Modernization of nasal prosthesis fabrication through the use of the Blender API, 3D scanning and printing

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Abstract

Purpose

To improve the efficiency, functionality and cost of nasal prosthesis production for cancer patients who have received a full or partial surgical resection of the nose. The main objective of this work is to digitize the entire workflow for nasal prosthesis creation by incorporating automation, 3D scanning and printing.

Materials and Methods

An industrial handheld 3D scanner (Artec, Luxembourg) is used to provide high resolution facial scans (0.1 mm) of the patient, specifically the nasal cavity and surrounding area. This has the advantage of minimizing geometric distortions compared to an analogue casting process. Using Zbrush (Pixologic, Los Angeles, CA, USA), the nose is sculpted digitally in 3D with the assistance of photographs taken prior to the surgery. Using the nose model and facial scan, an in-house Python script using the Blender API (Blender Foundation, Amsterdam, The Netherlands) fully automates the creation of a mold using a series of morphological procedures and rules. This includes the generation of both male and female pieces along with an insert to maintain breathing channels and a synthetic septum in order to mimic the functionality and feel of a real nose. The molds are then 3D printed and filled with silicon mixed with dyes in order to match the patients’ skin tone. Additional aesthetic flourishes are then added manually such as the addition of synthetic hair and dyes to create a realistic texture.

Results

The new workflow is able to reduce the nasal prosthesis production time from a manually intensive 2 days to 6 hours excluding printing time. This time and material savings between the two processes translates to an approximate cost reduction of $545 per prosthetic or 40% of the conventional cost of production. As of this writing, 4 patients have had prostheses created from the new semi-automatic pipeline.

Conclusions

The incorporation of 3D scanning/printing and the Blender API have allowed the semi-automatization of facial prosthesis production, reducing the time and cost while maintaining if not improving the quality of the prosthesis. Digitization of the process improves fidelity compared to analogue plaster molds and allows molds and the prosthesis to be easily reprinted and recast at a future date, which is not always possible with plaster molds should they become damaged over time. Some challenges remain to fully account for the variability of patient morphology which can cause failures in the mold generation script.
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Objective: To improve the efficiency and cost of nasal prosthesis production by replacing the physical workshop with a semi-automatic digital workflow.

Methods:

1. A high-resolution (0.1 mm) surface of the face is obtained using an industrial handheld 3D scanner (HickSalter, Luxembourg).
2. Pre-surgical photos are used as a visual aid in numerical sculpting of the prosthesis.
3. An in-house script using the Blender API automates the creation of a custom mold model and designs the interior insert to create nearly ready-to-use materials.
4. Most of the 3D models are completed and smoothed using Blender software.
5. The construction is cast with dye-colored silicone and vacuum.
6. Final polishing and coloring such as synthetic hair and additional skin tone is applied.

Results: The new workflow resulted in a 40% reduction in production time and hence cost. A digital workflow almost entirely eliminated the need for a physical workshop.

<table>
<thead>
<tr>
<th>Step</th>
<th>Time analogue (hr)</th>
<th>Time digital (hr)</th>
<th>Cost analogue (CAD)</th>
<th>Cost digital (CAD)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Impression + model</td>
<td>2</td>
<td>1</td>
<td>200</td>
<td>50</td>
</tr>
<tr>
<td>Modelling</td>
<td>3</td>
<td>0.5</td>
<td>150</td>
<td>10</td>
</tr>
<tr>
<td>Silicone casting</td>
<td>3</td>
<td>3</td>
<td>500</td>
<td>100</td>
</tr>
<tr>
<td>Total (CAD)</td>
<td>1.5</td>
<td>0.6</td>
<td>850</td>
<td>160</td>
</tr>
</tbody>
</table>

Conclusion: The incorporation of 3D scanning and printing and the Blender API have allowed the semi-automatisation of nasal prosthesis production, reducing the time and cost while maintaining if not improving the quality of the prosthesis.

Future Development: Improvements in the robustness of the workflow to work with a variety of nose and cavity shapes in addition to cases of partial retraction is being investigated. Additional automation using AI-generated nose models based on x-ray images of the patient is under development.