The SmartCast: A Dynamic Fracture Healing Device

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Mission Statement

To design and build a device that greatly increases the fracture healing rate of bones.

A major limiting factor for prolonged space travel is the rapid loss of bone mass experienced by astronauts. The risk of fracture in load-bearing bones increases significantly with loss of bone density, and it is unknown how fractures will heal in space. A fracture in space would be extremely dangerous to both the health of the astronaut and to the success of the mission, particularly if healing was impaired. On Earth, patients with reduced mobility experience similar healing impairment, requiring a suitable method for repairing fractures. The SmartCast is the solution to these bone fracture problems.

Fracture Healing on Earth

- Fractures heal by forming a callus and then bone
- Cyclic loading and compression are main stimulants of fracture healing
- Conventional treatment consists of fixation and partial load bearing
- Low-frequency vibrations enhance healing of non-union fractures

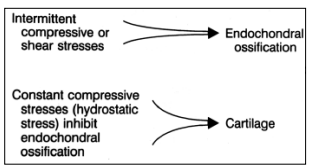

Fig. A: Effect of various types of mechanical stimulation on fracture healing

Fracture Healing in Space

- Microgravity conditions reduce normal loading on bone
  - Fracture healing process impaired, resulting in non-union
- Similar effects are observed in bedridden patients
- To ensure fracture healing in reduced loading conditions, proper fixation and mechanical stimulation are required
- Fixation immobilizes and protects the fracture
- Mechanical stimulation induces native bone cells to initiate a natural healing response

References

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Inside the SmartCast

The SmartCast delivers both fixation and healing components to maximize healing potential of bone fractures.

Fig. B: The SmartCast shown during use

1. Healing interface
   a) LCD display and buttons for user to select desired treatment
   b) Hard outer shell for protection

3. Skin contact layer
   a) Foam padding to protect limb from motor activity
   b) Cloth skin contact layer provides comfort

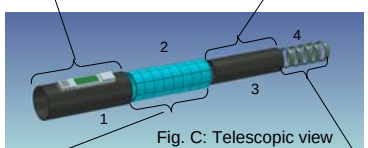
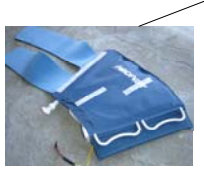
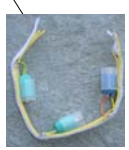


Fig. C: Telescopic view



2. Gel fixation component
   a) Variable pressure fixation
   b) Temperature responsive



4. Variable position "motor rings"
   a) Velcro straps with motors attached
   b) Multiple "rings" can be positioned to treat specific fracture location

Testing Procedure

- Artificial bones obtained from Sawbones were used to simulate human bone
- The frequency, amplitude, and propagation of mechanical vibration were measured at two locations
  - Motor level, to ascertain initial vibration frequencies
  - Bone level, to ascertain delivered vibration frequencies
- Vaseline was used to simulate soft tissue surrounding bone to determine propagation of vibration to the fracture site
- Data analysis was done using Microsoft Excel's Fast Fourier Transform

Testing Results

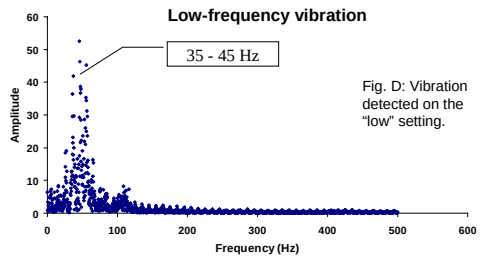


Fig. D: Vibration detected on the "low" setting.

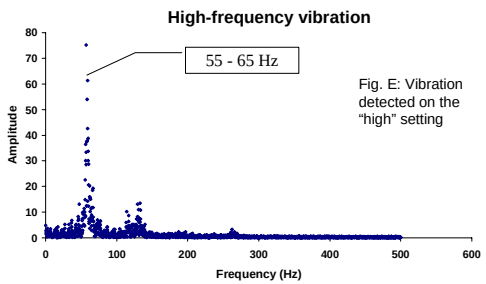


Fig. E: Vibration detected on the "high" setting

Summary

- Without normal loading, a novel device is needed to heal fractures
- The SmartCast combines fixation and healing components to enhance fracture healing by delivering appropriate mechanical vibrations
- Testing indicates the SmartCast delivers clinically relevant vibration frequencies to fractured bones.

Acknowledgements

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