Bone Stimulators and Their Use in Horses and People

New Mexico Supercomputing Challenge Final Report
April 2, 2014

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Executive Summary

Twenty-four horses die each week at racetracks across America due to fractures. Osteogenesis Imperfecta (OI), also known as "brittle bone disease", is a rare genetic bone disorder that affects 25,000 to 50,000 people in the United States currently. Our project goal was to find a faster way to heal a broken bone in a horse's body by using human treatment options currently found in the medical community. The bone density of people with Osteogenesis Imperfecta (OI) is comparable to that of horses, which is a good basis for comparison. The Exogen Bone Stimulator is currently used within the OI Community to decrease the fracture healing rate from 6-8 weeks to 3-5 weeks.

In this project we used StarLogo to model a broken bone, the normal healing rate and decreased healing rate by using the Exogen Bone Stimulator. We have tried to apply the known medical use of human bone treatment to use in veterinary care of horses. We believe that as the Exogen Bone Stimulator does decrease the healing rate in humans from 6-8 weeks to 3-5 weeks that this technology will work the same in horses. A main difference between horse and human bones is that horse's bones are hollow and longer. We model the larger bone size with and without the Exogen Bone Stimulator to try to predict what the healing rate change may be in horses.

Introduction

Twenty-four horses die each week at racetracks across America due to fractures. Instead of allowing a fracture enough time to heal, horses are given pain medication. This allows the horse not to feel any pain in their leg, thus enabling weight bearing before the fracture is fully healed. This practice causes extensive damage to a horse's bone.

We chose to combine our knowledge of Osteogenesis Imperfecta (OI) and our interest in horses into a comprehensive project that we could all work on as a team. The bone density of people in the OI Community is comparable to that of horses, which is why we looked to the OI Community for our basis of comparison. One of our team members also has OI and has provided us a basis for understanding fractures, bone density and the healing process (*see Appendix A*). We hoped to find a way to eliminate euthanizing and save the lives of racehorses by decreasing the normal healing rate from 6-8 weeks to 3-5 weeks.

OI, also known as "brittle bone disease", is a rare genetic bone disorder that affects 25,000 to 50,000 people in the United States currently. Fragile bones that break easily characterize OI. This is due to poor collagen production in the body and bone from a dominant genetic mutation to the type 1 collagen genes, COL1A1 or COL1A2. *Osteogenesis Imperfecta* literally means "bone that is imperfectly made from the beginning of life." [1] A person is born with this disorder and is affected throughout his or her lifetime. There is no known cure, only treatment of fractures, bone-rodding techniques (*see Appendix B*) and Bisphosphonate medications such as Pamidronate are used for care.

Bone density in humans refers to the ratio of weight to the volume or area of the bones. Bone mass refers to the weight of the skeleton. Bone mass can be measured in the total body or in specific regions of the skeleton such as the spine, hips, legs and arms. [2] This measurement is done in people using Dual X-ray Absorptiometry (Dexa Scan). Results for children are given as a Z-score. A Z-score of 0 is average, a Z-score of +2 is above average and a Z-score of -2 below average. Z-scores do not take into account the child's height or body size. OI children and adults often have bone density in the -2 to -5

[1] OI Foundation
[2] www.niams.nih.gov/Health_Info/Bone/Bone_Health/bone_mass_measures.asp

range. This low bone density and poor bone production often leads to fractures in the hundreds within their lifetimes.

The cannon (long) bones of horses have three parts. The diaphysis, or middle portion, of the bone is a hollow tube formed by dense bone. When the bone density of this area becomes too low, fractures often occur. Fractures in the cannon bone often lead to euthanizing the injured horse. If the bone can be healed, micro-fractures also known as "Bucked Shins" can occur in the healing cannon area when horses are forced by into training to soon. Stress fractures of the bottom portion of the cannon (distal condyle), or hoof, is another common injury in racehorse. This is often corrected with surgical pins (*see Appendix B*).

The bone density in racehorses is measured by mineral content which is approximately 70% of the skeleton's strength. An adequate supply of the minerals calcium and phosphorus is critical for maintenance of bone mineral content and strength. [3] The horse's diet can be a large factor if they do not receive the minerals needed and can lead to lower bone density. Bone density can also be affected by too much or too little training. Normal training increases bone density however too much high-intensity training can cause micro-fractures. Not enough training can also cause bone density to decrease from lack of exercise. If bone density becomes too low fractures can and do occur.

The Exogen Bone Stimulator is in use today largely in the OI Community. Bone stimulators are used in this community as it increases the healing rate of "non-union" and slow healing fractures of OI Patients. A "non-union" fracture is a when the two pieces of broken bone do not touch once the bone is set back in place (see Appendix B). If the two pieces do not touch, the healing process is either very slow or non-existent. The Exogen Bone Stimulator consists of a main operating unit with a permanently connected transducer and a separate fixture strap. The strap is placed around the fractured bone, coupling gel is applied to the transducer head and the transducer is secured directly over the fracture site. The device is programmed to deliver ultrasound waves in 20-minute self-administered sessions by the patient at home. These ultrasound waves stimulate the two pieces of bone to grow towards each other even though they are not touching by

[3] Ray Geor, BVSc, PhD, Dipl. ACVIM, "Are Your Horse's Bones Tough Enough?", TheHorse.com

stimulating the bone at each end to grow towards each other. The ultrasound waves activate cell receptors causing a series of cascade reactions which is necessary for bone repair. This is a very complex "biological, chemical and physical process" occurs inside the bone which allows the bone to heal[4]. The waves also stimulate bone that is touching to heal faster than the average 6-8 week timeframe.

In our project, we are modeling the healing process comparing the OI human bone and the horse's bone with and without the Exogen Bone Stimulator. The healing process in both human and horses works the same way and does not appear to be affected by bone size, volume or density. This is a very complex chemical process of the restoration of the bone structure. The most valuable data in our case is the healing time, which in some cases depends on the type of the fracture as well. In any case, the Exogen Bone Stimulator decreases the healing time. In our modeling, we are considering such complex processes as the blood circulation restoration inside the fracture and the bone remolding.

We believe that this same technology could be used in the racehorse community to also increase their healing rates and prevent their untimely deaths by reducing the costs involved with veterinary care. With the development of better technology, more human medicine and treatment options are becoming available in the equine veterinary science field.

Description

We began our research on OI, horses and the Exogen Bone Stimulator the Internet. The Exogen has been demonstrated to heal 86% of stubborn-to-heal non-union bone fractures. Clinical studies also demonstrate that Exogen speeds the healing of an indicated broken tibia or broken radius by 38%.[5] As we did not want to rely only on Exogen's research data, we also conducted a survey within the OI Community regarding their personal experiences with the bone stimulator and whether they saw a reportable decrease in their healing rate from the normal 6-8 weeks to 3-5 weeks. Our survey did not

[4] Miramini S., Zhang L, Mendis P., Richardson M.
http://www.civil.mrt.ac.lk/conference/ICSECM_2011/SEC-11-178.pdf
[5] www.exogen.com

receive a huge response but the responses we did receive do seem to be in line with Exogen's posted research data.

We used StarLogo for our model programming. We began by modeling the human bone with a fracture. Then we programmed the model to show the normal healing rate of 6-8 weeks. We then programmed the model to show the Ultrasound waves and the healing rate decreasing to 3-5 weeks. Our modeling for horse bone is the same as the healing process and time is the same for both humans and horses. Depending on the size of the bone, while considering that the horse's bone is very similar to the human and the only difference is the size, we assume that the use of the Exogen Bone Stimulator in horses can decrease the healing time as well. Depending on the type of the fracture, specific treatment is applied in equine medicine. Even after surgery the process of healing in the horse is quite lengthy. "Internal fixation, compression devices, transfixation devices" are all used to heal the horse's bone, but even with all this it takes a couple of months to heal.[6] We have no data or knowledge of using the Exogen Bone Stimulator in horses by any clinic but we think that horses might benefit from using this technology.

Results

We have done deep research in types of bone fractures and bone density in people and horses. We also researched the anatomy of the human and horse's bones. The whole idea of using the Exogen Bone Stimulator in healing the bone fractures while reducing the healing time seems to be very interesting while applying in equine medicine as well, saving racehorses from unnecessary euthanizing, and giving them a second chance while reducing the healing time would help save the cost of healing. We are in the process of finishing the modeling of the fracture healing. We are working on the modeling of the healing process itself. Human bone is more complex in structure than the horse's bone. Our models showed that indeed the healing rate did not change with the density of the bone material itself, but the structure of the bone seemed to make a significant difference. The horse

[6] Kilby Emiy, How Horse Bones Mend
http://www.equisearch.com/horses_care/health/anatomy/equinebones_111505/

bone, which is hollow and therefore has a lower effective density per diameter, actually healed fractionally faster with the Exogen machine than a human bone.

Conclusions

We have done deep research in types of bone fractures and bone density in people and horses. It included the development of understanding and use of multiple medical terminology, plus knowledge of the human and horse anatomy. The whole idea of using the Exogen Bone Stimulator in healing the bone fractures while reducing the healing time seems to be very interesting while applying in equine medicine as well. After modeling and much researching, we believe that the Exogen Bone Stimulator does decrease the healing rate from 6-8 weeks to 3-5 weeks in the OI people who use the machine. As humans and horses heal in the same way and timeframe, we believe to the Exogen Bone Stimulator can be used on horses as an effective fracture treatment and cost saving care option for horses.

Recommendations

This was a very large project with a lot of research to be done. We sometimes had a very difficult time understanding where we were trying to go with this complex medical problem. We are still in the process of finishing our models while studying and researching the complex process of bone healing. We visualized the process of healing through modeling with blocks the healing process, including the blood circulation inside the bone. We have better understanding and are trying to finalize their models. Modeling the problem proved to be more difficult than we initially thought it would be however the entire team was able to learn how to use StarLogo.

Acknowledgments

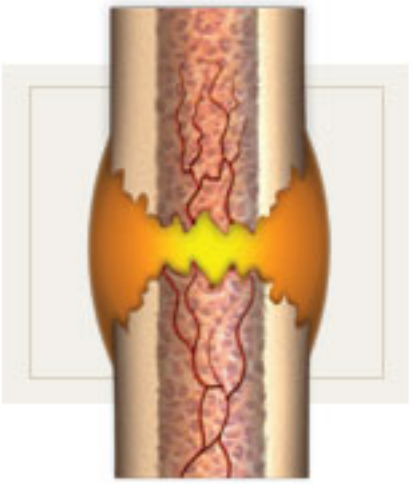
We would like to thank our teacher, Mrs. Sagartz for all of her help, direction and instruction on StarLogo and our project. We would also like to thank Mr. Thomas for all of his help and direction on how we should model this problem in StarLogo.

Resources

http://www.animalcorner.co.uk/farm/horses/horse_anatomy.html
http://www.civil.mrt.ac.lk/conference/ICSECM_2011/SEC-11-178.pdf
http://www.equisearch.com/horses_care/health/anatomy/equinebones_111505/
http://www.exogen.com
http://www.oif.org
http://www.niams.nih.gov/Health_Info/Bone/Bone_Health/bone_mass_measure.asp
http://www.thehorse.com/articles/13210/are-your-horses-bones-tough-enough
http://www.webmd.com/osteoporosis/guide/dexa-scan
http://www.wisegeek.com/why-are-broken-legs-so-dangerous-for-horses.htm

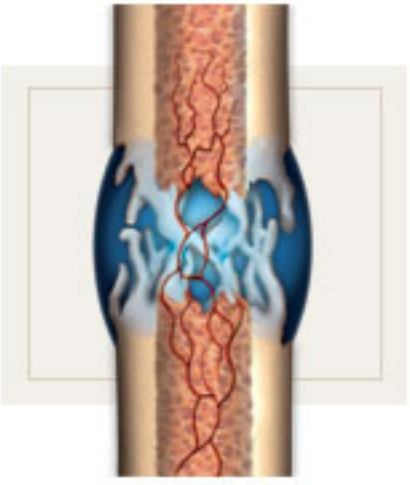
Appendix A: How fracture healing happens

Bone fracture healing is a complex process with four steps. All bone fractures must go through this process.



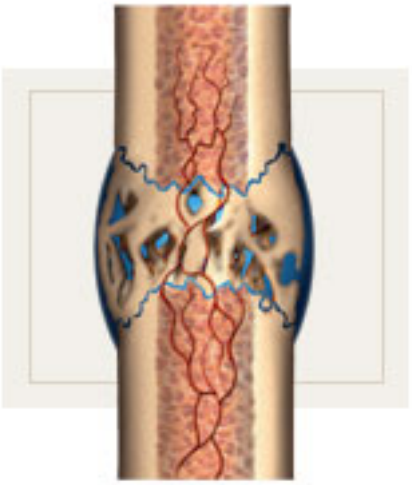
Step 1: Inflammation

When a bone fractures, white blood cells move in to the area to clean up debris created by the break. This creates inflammation, which triggers the growth of new blood cells — the first stage of healing.



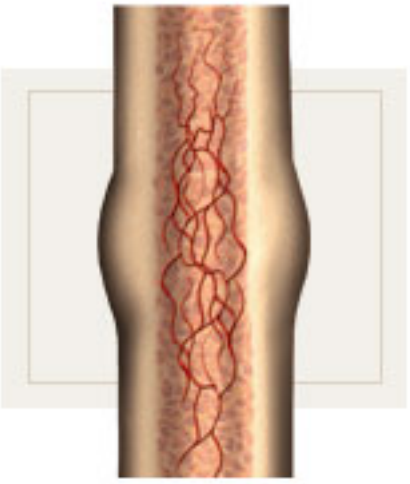
Step 2: Soft callus

As blood cells divide and multiply near the break, new blood vessels develop to fuel the repair process. The body also begins to create cartilage around the bone fracture to bridge the gap in the bone. Called the soft callus, this cartilage is simply fibrous tissue.



Step 3: Hard callus

Eventually, the body replaces the soft callus with a hard callus, connecting the bone fragments more solidly. This stronger callus, which creates a bulge at the site of the fracture, can generally be seen in X-rays just a few weeks after the bone fracture occurs.



Step 4: Remodeling

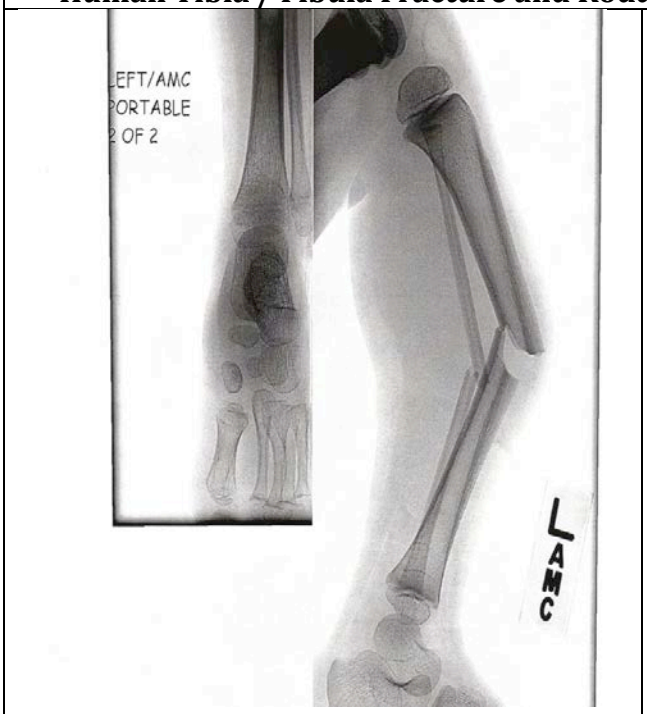
In the final stage of bone fracture healing, the body replaces old bone with new bone in a continual process called remodeling. Remodeling makes bones stronger and more compact and blood circulation in the bone improves.

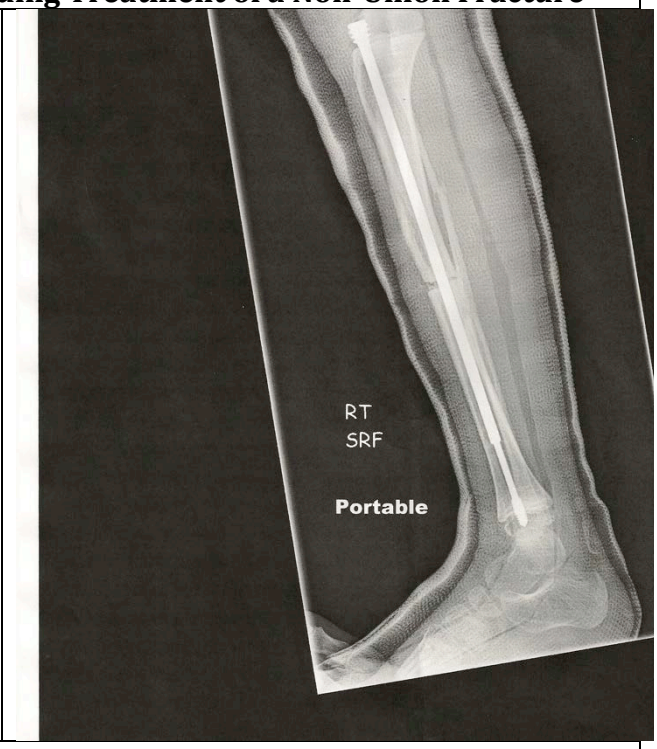
When a patient breaks a bone, doctors take measures to encourage strong, quick repair. These measures include:

- **Setting and immobilizing the break.** If necessary, a physician will move bone segments back into place before immobilizing the fracture using a cast or brace.
- **Surgery.** Some patients may need surgery to set and stabilize a fracture — a process that can involve metal plates, screws or nails. If fractures do not show signs of healing, additional intervention is necessary. Some doctors choose to perform additional surgeries; others turn to devices like EXOGEN.
- **Bone growth stimulation.** To help heal fractures, many doctors prescribe a device like EXOGEN — the only stimulator that uses ultrasound waves to stimulate the body's natural healing process, helping boost bone growth.
- **Therapy.** If a patient is in a cast for a long period of time, he or she may benefit from physical therapy to regain full use of stiff or weak muscles.

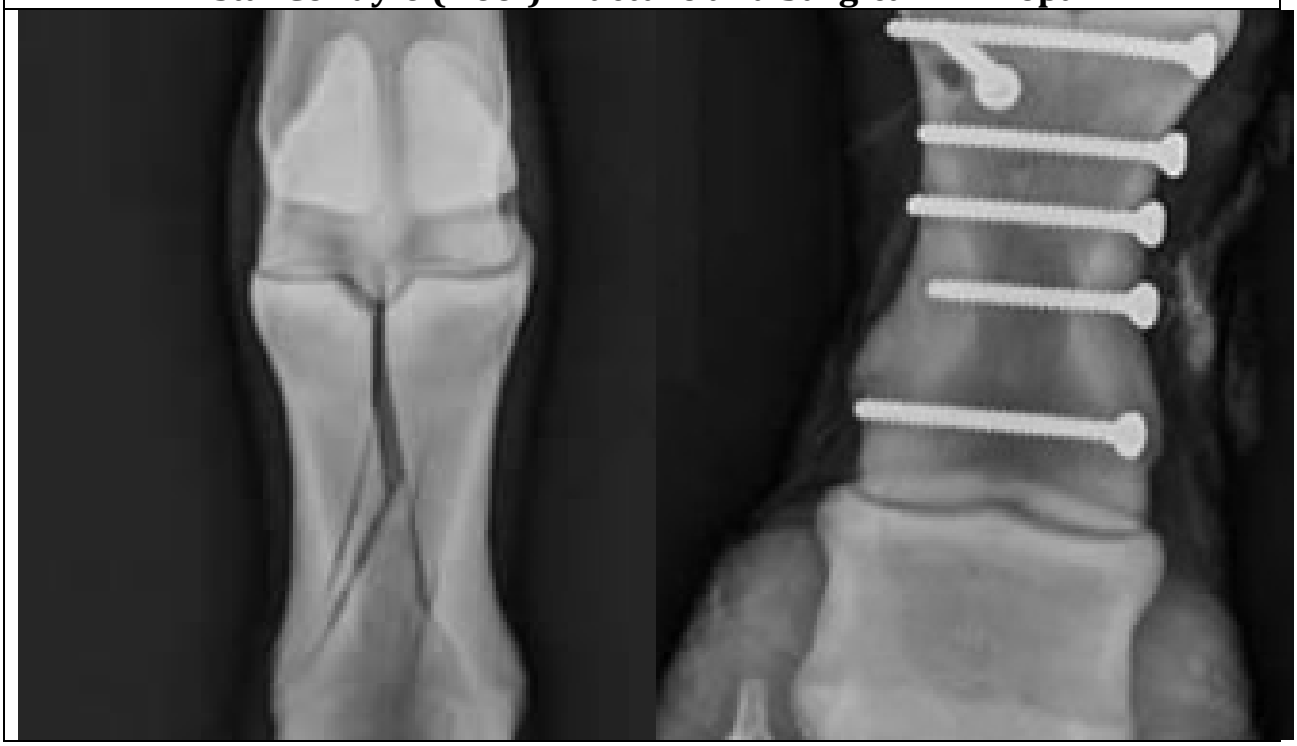
Appendix B: Human and Horse Fracture X-Rays and Treatment

Human Tibia / Fibula Fracture and Rodding Treatment of a Non-Union Fracture





Distal Condyle (Hoof) Fracture and Surgical Pin Repair



Appendix C: Exogen Process