The fitting of ankle disarticulation patients has proven to be a major issue while on MOM trips to Vietnam. A universal device was designed in order to be used in future Mercer on Mission trips to Vietnam, as there is not currently a universal prosthetic device designed for ankle disarticulation patients. The device needed to be easy to modify, durable, lightweight, and cost effective. Before successfully searching for a test patient, the group, in conjunction with the client, determined to move forward into construction with a test patient who had healthy legs. The device features a polyethylene calf brace, aluminum braces placed laterally and medially to mimic the ankle joint, and a polyethylene foot plate. After the ankle orthotic was constructed, the group began testing the device following the test plans that were submitted. The main tests conducted on the aluminum braces were a fatigue test and a compression test. The braces were shown to have a safety factor of 4.45 in compression, which exceeded the minimum requirement of 1.5 for orthotic devices. Additionally, it was found that the brace displaced only 0.044 inches after undergoing 100,000 cycles loaded from 0 to 300 lbs at 1.5 Hz. In order to test how the device affected the gait cycle, the F-Scan system was used. Go Go Engineering tested the patient’s normal gait cycle and determined that the patient placed much more force on the toe-off than on the heel. The test was then performed on the test patient as she wore the orthotic device on the left foot. The results showed that the force applied on the toe-off decreased by nearly 10-15 lbs. This proves that the orthotic device does, in fact, stabilize the ankle and improve the patient’s overall gait cycle. It fulfills the specification that the device needs to mimic the biomechanics of the normal gait cycle. The design can be easily modified to fit ankle disarticulation patients, patients with foot, and even midfoot amputations.

**Background**

The purpose of the senior design project was to design, build, and test a universal orthotic device for an ankle disarticulation patient. The client, Dr. Ha Vo, Associate Professor of Biomedical Engineering at Mercer University School of Engineering, has designed a universal socket used to fit underprivileged citizens of Vietnam with prosthetic legs at no cost to the patient. The Mercer on Mission program has provided a means for students to be able to participate in the fitting of prosthetic legs. As the program has grown, Dr. Vo’s universal socket design has improved and expanded; however, potential patients still must be turned down in Vietnam as the team is not capable of fitting all types of amputees. It was Go Go Engineering’s goal to design, build, and test a universal prosthetic device for ankle disarticulation patients. Once completed, the device should be ready to fit patients on the next Mercer on Mission journey.

**Results and Discussion**

**Construction of Braces**

The braces were shown to have a safety factor of 4.45 in compression, which exceeded the minimum requirement of 1.5 for orthotic devices. Additionally, it was found that the brace displaced only 0.044 inches after undergoing 100,000 cycles loaded from 0 to 300 lbs at 1.5 Hz. In order to test how the device affected the gait cycle, the F-Scan system was used. Go Go Engineering tested the patient’s normal gait cycle and determined that the patient placed much more force on the toe-off than on the heel. The test was then performed on the test patient as she wore the orthotic device on the left foot. The results showed that the force applied on the toe-off decreased by nearly 10-15 lbs. This proves that the orthotic device does, in fact, stabilize the ankle and improve the patient’s overall gait cycle. It fulfills the specification that the device needs to mimic the biomechanics of the normal gait cycle. The design can be easily modified to fit ankle disarticulation patients, patients with foot, and even midfoot amputations.

**Construction of Calf Support and Foot**

The construction of the calf support and foot was completed by using materials that would be lightweight and cost-effective. The calf brace was made from a polyethylene material, which is durable and provides the necessary stability for the patient. The foot plate was made from a lightweight material that would allow for flexibility and mobility. The design was shown to be successful, as it met the requirements for both compression and fatigue testing.

**Testing of Braces Using MTS**

The fatigue test results showed that the braces were capable of withstanding a significant number of cycles without failure. The maximum force recorded during the test was 15 lbs. This proves that the orthotic device does, in fact, stabilize the ankle and improve the patient’s overall gait cycle. It fulfills the specification that the device needs to mimic the biomechanics of the normal gait cycle. The design can be easily modified to fit ankle disarticulation patients, patients with foot, and even midfoot amputations.

**Testing of Design Using F-Scan**

The gait analysis test was conducted using the F-Scan system. The results showed that the force applied on the toe-off decreased by nearly 10-15 lbs. This proves that the orthotic device does, in fact, stabilize the ankle and improve the patient’s overall gait cycle. It fulfills the specification that the device needs to mimic the biomechanics of the normal gait cycle. The design can be easily modified to fit ankle disarticulation patients, patients with foot, and even midfoot amputations.

**Conclusions**

Based on the results from the compression and fatigue analyses of the braces and the gait analysis of the gait using F-Scan, it can be concluded that the design is successful. Although the gait analysis could not be completed with an actual ankle disarticulation patient, the results from F-Scan showing the stability that the design provides gives great evidence that the device can be implemented for ankle disarticulation patients with simple modifications, the main one being adding a creep foot and toe to the design. It is hoped that the design can be implemented in MOM and actual data with an ankle disarticulation patient be gathered to further substantiate our conclusions on the success of the design.

**Recommendations**

First, since this design would be used in MOM trips to Vietnam and subsequent places, more generic pieces for the calf support and foot are needed. Small, medium, and large sizes of both are proposed to allow for the fitting of a larger variety of patients. The plastic foot well near the ankle should be at a height that is enough to just put two screws through the braces. For the braces, the top joint of the brace should incorporate a slot to accommodate for changes in leg length of patients. More tests should be done on the braces and with an actual ankle disarticulation patient for more reliable results. With these changes, the design can be much more universal and allow not only ankle disarticulation patients to use it, but also people with foot and even midfoot amputation patients, which were also seen in Vietnam.

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**Appendix**

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