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Utilizing Best Practices of 3D-Modeling and Printing in Veterinary Medicine to Analyze Elbow Incongruity of a Maltese Canine

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Introduction

Research on the application of 3D-printed models in human medicine is extensive, but it is relatively new for veterinary medicine. With the increased numbers of certified veterinary radiologists and animal imaging facilities, best practices in 3D model design and printing can be explored. Accurate renderings of an animal's anatomy can be used to train new students, educate clients on their pets' needs, and guide veterinarian surgical approaches. Overall, the use of 3D printing in veterinary medicine provides novel, efficient, and successful approaches to treating various disorders. This rapidly evolving technology continues to become more widespread as more veterinarians learn how to harness the capabilities of 3D modeling and printing.

Background Information

Applications of 3D Prints in Veterinary Medicine:

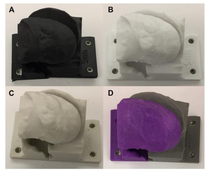
- Surgical Planning:
  - Examples include visualization of tumor margins, surgical technique practice, analysis of bone structures, and many more.
- Client Education:
  - Provide clearer explanations of proposed treatment options and associated risks.
- Surgical Implants:
  - Mainly 3D prints that are directly implanted into patient or external prosthetics.
- Student Education:
  - Can be undergraduate or graduate; this is an extremely cheap and effective educational resource.

Process of Producing 3D Printed Anatomical Models from 3D Imaging:

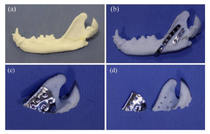
1. Acquire medical image files (DICOM files).
2. Produce desired 3D object file(s) (.stl or .obj) using Invivo 6.0 by Anatomage*
3. Manipulate 3D object file(s) as needed and generate printer file using Meshmixer 3.0*
4. 3D print desired model using Print Studio by Dremel*

* Software used in this specific project. Several alternatives are available to the public.

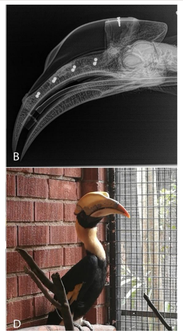
Successes From the Literature



3D printed equine joints for new veterinarians and veterinary students to practice the nuanced technique of intraarticular injections. Proved to be a very effective teaching tool (1).



3D printed mandibular implants for two felines with severely broken jaw. Both made full recoveries (3).



Shows a Great Hornbill with a 3D-printed prosthetic beak. Illustrates the potential for this practice to be successfully applied to certain exotic species (4).

Project Goals

- To review the literature and understand, then apply, the processes involved with creating 3D printed anatomical models.
- To study cases showcasing the successful uses of 3D printing in treating various disorders.
- To study cases where veterinary 3D printing was used to educate a student or a pet-owner.
- To investigate and analyze the extent of the technology's success in the industry.
- To understand the future directions and limitation of 3D printing as a treatment tool and educational resource.

Case Study

Patient Information:

- Canine, Maltese, 1.54 kg weight, intact male
- Presents with lameness in left leg
- Diagnosed at Western University-College of Veterinary Medicine with left elbow incongruity including lateral luxation of the left radius based on CT images of the limb.

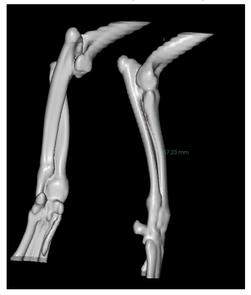
Goals:

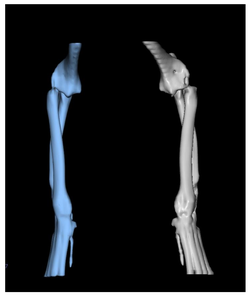
- Successfully create an accurate 3D rendering of the elbow joint.
- Investigate potential benefits to adding this process into treatment protocols.

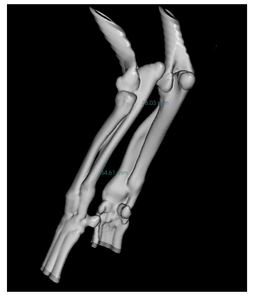
Methods:

- Acquired CT scans of patient
- Used 3D printing process described in the "Background Information" section to create virtual model and 3D print.

3D Model (.stl file):







Images of the virtual model for the Maltese elbow joint were created to take measurements, select specific regions, and manipulate original model (i.e. adding fake tumors for education purposes).

3D Print*:

Images of the final 3D print of the Maltese elbow joint were created to potentially highlight deformities to client, students, and veterinary staff. If deformity requires extreme surgical intervention, 3D model could be created as a bone implant.

Due to COVID-19, we were unable to retrieve images of the 3D printed bones from the University.

Significant Findings

Based on the literature, it can be concluded that the 3D prints I created of the Maltese elbow joint can be integrated into various components of the treatment protocol.

- The model (both virtual and 3D printed) can be used to provide necessary quantitative data such as length of bones, angles of articulation, and measurements on any other bone deformities.
- Visible deformities on the 3D print can be used to help the pet's owner gain a deeper understanding of their pet's health and how to best manage it.
- The high level of detail reflected in the model makes it a cheap and effective educational resource for veterinary students honing their diagnostic skills.
- The models can also be applied to undergraduate courses such as comparative or animal anatomy and physiology classes.

Conclusions

It is evident that there are abundant examples of 3D printing enhancing veterinary patient care and student/client education. This practice would most likely benefit and enhance any veterinary practice or institution, but many considerations must be made prior to making such a decision.

Limitations:

- Technology mostly not available for use on large animals.
  - Alleviated by work with graphic designers, clinicians, and anatomists to self-design models instead.
- Necessary equipment (CT/MRI machines, 3D printers, software) not available to many veterinarians due to cost, size, and client demand.
- Literature has small sample sizes due to the novelty of these treatment approaches, meaning large-scale efficacy has not yet been evaluated.

Future Directions:

- Bioprinting (3D prints created using live cells for implantation into the body).
- Use of 3D prints in post-operative monitoring.
- 3D prints that can be used to treat soft tissue injuries or completely replace regions of soft tissue if damage is too excessive.

Acknowledgements

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