XXVI Congresso Brasileiro de Engenharia Biomédica
Armação de Búzios – RJ – Brasil
October 21st to 25th, 2018

The Usage of Small 3D Printer in Hand Prosthesis Manufacturing

J V Schultz,[1]* M I V Orselli[1]
[1]Universidade Franciscana, Santa Maria, Brazil
**juliavschultz@gmail.com*

Background, Motivation and Objective. To fit an upper-limb amputee with a prosthesis in childhood age is not a common practice, in spite early fitting can facilitate the acceptability of a prosthesis (DOI: 10.1302/0301-620X.65B3.6841409). The expensive cost of commercial prosthesis and the rapid growth of children's body are some of the reasons that explains this fact. In addition, Brazilian United Health System (Sistema Único de Saúde, SUS), which plays an important role in providing prosthesis to brazilian citizen who need, allows only one request per person. Thus, 3D printed upper-limb prosthesis is a cheaper and functional possibility for children, specially due to the fast manufacturing mode. There are online communities, which have developed and tested different models of 3D-printing prostheses and provide STL archives for download, together with fitting and manufacturing instructions. However, there is a lot of undocumented issues that arise when a small-size printer is used for such purpose. We ought to investigated the issues concerning the usage of 3D printers of small size in manufacturing upper-limb prosthesis using the polylactic acid (PLA) thermoplastic as filament. We also aimed at defining printing parameters which can improve the quality and the strength of the printed object.

Methods. In this study we used a 3D printer (Cliever, CL1 - Black Edition) with 0.3mm to 0.1mm resolution in the three printing directions; print dimensions of 180mm x 180mm, in the table, and 100mm, vertical and a strudor nozzle diameter of 0.4mm. In this printer model, layer addition is controlled vertically by the printer table elevation, and horizontally by the simultaneous displacement of the table and the nozzle. We investigated the issues that may rise while using this small-size printer to build the Cyborg Beast (CB) (DOI: 10.1186/s13104-015-0971-9) and Raptor (RPT) hand-prosthesis. Both models are available in the Enabling The Future website (http://enablingthefuture.org/). Those devices uses the wrist movement of the residual limb to close a prosthetic hand, which is kept open by an elastic wire system . The package of 3D drawing contains all the separate part of the prosthesis, which are basically: a palm, distal and proximal phalanx for the five fingers, a forearm support and hinge pins. After downloading the archives , all the parts were printed using the same parameters: 10% of volume filling, a height of 0.15mm between layers, $2x10^{-6}$mm of wall thickness, 0^o of support angle, and the temperatures were 200^oC in the extrusor and 60^oC in the table of printing. Before the assembling the prosthesis, all the parts were sand, to allow proper function of the joints and the passage of the control cable system.

Results. Using the printing parameters described above, we were able to print the RPT parts with greater aesthetical quality than the CB. Specifically, CB hinge pins and the parts which compose the drive system where not properly printed and could not be used. In addition, wrist joint connectors in the forearm support could not match the palm pair due to deformities, resulting in the impossibility to assemble the prosthesis. Despite we could print all the RPT parts, we also observed some minor issues, namely: parts surfaces were always rough, requiring extensive sanding to allow proper connection and articulation; control cable cannulas and their respective fixation roles where also small, restricting the choice of control cable diameter and type.

Discussion and Conclusions. Small 3D printers are cheaper and take up little space. Thus, could easily be bought and installed in many health unities to prototype and manufacture functional upper-limb prosthesis. However, our results showed that using small-size 3D-printers for children prosthesis manufacturing may be tricky, once they may not have the necessary resolution to print small parts, such as hinge pins, control cable cannulas and fixation holes. In addition, this kind of low volume and low resolution printer seems to perform better with flat objects. We had less unwanted events and a better performance when printing the RPT than the CB model, possibly because RPT parts are more flat than CB. This indicates that some prosthesis models, specially the more anthropomorphic ones, may require more sophisticated printers to be adequately manufactured. Some of the problems observed, may be partially solved with a better adjustment of the printing parameters or overcomed with structural modifications. Surface roughness, for example, may be reduced by a better adjustment of the nozzle and table temperatures and overcomed by sanding the parts and adding protective material to the parts where the skin and the prosthesis are in contact. Hinge pins may be substituted by rivets or screws since structural modifications in the prosthesis model are made (increasing the hinge hole diameters, for e.g.). The little space available for the control cable in the cannulas, which may prevent the prosthesis to work properly, is also an issue that should be solved with structural modifications. In this case CAD softwares such as Blender, FreeCad and OpenScad have to be used in order to resize or re-build the necessary structures.Finally, one may find many difficulties in using small printers to manufacture other prosthesis types as the elbow-controlled ones. In those devices, the forearm support size may not fit the printing area. In brief, we conclude that it is feasible to use the small 3D printer for manufacturing hand prosthesis, thought the device's limitations have to be considered when choosing the prosthesis model.In addition, some modifications on the available 3D models can facilitate the fitting and assembling process.

Acknowledgment. This work had the financial support Franciscan University, through the PROBEX scholarship.

Keywords. 3D printing; small 3D printer; Raptor; Cyborg Beast;