OPEN-SOURCE DEVICE FOR VARIABLE ULNAR EMINENCE

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INTRODUCTION

The availability and economy of current 3D printing technology is closing the gap between the availability of Personal Adaptive Devices (PAD) and those in need of PADs. Given a few conventional measurements, a 3D-printed glove can be made from simple, inexpensive filament thermoplastics within 24-hours. The advent of "Rapid Prototyping" are easy-to-fit, ready-to-use personal adaptive devices.

A 26 year old patient, (C. C.), has a congenital amputation of the left upper-extremity combined with variations in ulnar head prominence. Through the facilities at Florida Atlantic University (FAU), and assistance from Dr. Aaron Berger, we were able to build and refine a modified version of the Raptor II model that allows for greater ambidexterity.

Herein, we present the modifications of an open-source 3D model to demonstrate its versatility and potential clinical acceptability as a medical device option for those with upper-extremity congenital anomalies with variations in ulnar head prominence.

METHOD

Models were developed applying various CAD software packages in conjunction with "Open Source" models provided by the Enabling the Future group. This allows for the customization of each PAD. This is critical as each PAD is as unique as is each client served. Occupational evaluation resolved comfort issues by using readily available padding and cushioning including moleskin, wool packing and adhesive blue foam padding applied to Velcro straps.

Measurements for ulnar variance were taken in zero rotation, to adjust the scale in the CAD program for the Raptor II design. Our preliminary efforts demonstrated limited ambidexterity in patient, C.C., whose complex anatomy was hindered by the Raptor's initial design. Modeling determined the best fit was at 138% scale. Total print time was 12 hours. To address the patient's extension of the ulnar head prominence, recess modifications were also designed using CAD software.

RESULTS

Although preliminary use of the Raptor II design (Fig.1) gave patient C.C. limited ambidexterity, he was able to lift objects up to 30 pounds. Additional padding led to an increase in comfort and prevented skin breaks and frictional damage. However, after two months, C.C. felt significant discomfort due to muscle development as a result of extensive use. Further observation indicated the need to remove material from the Ulnar Prominence on the PAD itself (Fig. 2).

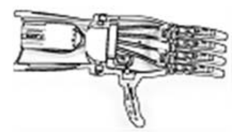
Fig. 1

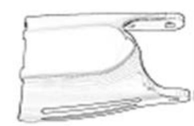
Fig. 2

Subsequently the patient showed greater dexterity and was more comfortable with the additional 2.1% scale and material recess which led to a greater ability to complete routine tasks including steering wheel control, bicycle riding, tying shoes, etc.

DISCUSSION

For providers, an ideal prosthesis is one that conforms to any patient; however this is challenged by patient growth or changes in medical condition(s). Our concept shows that this design can be easily modified and scaled to each patient and can be easily replaced or updated as needed by the patient.

Families typically face difficult financial challenges securing PADs for children due to cost and gaps in insurance coverage. Our approach which includes a collaborative community alleviates the financial stresses and difficulties while providing unfettered access.

This device also increases a patient's self-esteem and confidence. 3D printing has brought the discussion of disability out of the shadows. Young children perhaps embarrassed by their own appearance can now proudly display "the hand I designed."

CONCLUSION

We demonstrate a rapid prototyping process that enhances a versatile clinical application for custom hand prosthetics.

CLINICAL APPLICATIONS

This device has been shown to promote the use of unused, atrophied forearm extensor and flexor muscle groups. With additional padding and design modification(s), we can likely further decrease patient discomfort, risks for skin breaks and ulceration.

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American Academy of Orthotists & Prosthetists
42nd Academy Annual Meeting &
Scientific Symposium
March 9 – 12, 2016