patient motion analysis, it is observed that a graphical depiction of the gait analysis's multiple measured parameter values for ankle, knee, and hip angles reveals that the data are within the acceptable range of the standard reference data for the patient's lateral view position when wearing the unique prosthetic foot model.
- Based on the manufacturing process, it is established that the AFO and flex foot prosthetic elements are manufactured on FDM machines with PLA material. The process is finished in less than 7 hours, with AFO sections averaging 10-15

minutes of hands-on time and roughly 10 hours for flex-foot prosthetics. To put it another way, employing 3D printing to construct a P&O device for a patient takes far less time than traditional procedures.

- Based on the design criteria and shortcomings of previous walker designs, a walker design that can meet the user's requests is designed. To create a walker design and test its stability, finite element modeling is performed. Based on the simulation data the maximum stress caused by the aluminum walker is 13.781 MPa in the sitting position and 11.781 MPa in the standing position, the lowest value among the materials tested. As a result of the observation data, aluminum is the preferred material for the mainframe structure of the CP walker device.

9.2 FUTURE SCOPE

The future undoubtedly involves integrating high-end technology into prosthetic and orthotic elements. Currently, 3D printing is widely utilized in the creation of various devices, with ongoing advancements, particularly in neuroprosthetics.

Myoelectric/ bionic arms are very popular but not affordable to the majority of people due to their high prices. Several prototype developments are underway in this regard, including the creation of low-cost myoelectric arms. If myoelectric arms are available at an affordable price, it will be immensely helpful for many people. This is because mechanical upper limb prostheses often require a significant amount of manual power to operate and lack the smooth functionality provided by myoelectric alternatives.

Since bionic/myoelectric appliances are heavy, plans can be made to build lightweight orthotic and prosthetic devices. Water-resistant prosthetic and orthotic components can be designed so that patients can use them while bathing and swimming.

Furthermore, the usage of prosthetic and orthotic devices may be done by employing variable parameters specified in smart devices to obtain the desired indication. By installing software in the smartwatch and feeding it a certain walking speed, the smartwatch may beep an alarm if an inappropriate amount of pressure is applied.

The current work can be expanded in the following ways:

- Artificial intelligence in prosthetic and orthotic rehabilitation.
- The final designs obtained can be verified experimentally.

- By monitoring underfoot pressures during walking, Force Sensitive Resistors (FSRs) can be utilized to kinetically evaluate human gait.
- In the future, it is intended to compare the changing effects produced by using various types of materials for the enhancement of P&O devices using the AM technique.
- It is proposed to design a motorized sensor-based hand splint for stroke patients who are wheelchair-bound for activities of daily living.
- There are many technological shortfalls or limitations, such as for paraplegics due to spinal cord injury, where reciprocating gait orthosis is used but is not easily available, or for CP with diplegia children cases where crouch gait is very common and difficult to control with existing passive knee systems.
- Active orthotic knees are rarely accessible to meet the needs of patients and are also expensive. It is proposed to create cost-effective customized devices made with low-cost technologies, which are greatly needed.