

This article and any supplementary material should be cited as follows:

Dillon MP, Fatone S, Hansen AH. Effect of prosthetic design on center of pressure excursion in partial foot prosthesis. *J Rehabil Res Dev.* 2011;48(2):161–78.

DOI:10.1682/JRRD.2010.09.0167

### **Appendix: Design and fabrication of partial foot device**

After cast modification, a pelite liner was made for the residual foot as well as the leg segment. The completed cast and liner were positioned on a casting footboard (Southern Prosthetic Supplies, Georgia) over a tracing of the inside sole lining of the shoe. The cast was held firmly in position with the use of a stand so that the desired alignment could be maintained during manufacture of the prosthetic forefoot. Polymer-based clay was used to construct a wall around what would become the edge of the prosthetic forefoot. The distal end of the pelite liner was covered with a parting agent, aside from a small square that provided an area where the forefoot could adhere to the pelite liner. Having the liner and forefoot join in this way maintained the alignment of the prosthetic foot, the liner, and the cast during the remainder of the fabrication process. The prosthetic forefoot was constructed of a two-part, expanding, rigid, urethane foam (Pedilen<sup>®</sup> Rigid Foam, Otto Bock Health Care; Duderstadt, Germany). The urethane forefoot was then sanded to shape, bearing in mind that the device needed to fit inside the shoe after lamination.

With the liner and forefoot positioned on the cast, large-size Camber-axis ankle joints (Becker Orthopedic, Troy, Michigan) were screwed into the cast with the axis of the joints over the apex of the malleoli, ensuring the vertical height of the joints were similar as per the manufacturer's instructions. The joints were locked in a neutral position using the appropriate "kidney"-shaped insert. An acrylic laminated (80:20 Lamination Resin, Otto Bock Health Care) socket was made incorporating eight layers of Nyglass and bidirectional glass fibre (Southern Prosthetic Supplies) reinforcing over the ankle joints and edge of the leg shell. Once the resin had cured, the plaster cast was "chipped out" and the ankle joints were removed. The device was then cut circumferentially through the ankle to produce independent foot and leg pieces. The leg piece was bivalved to produce anterior and posterior leg shells with the ankle joints remaining as an integral part of the anterior shell.

Trimlines were established to provide clearance for the common peroneal nerve proximally and to allow full ankle joint range. Trimlines around the joint were finished according to the manufacturer's recommendations. Around the residuum, the trimlines were just distal to the ankle flexion crease and above the proximal surface of the calcaneus. A three-fold nylon webbing strap was riveted onto the medial side of the leg shells, creating a hinge that allowed the shell to open for donning. Two nylon webbing straps were then riveted onto the socket around the proximal and distal ends. Each of these straps had a metal loop on one end and a Velcro<sup>®</sup> closure on the other to secure the leg shell closed once the subject donned the device.

The prosthetic forefoot was designed to allow stiffness to be varied based on roll-over shape. The ankle-foot roll-over shape has been defined as the effective geometry the ankle-foot complex conforms to between initial contact and opposite initial contact [1]. The stiffness of the foot and, therefore, the geometry to which the ankle-foot complex conforms to during gait can be manipulated by altering the location, width, and number of cuts placed in the dorsal surface of the prosthetic forefoot.

The procedure for making the cuts in the prosthetic foot was similar to that used to determine cut locations in the forefoot of the Shape&Roll prosthetic foot [2]. The locations of the cuts were determined with use of a custom MATLAB program (MathWorks; Nattick, Massachusetts). This program used prosthetic foot length, bandsaw cut width, height of the prosthetic foot just beyond the end of the residuum, height of the distal end of the prosthetic foot, and the intended plantar thickness of the forefoot to determine the number of cuts needed and the location of these cuts to achieve a particular roll-over shape. The goal roll-over shape radius was set to 1.25 times the length of the entire foot. This value was

used because the able-bodied ankle-foot roll-over shape radius tends to be near 0.19 times the height of the person [3] and a person's foot length is usually about 0.152 times their height [4]. An iterative procedure was used to find the number of cuts and their spacing such that the plantar surface of the forefoot would conform to the goal radius (and therefore stiffness) upon closure of the cuts when the foot was loaded.

The prosthetic foot was mounted in a jig so that the saw cuts would be perpendicular to the sole of the forefoot and the long axis of the foot. The bandsaw blade produced 1 mm wide cuts. Each cut was made from the dorsum of the prosthetic forefoot and ended about 6 mm above the plantar surface of the foot, thus leaving the plantar surface intact. A second set of cuts were made midway between the first cuts. Shims of 1 mm thickness were made from Polyethylene and inserted into each of the secondary cuts and sanded flush with the dorsum of the foot. The design of the forefoot, therefore, allowed two different forefoot stiffness conditions to be randomized. When all the cuts were open the foot was more compliant ("compliant" forefoot condition). When the shims were inserted into every second cut, the foot had the optimal compliance and would conform to a radius typical of the nondisabled roll-over shape ("stiffer" forefoot condition).

Conditions that restricted ankle range of motion were randomized by varying the kidney-shaped inserts of the Camber-axis joint. The following conditions were assessed: locked ankle (silver insert), 0° dorsiflexion stop (dorsiflexion stop at neutral) with free plantar flexion (green insert), 10° dorsiflexion stop with free plantar flexion (black insert), and free ankle (no insert). Portions of the green and black inserts were ground away to achieve the required range of motion. The below- and above-ankle conditions were achieved by unscrewing the ankle joint axis screws and removing/replacing the anterior and posterior leg shells.

## REFERENCES

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