Tibial Stent Design Team Progress Report

Client: *Dr. Matthew Halanski*
Advisor: *Dr. Paul Thompson*

Team:	*Evan Lange*	*elange2@wisc.edu (Team Leader)*
	Karl Kabarowski	*kabarowski@wisc.edu (Communicator/BSAC)*
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Date: *March 14th, 2014 – March 28th, 2014* *(Week 8-9)*

Problem Statement

(revised 02/03/14)

Tibia fractures are common in children, and these injuries are currently managed nonoperatively using casts; however, a surgically implanted device would provide more structural stability and aid the healing of the fracture. Adult patients with this injury typically have a rigid intramedullary device implanted into their tibia bone. Unfortunately, these implants cannot be used in pediatric patients due to the presence of growth plates at the implantation site. A previous design team produced a working device that can enter the medullary canal through a hole in the side of the bone and then expand outward to stabilize the fracture, held in place by static friction against the canal wall. This device is flexible enough to fit into the canal, yet rigid enough to maintain fracture reduction, can be secured in place with screws, and can be removed from the canal when desired; however, the device is not fully fixated against the walls of the bone canal, and the friction force of the device is not sufficient to prevent axial rotation within the canal. This rotation can lead to device failure resulting in unnecessary pain for the patient and extra surgery to correct the issue. Last semester, this team designed a theoretical device consisting of a threaded segmented centerpiece inside of a metal biaxial braid. When the centerpiece is rotated, the braid experiences a compressive load, which causes it to expand radially. This radial expansion would ultimately provide the force to stabilize the fracture; however, the current design does not allow for sufficient force to be applied to the centerpiece.

The goal of this semester is to improve the design from last semester by strengthening the centerpiece joints, which will give us the ability to build and test a prototype, and develop a novel tool that can rotate the centerpiece when the implant is placed into a bone.

Last Week's Goals (14-21 days ago)

- Complete bend testing of K-wires and determine final diameter for use as centerpiece in this design
- Complete SolidWorks modeling of caps, determine quantity to be ordered, and contact fabrication company
- Contact a Biomechanics, Engineering Physics, or Mechanical Engineering professor for guidance on the best method to obtain a benchmark bending stiffness for our device
- Outline plan for testing of braided cylinder

This Week's Goals/Individual Goals (14-0 days ago)

- Conduct research on flexible hollow drive shafts
- Determine K-wire thread count
- Construct testing apparatus & complete bend testing of K-wires to select a diameter for the centerpiece that will result in minimal plastic deformation after inserting the K-wire through the 45° hole in the side of the bone
- Obtain and prepare materials for preliminary bend testing apparatus
- Conduct preliminary bend testing of proof-of-concept device inside PVC tubing to investigate the impact of braid expansion on bending/shear properties of fracture point

- Meet with Dr. Halanski to get his feedback on final design and a method of implementing the device that involves putting the device into the canal at the top of the bone and removing from the bottom

This Week's Accomplishments

- Determined K-wire thread count for all K-wire diameters
- Extensive research on hollow flexible shafts conducted
    - conclusion: products do exist that could be used for our purpose – one of the devices that we found was the tool that is used to ream out intramedullary canals, so these devices can be used in the body and exist on the correct size scale for use with our device
- Constructed to-scale version of a lateral cross section of the bone canal using nails hammered into a 2x4
    - bent K-wires around these nails so that they follow the same path that they would when being inserted into the body
    - measured plastic deformation of the K-wires using ImageJ
    - conclusion: selected K-wires of diameter 5/64" for use as centerpiece because it showed acceptable levels of plastic deformation – 3/32" diameter may also be useable, so we may order caps for both diameters & construct devices using both 5/64" and 3/32" diameters
- Obtained PVC pipe and weights for braid bend testing using proof-of-concept device
- Completed SolidWorks models of top and bottom caps for using both 5/64" and 3/32" diameter K-wire centerpieces
- Created drawing of plans for fabrication of braid bend testing apparatus
    - Plan to fabricate apparatus and conduct testing after client meeting on Friday
- Client meeting scheduled for Friday (3/28)
    - Plan to discuss implementation strategy for the device and obtain feedback on final design before ordering the device

Project Difficulties

- none

Next Week's Team Goals

- Analyze bend testing results over the weekend to confirm the efficacy of the proposed device
- Finalize design specifications over the weekend
- Confirm thread count of 5/64" and 3/32" diameter K-wires
    - +/-1 thread per inch error on the counts from the images due to the angle that the image was taken
- Order caps of both 5/64" diameter center hole & 3/32" diameter center hole from fabrication firm on Monday
- Contact manufacturers of hollow flexible shafts to discuss use of their product with our device
- Investigate the amount of torque that must be delivered to the nut for maximal fracture stabilization by the braid
    - plan preliminary testing if necessary – modify proof-of-concept to current design (no longer twisting centerpiece), scale down braid to appropriate length and measure torque required inside PVC

Summary of Design Accomplishments

- The team is meeting weekly to accelerate the design process
- The team has a meeting scheduled with the client to discuss goals for this semester and to obtain information about quantifying device performance constraints
- The team has met with Dr. Halanski to discuss goals for this semester

- The team has completed the Design Matrices for this semester and the Midsemester Presentation
- The team has completed the Midsemester Report
- The team has conducted bend testing of K-wires and finalized 2 candidate diameters that are ideal for use with this device

Expenses

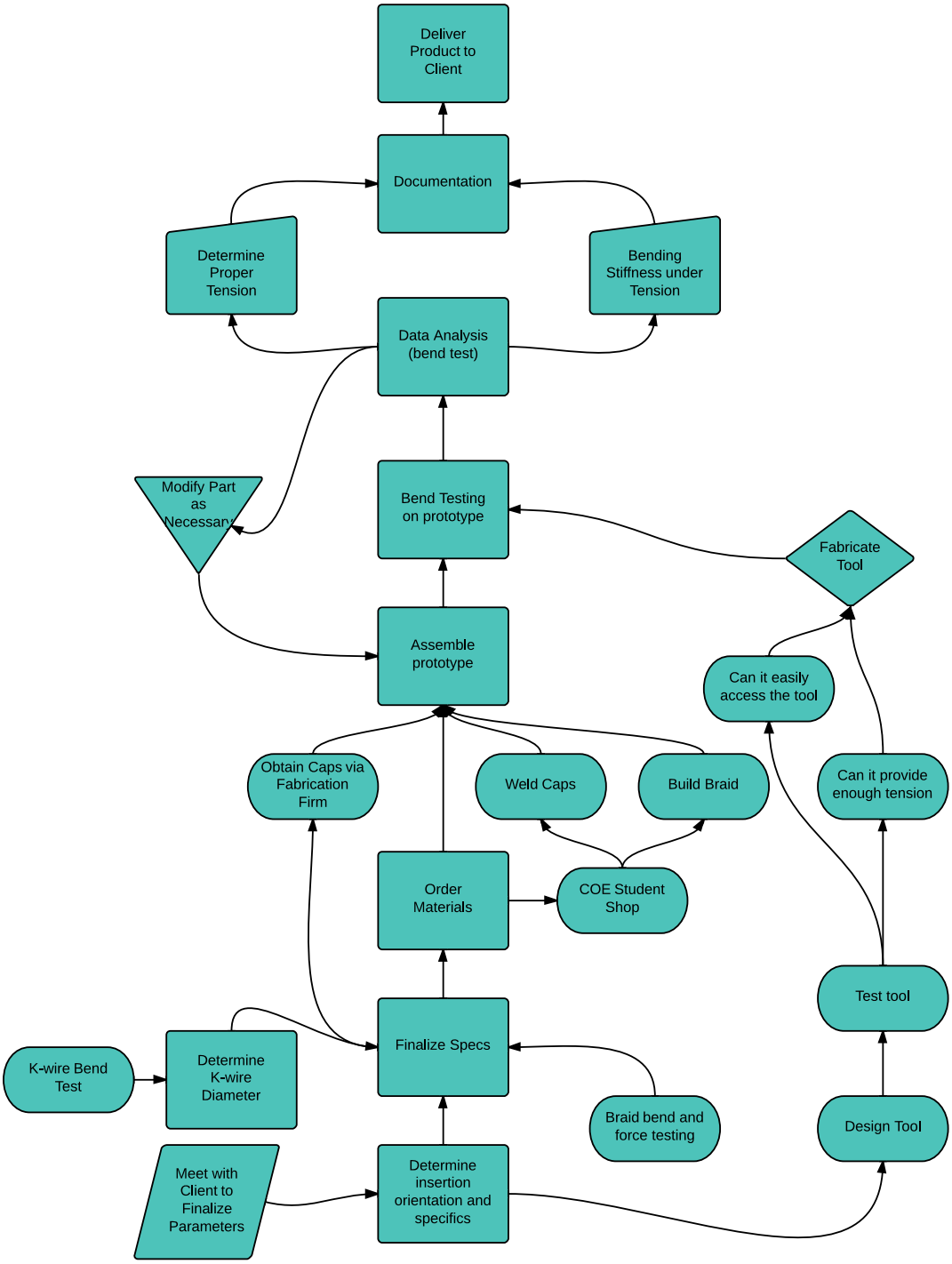
- none at this time

Schedule for Spring 2014

Task	*January*	*February*				*March*					*April*				*May*	
	31	7	14	21	28	7	14	21	28	31	4	11	18	25	2	9
Groundwork																
Set Meeting Time	X	X														
Brainstorming	X	X	X	X	X	X	X	X	X							
ECB 2005 Access	X	X	X	X												
Testing																
Cast Material					X	X	X									
Braided Structure					X	X	X									
Prototyping																
Order Materials						X	X	X								
Build Prototype							X	X	X							
Test Prototype								X	X							
Deliverables																
Progress Reports	X	X	X	X	X	X	X	X	X							
Notebooks	X	X	X	X	X	X	X	X	X							
PDS	X	X	X	X												
Midsemester Presentation				X												
Midsemester Report				X	X											
Final Poster																
Final Report																
Meetings																
Advisor Meeting	X	X	X	X	X	X	X	X	X							
Team Meeting	X	X	X	X	X	X	X	X	X							
Client Meeting			X			X			X							
Website																
Update	X	X	X	X	X	X	X	X	X							

Activities

Person(s)	Task	Time (hrs)	Weekly Total	Semester Total
Evan	*Team Role (Leader)*		17.5	67.5
	Weekly progress report	1.0		
	Developed next week's team goals	1.0		
	Other			
	Image Editing & Thread Counting	4.0		
	Drawing of lateral cross-section of tibia	4.0		
	Obtain various materials for testing	1.0		
	K-wire Bend Testing (Tues)	2.0		
	K-wire Bend Testing (Wed)	2.0		
	Weekly Team Meeting	1.5		
	Bend Testing PVC fabrication drawing	1.0		
Karl	*Team Role (Communicator)*		6.5	56.5
	Contacted Dr. Thompson and Dr. Halanski re: Fri Meeting	1.0		
	Other			
	Weekly Team Meeting	1.5		
	K-wire Bend Testing (Tues)	2.0		
	Brainstorming	2.0		
Tyler	*Team Role (BPAG)*		12.0	48.0
	n/a			
	Other			
	Research Drive Shafts & Testing	6.5		
	Weekly Team Meeting	1.5		
	K-wire Bend Testing	2.0		
	SolidWorks	2.0		
Sarah	*Team Role (BWIG)*		9.0	44.0
	Updated design website	0.5		
	Other			
	Research	6.0		
	Weekly Team Meeting	1.5		
	K-wire Bend Testing & ImageJ analysis (Wed)	1.0		


Deliver Product to Client
Documentation
Determine Proper Tension
Bending Stiffness under Tension
Data Analysis (bend test)
Modify Part as Necessary
Bend Testing on prototype
Fabricate Tool
Assemble prototype
Can it easily access the tool
Obtain Caps via Fabrication Firm
Weld Caps
Build Braid
Can it provide enough tension
Order Materials
COE Student Shop
Test tool
K-wire Bend Test
Determine K-wire Diameter
Finalize Specs
Braid bend and force testing
Design Tool
Meet with Client to Finalize Parameters
Determine insertion orientation and specifics