Automation of the Taylor Spatial Frame for improved deformity correction

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Abstract

Goal: Create a device that automatically adjusts the Taylor Spatial Frame semi-continuously in smaller, discrete increments

•The Taylor Spatial Frame is an external fixation device for treatment of fractures and deformities through its motion with six degrees of freedom.

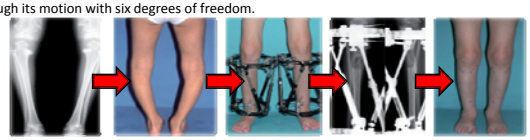

Figure 1: Treatment of tibia vara with the Taylor Spatial Frame[1]

- Current treatment options are limited
  - Depend on the patient to manually adjust the frame correctly
  - Only allow acute movement limiting the amount of bone movement per day
  - *Ilizarov observed "the better the distraction frequency the better the outcome"*
- Our device is designed to solve these problems
  - Automate strut adjustment
  - Allow more distraction per day, decreasing treatment time
  - Increased quality of regenerated tissue expected

Figure 2: Taylor Spatial Frame

Design Goals

Automated adjustment
- Computer controlled motor movements

Semi-continuous movement
- Frequent, small steps simulate continuous movement

Ease of use
- Doctors: Input deformity data into computer
- Patients: Connect device to control unit for ~8 hours each day

Safety
- Emergency stop button for patient

Low cost
- Shortened treatment time decreases costs

Appropriate size and weight
- Attachment to the strut protrudes no more than 1½ inch

Durability
- Each unit and its parts should be able to last at least 10 treatment periods

System Overview

Essential System Properties
- Automated control
  - Computer software programs
  - Motor controller subunits
- Semi-continuous movement
  - Stepper motors
- Durability and weight
  - Aluminum struts
  - Delrin (plastic) gears
  - Carbon composite rings

Treatment Steps:
1. Frame is surgically attached
2. Doctor inputs the fracture data into the control unit
3. Patient plugs frame into the unit overnight for the treatment duration

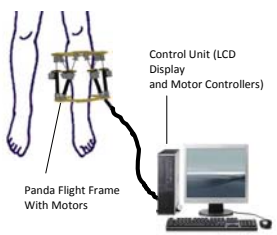

Figure 3:Total setup of the Panda Flight Frame

Strut and Motor Assembly

Struts

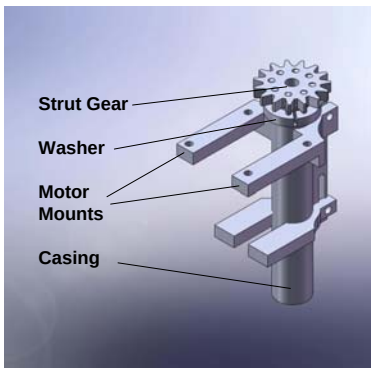

Figure 4: Strut casing with motor clamps and strut gear

- Struts connect to frame with U-joints at both ends
- Motors screw into clamps
- Threaded rod (cold-rolled steel, 5/16" diameter, 18 threads/in) located inside casing
- Strut gear connects to gear around motor shaft
- Gear ratio (strut gear : motor gear)=2:1

Gear-strut Interface

•Two gear system
- One attached to drive shaft, one attached to threaded rod

•Threaded strut gear
- Allows for vertical movement of the threaded rod when the gear turns

•Threaded gear is connected to a washer via screws
- Transfers rotational motion to washer from gear

•Washer fits into a fixed shoulder joint
- Limits axial and lateral movement of gear/washer

Figure 5 :Actual gear and washer setup

Motors

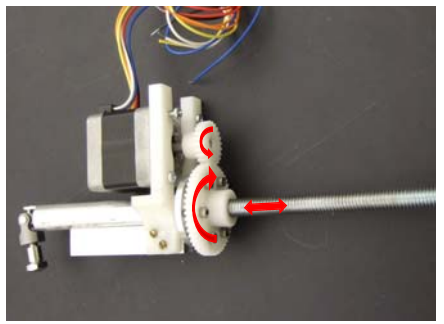

Figure 6: Perpetuation of movement the strut assembly

Stepper Motors
- Provide high torque with discrete movement intervals
- *Dimensions:* 1.38" x 1.38" x 1.38"
- *Weight*: 0.37 lbs.
- *Holding Torque*: 16.99 oz-in (required torque: 8.94 oz-in)
- 1.8˚/step

Figure 7: Stepper motor used to actuate the frame

Control Systems and Software

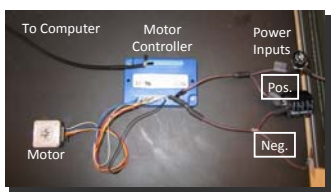

Figure 8: Motor and Motor Controller Assembly

Motor Controllers
•Each controller is connected to a single motor and to each other
•*Dimensions*: 4" x 2.7" x 1"
•RS-232 Interface (TxD, RxD & Gnd)

Data Format Conversion Macro
- Converts html data from TSF Chronic Deformity Correction Program to usable format

Motor Control Labview Program
- Uses converted data to calculate incremental motor movements
- Sends ASCII commands to motor controllers through serial cable

Figure 9: Labview program

Conclusions

•The Panda Flight Frame decreases patient responsibility for daily strut adjustments
•The automated system removes much of the human error involved in the use of the Taylor Spatial Frame
•Semi-continuous movement of the device will:
- decrease treatment time, saving time and money
- promote the growth of stronger bone tissue

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