The Osteonexus: Actively Dynamized Fracture Healing

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OBJECTIVE

Develop a device which promotes fracture healing via actively induced, controllable axial micromovements at the fracture site directly beneficial for:

- Patients who are unable to sufficently amublate or load their bones
  - Elderly, traumatized, or paraplegic
  - Astronauts
- Patients in the general public desiring a quicker healing response

INTRODUCTION

Fracture healing requires:

- Good fracture fixation
- Partial loading of fracture site

Partial axial loading:

- Through micromovements of 1 mm at 0.5 Hz have been shown to speed fracture healing by 27%[1]
- Stimulates callus formation
- Accelerates remodeling of osteocytes late in the healing phase[2]

The Osteonexus Active Dynamizer:

- Incorporates effective fixation
- Provides controlled micromovements to promote fracture healing
- Accommodates patients unable to load bones

PROTOTYPE EVALUATION

Finite Element Analysis

- Stresses at fracture site modeled using ABAQUS™ :
  - Active dynamization (1 mm displacment)
  - Static fixation (300 N load on tibia)
- Tibia in early stages of fracture healing (0-4 weeks) modeled using[3]:
  - Cortical shell elastic modulus, 17.4 GPa
  - Fracture site elastic modulus, 8.7 GPa
  - Bone Poisson's ratio, 0.39
- Fixator properties:
  - Steel elastic modulus, 210 GPa
  - Steel Poisson's ratio, 0.28
- All components modeled as isotropic materials.

Power Feedback:

- Springs of varying stiffness:
  - Used to induce mechanical resistance
  - Positioned between two components of Osteonexus
  - Calibrated using Instron 5565 system
- Voltage and current across motor measured using LabVIEW 7.1 and ELVIS data acquisition board
- Five seconds of data recorded for each spring

THE OSTEONEXUS ACTIVE DYNAMIZER

The Osteonexus Active Dynamizer produces **healing-enhancing, axial micromovements** at the fracture site that simulate physiological loading.

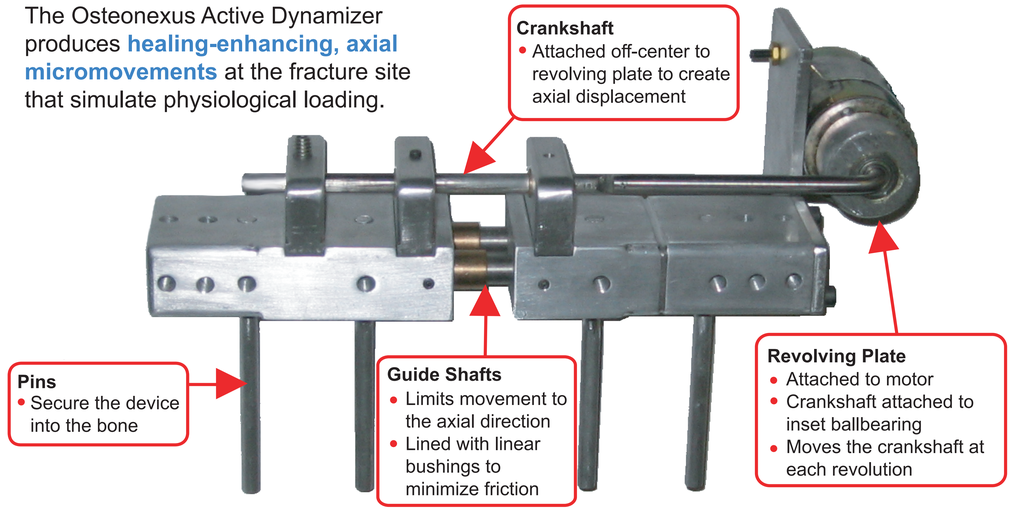
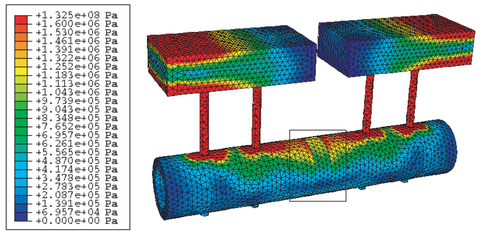


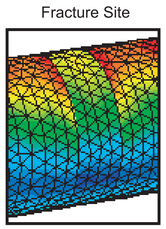
Figure 1. The Osteonexus prototype.

FINITE ELEMENT ANALYSIS

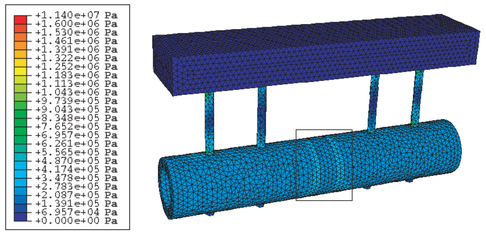
a) Osteonexus Active Dynamization



Maximum stress at fracture site: 1.3 MPa



b) Static Fixation



Maximum stress at fracture site: 0.3 MPa

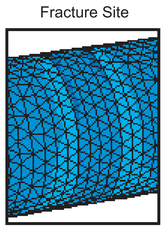


Figure 2. Stress distribution in tibia a) with active dynamization fracture fixation under 1 mm displacements. b) with static fracture fixation under weight bearing conditions of a 70 kg man.

- Stresses at fracture site are reduced under static fixation in comparison to active dynamization.
- Stresses on the order of magnitude of 1 MPa have been correlated to osteocyte differentiation and endochondral ossification[4,5].

The Osteonexus is expected to provide a faster healing response than current static fracture fixation methods.

POWER FEEDBACK

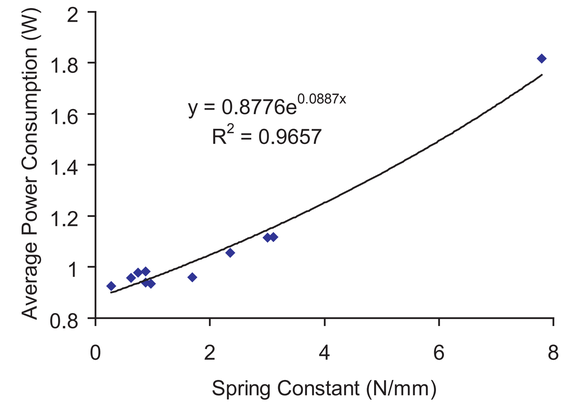


Figure 3. Average power consumption as a function of spring constant.

- The stiffer the spring, the more motor power is required to induce micromovement.
- The relationship between average power consumption and stiffness can be used as a standard curve.

Motor power draw can be correlated to fracture site strength to monitor the healing process.

CONCLUSIONS

- The Osteonexus is a unique dynamizing external fixator that actively induces controllable micromovements.
- Finite element analysis demonstrates that the Osteonexus design produces therapeutic stresses at the fracture site that would reduce healing time.
- Power consumption of the device provides the physician with a diagnostic tool to monitor fracture healing process.

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