COMPARING PERIOSTEAL MORPHOLOGY BETWEEN CERVINE AND HUMAN TIBIAE

Alexander D.W. Throop¹, Alexander K. Landauer¹, Alexander Martin Clark Jr.², and Laurel Kuxhaus¹

¹Clarkson University, Potsdam, NY, USA
²Canton-Potsdam Hospital, Potsdam, NY, USA
email: lkuxhaus@clarkson.edu, web: http://people.clarkson.edu/~lkuxhaus/

INTRODUCTION

Novel fracture fixation devices, such as improved external fixators, fixation plates, or intramedullary nails, must be tested in situ before being used in patients [1]. Animal models are often more economical for preliminary testing; porcine and ovine tibiae morphology is similar to human tibiae [2, 3]. Furthermore, cervine vertebrae have been established as a suitable proxy for human vertebrae in mechanical testing [4]. Cervine (deer) tibiae are readily available in many regions and typically discarded after butchering. Yet there is no existing report of cervine tibiae dimensions. Therefore, the goal of this work is to compare periosteal dimensions of cervine tibiae to previously-reported human tibiae dimensions. If similar, cervine tibiae could be another cost-effective tibiae model for orthopaedic implant testing.

METHODS

This study used eight right tibiae from fresh-frozen cervine specimens (four males, O. virginianus, white tailed deer; approximate ages 1.5-3.5 years) that were obtained locally (Nolt’s Custom Meat Cutting, Lowville, NY). All soft tissue was removed from each tibia. Following this preparation, external dimensions were measured three times by the authors of this work. All tibiae were kept hydrated with saline solution during the dissection and measurement.

Dimensions were measured on each tibia. Length (LN) was measured with a tape measure with accuracy of 1 mm (Kobalt 25-ft Metric and SAE tape measure, Lowe’s, Mooresville, NC). The remaining measurements were made using calipers (6-inch dial caliper, General Tools, New York, NY) with an accuracy of 0.01 inches.

Eleven measurements were made in both the anterior-posterior (AP) and medial-lateral (ML) planes, as visually determined by the researchers. These measurements were: proximal epiphyseal (PE) and distal epiphyseal (DE) widths; proximal diaphyseal (PD) and distal diaphyseal (DD) widths at a distance of 20% of the overall length from each end; and mid-diaphyseal (MD) widths at 50% of its overall length. Figure 1 shows a cervine tibia with the location of each measurement.

RESULTS AND DISCUSSION

The mean measurement across researchers of each dimension was computed. These values were compared with previously-published measurements from cadaveric human tibiae [5]. The percent difference between each cervine and human dimension was calculated (Figure 2).

Several aspects of the cervine tibia are very similar to that of a human. Thirty-seven of the forty-eight diaphyseal measurements are within 20% of the median of the reported human values; in most cases, this difference was less than a few millimeters.
Figure 2: Percent difference of all eleven measured dimensions in deer compared to humans. A positive percent difference means that cervine measurement is smaller than the human measurement.

There is a marked difference between the epiphyseal dimensions; many differ by over 20% from the human dimensions. This variation could be attributed to the fact that the tibia in humans connects to the talus (ankle), yet in the deer, the tibia connects to the metatarsus (a distal leg segment.) This is consistent with the load-bearing roles of the human (biped) ankle compared to that of a quadruped. Given that the epiphysis is typically potted in a bonding material for testing fracture fixation devices, this dimensional difference should not notably influence the results when testing mid-shaft fixation devices.

Cervine tibia length (LN) is slightly shorter than that of human tibiae. This may be because four of the eight specimens measured were young, from a deer of approximately 18 months of age. It is notable that the tibia of greatest length was from the oldest male specimen (Table 1). The tibiae from older male cervine specimens may be the most appropriate model.

Limitations of this work include a limited sample size and the fact that only periosteal dimensions were measured. Comparison was made to previously-published human tibiae dimensions, which may not accurately capture anatomic variation. Additionally, the age estimation of the specimens is based on the expertise of the meat processor, and is therefore only approximate.

CONCLUSIONS AND FUTURE WORK

Based on the measurements collected here and compared with previously-reported human tibia measurements, the cervine tibia can be a suitable proxy for the human tibia for evaluating new fracture fixation devices. This could impact biomechanical testing protocols, laboratory education in orthopaedic surgery, and the development of novel devices. Future work will include measuring more, older specimens; comparing the bone-mineral density between cervine and human tibia, and also making interior, endosteal measurements of the cervine tibiae to compare with human tibia measurements.

REFERENCES


ACKNOWLEDGEMENTS

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<table>
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<tr>
<th>Measured Dimensions</th>
<th>LN</th>
<th>AP.PE</th>
<th>AP.PD</th>
<th>AP.MD</th>
<th>AP.DD</th>
<th>AP.DE</th>
<th>ML.PE</th>
<th>ML.PD</th>
<th>ML.MD</th>
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