The Perfect Fit: Using 3D technologies to create custom-fitted prosthetic arm sockets.

By Emelie Strömshed, May 2016

Through a newly developed manufacturing process using 3D technologies, amputee patients can be provided with more customized prosthetic products while at the same time streamlining the process for the prosthetist, cutting both lead time and cost.

The new process, called The Perfect Fit, is a seven-step methodology developed as an easy-to-follow guide for prosthetists without requiring an extensive experience in CAD. It uses a combination of 3D scanning, 3D modelling and 3D printing to create custom-fitted prosthetic arm sockets and was developed in collaboration with the orthopedic company Aktiv Ortopedteknik in Lund, Sweden.

The seven main steps of the developed process.

The process has shown to cut the direct costs of manufacturing the sockets with nearly 60%, corresponding to a total of 260 000 SEK per year when looking at the current amount of sockets produced at the company. The new process also liberates 400 work hours, or 50 complete workdays, per year when compared to the conventional manufacturing process - time that can be used by the prosthetist to spend more time with patients, produce more sockets or to complete entire prostheses or other prosthetic products.

A prosthetic socket plays an important role for the success of the entire prosthesis; it encloses the residual limb and determines comfort, aids suspension and provides the wearer with both sensory and pressure feedback. Therefore, the socket has to be fabricated according to each patient's individual anatomy and preferences [1].

In the prosthetics industry, the most commonly practiced method of manufacturing the socket is both a rather time consuming and manual labour-intensive process that involves creating a cast directly from the patient's body. The cast is then used to make a plaster model of the residual limb. This is followed by a number of steps involving manual processing of the plaster model, creating a test socket, patient fittings, adjustments of the fit and lastly creating the final socket. Although the socket is being moulded directly from the patient's body, a good fit can still be difficult to obtain. The many manual steps open up for human error and going back in the process to make detailed adjustments is not always possible [2], [3].

Creating a cast of the residual limb in the conventional manufacturing process.

With today's 3D technology, such as scanners, printers and various software, precise re-creation, design and production of complex geometries have become reality [4].

The Perfect Fit-process uses a low-cost 3D scanner mounted on an iPad to collect necessary patient data in the form of a digitalization of the residual limb. This data is then modified in a 3D modelling software to adjust pressure points and to design the socket by offsetting the surface of the scan with a distance equal to the desired socket thickness. The original scan is then used to subtract material, creating a hollow socket with an inner surface shaped according to the patient's anatomy.

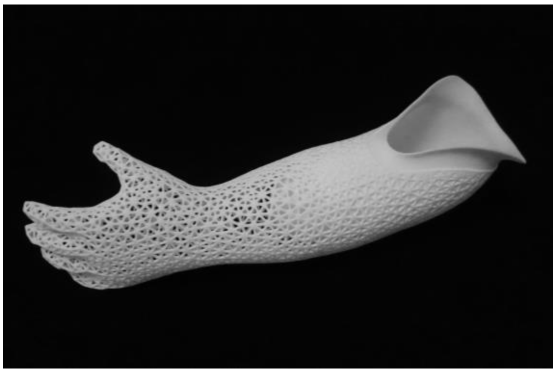
The process allows to create perfectly fitted sockets both for passive as well as myoelectric prostheses. In the latter case, a pre-made electrode module can easily be imported during the 3D modelling procedure to create attachments for the necessary electrodes that later will allow the wearer to control the movement of their prosthetic hand.

Patient wearing a 3D printed socket intended for a myoelectric prosthesis.

The final design is then sent for 3D printing and by using for example the common SLS printing technology, strong and durable nylon sockets with good surface finish are produced. After this the socket can be fitted on the patient and used in the further work of completing the entire prosthesis.

When tested with actual amputee patients, the developed process proved to produce ready-to-use, custom-fitted sockets. It also provides the prosthetist with full control over socket thickness while reducing the number of manual processing steps that could otherwise open up for human error. If modifications of the socket would be necessary, the patient data is saved and available in the form of a digital scan as opposed to the conventional method where a completely new cast mould of the residual limb would have to be made.

During the process testing it also proved to be possible to combine the process output with other anatomical data; a complete cosmetic arm was produced by integrating a passive socket, created by using the process, with an existing surface model of an arm. By using a 3D modelling software, the arm could be adapted and decorated according to the wearer's anatomy and preferences.



The 3D printed cosmetic arm integrated with a passive socket.

This further demonstrates some of the possibilities offered by 3D technology in the manufacturing of prosthetics and is perhaps a hint of what the future holds for prosthetic users in terms of increased personalization and options. Only the imagination sets the limits.

Patient wearing the 3D printed arm.

[1] Spires, M.C., Kelly, B.M., Davis, A.J. (2013). Prosthetic Restoration and Rehabilitation of the Upper and Lower Extremity. New York: Demos Medical Publishing.

[2] Stark, G. (2001). Prosthetic Primer:Upper-Extremity Limb Fitting. *In Motion*, 11(4). Retrieved September 18, 2015 from http://www.amputee-coalition.org/inmotion/jul_aug_01/primer.html

[3] Frank, S-O., prosthetist and orthopaedic manager at Aktiv Ortopedteknik, Veraeus, C., prosthetist at Aktiv Ortopedteknik, Lund, Sweden. Interview (2015, 14 September).

[4] 3Dprinting.com. (n.d.). What is 3D printing?. Retrieved September 20, 2015, from http://3dprinting.com/what-is-3d-printing/

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