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Overview of Presentation

● Poster Overview
● Abstract
● Problem Statement
● Background Information
● Design Criteria
● Final Design
● Testing
● Discussion
● Future work
● References
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 8.67 MPa with no support and 8.12 MPa with the tape muzzle to 0.821 MPa when fully supported. These calculations allowed us to prove a statistically significant effectiveness of the nylon muzzle.

**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 8.67 MPa with no support and 8.12 MPa with the tape muzzle to 0.821 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.
- Increase patient wellbeing by reducing pain and suffering.

**Objective:**
- Create a nylon muzzle
- Must evenly distribute the forces exerted by the dog bite — approx. 8.67-3.1091 N [1]
- Quantitatively prove nylon muzzle provides more stability.
- Finite Element Analysis, cantilever and suspension bridge mechanics

**BACKGROUND**

- **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 6. As the maserette 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 6, 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 6, 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 fully functional healed [5]
- Mathematically prove nylon muzzle superior to tape muzzle

**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

**FINITE ELEMENT ANALYSIS**

**Finite Element Analysis of Simple Canine Muzzle Model**

- Solidworks developed model of a simplified canine muzzle 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 muzzle.
- Three separate tests were conducted to determine mean 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 tool's data was conducted.

**TESTING**

**DATA ANALYSIS**

**Stress at Fracture Site for Each Support**

- **FEA:**
  - Peak stress decreased 89.7% and 90.4% with full support, when compared to no support and tape support, respectively.
  - Minimum 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: 5.330 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.

**ACKNOWLEDGMENTS**

We would like to thank our advisor Dr. Randolph Ashton, our client Dr. Graham Thatcher, and the BME department for providing us with the opportunity, support, and guidance throughout the design process.

**REFERENCES**

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 and 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
Canine Mandibular Fractures:

- The fracture most commonly occurs 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 1. 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]
Background Information

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 2, 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 3, could be used as a more cost-effective method of treatment.
Design Criteria

Performance:
- Support fracture for minimum of 6 weeks or until functionally healed [5]
- Mathematically prove nylon muzzle superior to tape muzzles

Safety:
- Must not impede bodily functions of dog
- Must prevent stress concentrations and further fracturing
- Material must be non-toxic, comfortable, and washable

Size:
- Design must be applicable to varying snout sizes
Final Design

Materials:
- Nylon-spandex blend fabric
- Nylon mesh
- Nylon thread
- 1” Nylon straps
- 1” Parachute Buckle
- Foam padding
- Acrylic Supports

Equipment & Software:
- Sewing Machine
- 3D scanner
- 3D printer
- SolidWorks
- Meshmixer
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
  ○ Nylon muzzle support
  ○ Tape 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 nylon muzzle support

**Figure 9**: FEA with tape muzzle support
Data Analysis

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: 8.07 MPa        Tape: 8.12 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: 5.35 MPa        Tape: 5.41 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

Figure 10: Boxplot of stress with various support types
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 Model to Refine FEA
Acknowledgements

We would like to thank our advisor Dr. Randolph Ashton, our client Dr. Graham Thatcher, and the BME department for providing us with the opportunity, support, and guidance throughout the design process.
References

Questions?