Feasibility and cost of rapid prototyping and 3D printing patient-specific cutting guides in canine patients with primary skull tumor

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Introduction

- Primary skull tumors in dogs are rare, with the most common tumors including osteosarcoma (OSA), osteoma, and multilobular osteochondrosarcoma (MLO).1-2
- OSA and MLOs are locally aggressive and clean surgical margins are important for long-term local control.1-2
- Presurgical planning, including advanced imaging, can aid in the identification of surgical margins but intraoperative resection remains challenging due to anatomic variations and surrounding vital structures, including brain parenchyma.3
- Rapid prototyping and three-dimensional (3D) printing of patient-specific cutting guides may aid in intraoperative planning but are not well reported in veterinary medicine.
- The objective of this study was to assess the feasibility and cost of rapid prototyping and 3D printing a patient-specific sterilizable cutting guide in canine patients with primary skull tumors undergoing surgery
- **Hypothesis:** Design and printing of the cutting guide will be possible in a time sensitive and cost-effective manner for canine patients diagnosed with primary skull tumors.

Materials and Methods

CT scans of dogs with skull tumors of primary bone origin were evaluated and a complete study with volume metadata and minimum slice thickness of 0.625mm was selected.

Cutting Guide Design:

- Margins of the tumor were defined on CT using standard imaging reconstructions were performed.
- A margin of 5 mm was identified beyond the tumor in all lateral planes based on the previously defined tumor margins.
- A cutting guide was designed using Ansys SpaceClaim by creating a 4mm thick outline from the previously identified margin, following the contour of the skull (to account for a 1mm burr diameter).
- Two fixation points were created in areas of thick bone or overlying structures, including brain parenchyma.
- A cutting guide STL file was uploaded to a Formlabs Form 2 Stereolithography (SLA) printer.
- The SLA printer created a thin layer of grey resin followed by photopolymerization by laser to build the cutting guide layer by layer along with a resin support system that stabilized the print process.
- The support lattice printed with the cutting guide was then removed to reveal the finished product (Figure 1).
- The cutting guide was exposed to UV light to cure and stabilize the resin.

Cutting Guide Fabrication:

- The cutting guide STL file was uploaded to a Formlabs Form 2 Stereolithography (SLA) printer.
- The SLA printer created a thin layer of grey resin followed by photopolymerization by laser to build the cutting guide layer by layer along with a resin support system that stabilized the print process.
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Results

Based on this pilot study, with access to medical segmentation and computer aided design software (CAD), a cutting guide can be created and manufactured for $75-125CAD, not including labor costs. Cutting guide design takes <1 hour and a send out printing turnaround time of approximately 1 week. With access to an SLA printer, the cost of materials is ~$25 + 7 hours of print and processing time.

Discussion

- Our results indicate that design and production of a sterilizable, patient-specific cutting guide is possible in a short time period with minimal cost, if there is access to an individual/team with digital design expertise, the applicable software and printing is outsourced. Initial investment for the printer ($5500) is high but this equipment is readily available in many academic institutions and medical grade printers or materials are not necessary. SLA printing was elected due to increased accuracy, better resolution (25μm layers) and reduction in defects compared to previously described techniques for printed cutting guides.4 Benefits of SLA include high temperature resistance, allowing autoclave or gas sterilization, depending on which resin is used.5
- The ability to create a surgical cutting guide for craniectomy will improve preoperative planning and repeatability of outcomes, and may decrease the risk of incomplete tumor resection. Being able to transfer preoperative planning directly into the surgical theater leads to increased surgeon confidence, which will likely decrease surgical time. In addition, consistent surgical resection will allow for placement of prefabricated customized implants at the time of the procedure.6
- In addition to cranial tumors, this process of creating a rapid prototyped patient-specific cutting guide can be applied to other complex oncology or orthopedic procedures that require accurate resection margins or customized implants.
- Rapid prototyping and 3D printing of a patient-specific sterilizable cutting guide in canine patients with primary skull tumors is possible with access to STL software and training. The next step in this research will be the application of this guide in a clinical patient.

References:


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