VetMed: Affordable Muzzle for Canine Mandible Repair

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Client: Dr. Graham Thatcher, UW School of Veterinary Medicine

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ABSTRACT

A common injury seen in canines is the fracture of the mandible. The standard non-invasive method of treatment is a tape muzzle that helps to stabilize the fracture up to and after surgery. These muzzles however can cause further displacement of the fracture site due to the pivot point it generates. Our client, Dr. Thatcher, would like our team to design a nylon muzzle that provides adequate support and evenly distributes the bite forces in the jaw to aid in proper healing and to quantitatively prove that the nylon muzzle offers superior support. The team developed three designs and evaluated them using a design matrix against criteria developed by the team. Post evaluation, it was determined that we would focus on the mesh design. Using this design, we created a model in SolidWorks used simulations to analyze the stress distribution across the mandible. It was determined that peak stress decreased from 8.07 MPa with no support and 8.12 MPa with the tape muzzle to .821 MPa when fully supported. These calculations allowed us to prove a statistically significant effectiveness of the nylon muzzle.

PROBLEM STATEMENT

Design Motivation:

- Our client is in need of a nylon muzzle that provides superior support than the current practice of a tape muzzle

Objective:

- Create a nylon muzzle
  - Must evenly distribute the forces exerted by a dog bite → approx. 620.33-1,091.1 N [1]
- Quantitatively prove nylon muzzle provides more stability
  - Finite Element Analysis, cantilever and suspension bridge mechanics

BACKGROUND

Figure 1: Mandibular Fracture

Figure 2: Tape Muzzle

Figure 3: Commercial Nylon Muzzle

- **Canine Mandibular Fractures:**
  - The fracture most commonly occur at the mandibular carnassial tooth, also called the M1 tooth. [2]
  - Fracture under the M1 tooth can occur in two general patterns: favorable (blue) and unfavorable (red) as shown in Figure #. As the masseter contracts, a favorable fracture pattern brings the parts of the jaw together, while an unfavorable fracture pattern causes the parts of the jaw to separate. [3]
- **Current Treatment:**
  - Current treatments involve costly surgeries that may not be accessible for some pet owners. [4]
  - Standard practice is to use a tape muzzle, as shown in Figure #, to stabilize the fracture up to and after surgery. However, tape muzzles have been known to cause a pivot point around the fracture site that can lead to further displacement of the fracture.
  - Muzzles, similar to those shown in Figure #, could be used as a more cost-effective method of treatment.

DESIGN CRITERIA

- Must not impede eating, drinking, breathing, and blood supply of dog
- Design must be applicable to varying snout sizes
- Must prevent stress concentrations and further fracturing
- Support fracture site for minimum of 6 weeks or until functionally healed [5]
- Mathematically prove nylon muzzle superior to tape muzzles

FINAL DESIGN

Materials

- Nylon-spandex blend fabric
- Mesh
- Nylon thread
- Parachute buckle
- Nylon straps
- Foam padding
- Acrylic supports

Equipment & Software

- Sewing machine
- 3D scanner
- 3D printer
- SolidWorks
- MeshMixer

Figure 4. Muzzle on skull

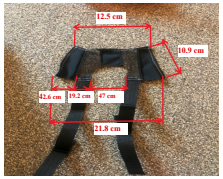

Figure 5. Final Muzzle Product

Figure 6: CAD muzzle

TESTING

Finite element analysis of simple canine mandible model

- Solidworks developed model of a simplified canine mandible with the fracture site represented by an extruded cut at a location similar to that of the M1 tooth.
- To represent the average bite force in canines, 855 N was applied across the top of the mandible
- Three separate tests were conducted to determine max stress at fracture site for varying support levels.
  - No support
  - Tape muzzle support
  - Nylon muzzle support
- For the two conditions with support, 855 N was applied to the bottom of the mandible where the support is located.
- Each simulation automatically generates a scale which depicts the range of stress values throughout the jaw, the top value being the maximum stress calculated.
- In order to determine specific stress values around the fracture site, the probe tool was used. Ten points were individually selected and statistical analysis of each test's data was conducted.

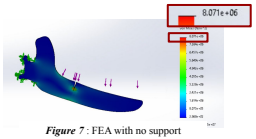

Figure 7 : FEA with no support

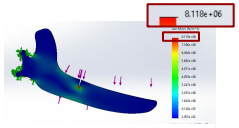

Figure 8 : FEA with tape muzzle support

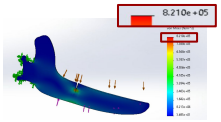

Figure 9: FEA with nylon muzzle support

DATA ANALYSIS

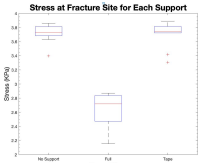

Figure 10: Boxplot of stress with various support types

FEA:

- Peak stress decreased 89.7% and 90.4% with full support, when compared to no support and tape support, respectively.
  - Maximum stress:
    No support: 8.071 MPa Tape: 8.118 MPa Full: 0.821 MPa
- Full muzzle support resulted in a 91.0% drop in average stress around the fracture compared to no support, and a 91.1% drop compared to tape support
  - Average stress near fracture:
    No support: 5.350 MPa Tape: 5.412 MPa Full: 0.483 MPa
- $p<0.001$ when sampling near fracture site comparing full support to tape and no support
- No significant change when comparing tape and no support

DISCUSSION

Computer Modeling

- Significantly less in stress at the fracture point mandible when fully supported along the jaw.
- Tape support muzzle creates an increase in maximum and average stress; three point bending occurs at the fracture site.
- Decreasing the stress experienced in the mandible limits displacement of fracture throughout healing process.

Physical Prototype

- Prototype was close fitting and secure around around the snout.
- Support rods were secured in foam to provide additional comfort and protection.
- Stresses experienced with the physical model have not been conducted yet.

FUTURE WORK

Improvements:

- Order alternative materials for prototype
- Enhance simplified mandible
- Refine FEA simulation

Testing:

- Validate model of muzzle in experiment
- Analyze components for durability, flexibility, and comfort

Figure 11: Goal Mandible to Refine FEA

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