Investigation of Additive Manufacturing Processes and Materials for Upper-Limb Socket Fabrication

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Background

Prosthetic sockets connect prosthetic devices to the patient's residual limb, which means proper socket fit is required for comfortable and safe wear [1].

Children, who grow at a rapid rate, need to replace their sockets every few years.

Current socket fabrication methods are:
× Labour intensive
× Time consuming
× Wasteful of material


[3]

Additive manufacturing (AM), or 3D-printing, is the technology that builds a 3D object by adding material one layer at a time.

AM socket fabrication methods can:
- ⬇ Time required to make sockets
  - ✓ Faster fitting for patients
- ⬇ Clinician labour required
  - ✓ More clinician time focused on patient experience
- ⬇ Wasted material
  - ✓ More environmentally friendly
- ⬇ Clinician exposure to harmful substance
  - ✓ Improved clinician health and safety
- ⬇ Costs of sockets for patients
  - ✓ More affordable to maintain comfortable socket fit

Previous studies have shown that AM is suitable for fabricating lower-limb sockets without compromising strength or comfort [2].

However, little is known for its application in upper-limb socket fabrication.

Research Question

Which combination of AM processes and materials can produce upper-limb sockets that satisfy the same criteria as sockets that are currently fabricated at Holland Bloorview?

Methods

A literature review was performed to identify potential AM processes and materials, and previous applications of AM in prosthetic devices.

A set of desired socket criteria was developed in collaboration with clinicians at Holland Bloorview.
- Diagnostic sockets:
  - Transparency, thermo-mouldability, cost
- Deterministic sockets:
  - Strength, comfort, bio-compatibility

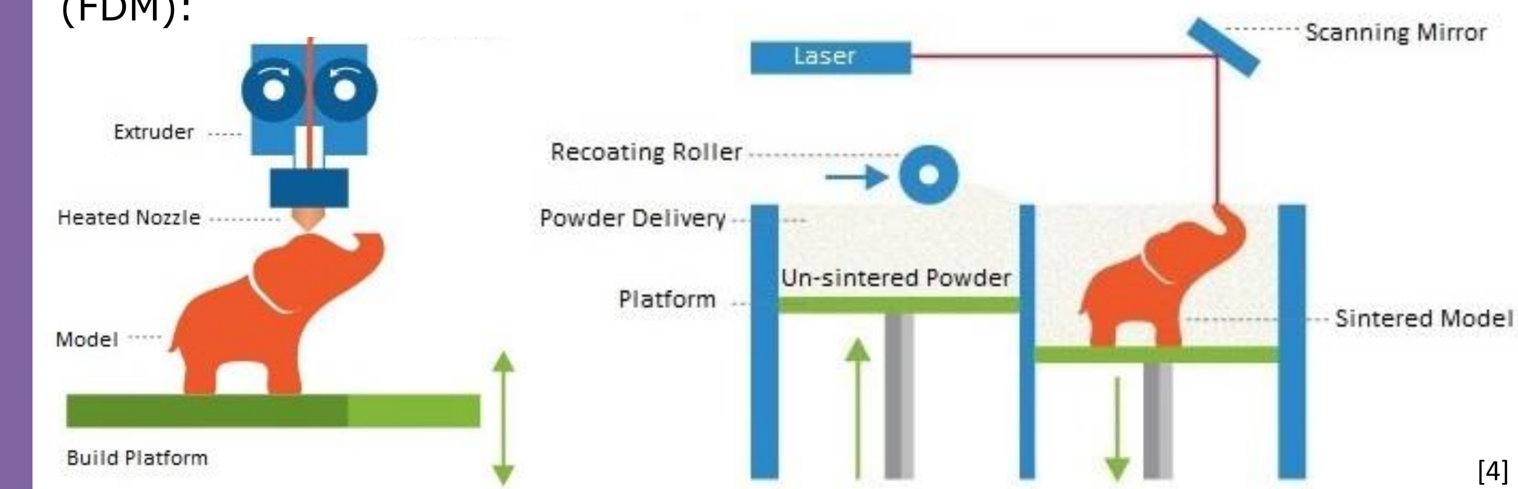
Sample below-elbow sockets that have potential to meet these criteria were ordered from various AM service centers for comparing and testing.

Digital technologies could transform prosthetic fabrication and improve the clinical experience of children with prostheses

Results

Two AM processes show potential for making sockets that fit the required criteria:

Fused Deposition Modeling (FDM):   Selective Laser Sintering (SLS):



[4]

In FDM, layers of melted material are placed on top of each other to build the object one layer at a time. This process has materials suitable for making diagnostic sockets, such as PETG and PLA, as well as definitive ones, such as ABS and PA12.

In SLS, a laser is used to melt powdered material in the shape of the object, one layer at a time. This process has materials suitable for making definitive sockets, such as PA11 and PA12. The advantage of using SLS is that the printed objects have equal strength in all directions, unlike objects printed in FDM which are weak between the layers.

Conclusions

The processes and materials identified show promising properties for use in upper-limb socket fabrication. The sample sockets ordered from AM service centers will be tested and compared to determine which produces the best sockets, and whether these can replace current sockets fabricated at Holland Bloorview.

Relevance to Holland Bloorview Clients & Families

AM can allow for faster, cheaper and better sockets and socket fit. For children, who grow out of their sockets quickly, incorporating AM fabrication techniques could greatly reduce the cost per socket and the time required to attain a perfect fit.

References

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