WEEKLY SPONSOR COMMUNICATION

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TEAM NAME AND NUMBER:	AESCULAP 1
DATES COVERED IN THIS COMMUNICATION:	APRIL 18, 2016 TO APRIL 24, 2016
WEEK NUMBER:	10 OF 15

Overview

This week we individually researched various topics to provide our team with sufficient knowledge to decide the distraction method design we will be pursuing. These topics included: grip strength, cost estimates and sterilization techniques. Christian also generated sketches for force analyses of the Pliers and Internal Expansion designs and a measurement system for Internal Expansion. I began working on ideas for the interchangeable connect system and created a 3D model of one of the ideas. Additionally, we also ordered a pair of parallel pliers from McMaster Carr.

Accomplishments

1. Alexis researched grip strengths to establish a baseline of what our distractor's mechanical advantage must be to distract the minimum 1000N target specification. She found the lowest average grip strength based on age groups of 18-29, 30-39, and 40+ to be 328.64N for the age group 40+[1]. A table depicting the grip strength of the age groups can be found in Appendix A.

2. Christian sketched force analyses for the Pliers and Internal Expansion designs, which are illustrated in Exhibits 1 and 2. He did so to determine the idealized relationship between the distraction force and the force applied by the surgeon to the distractor and to establish a system of equations to be used to determine the length of the handles in these designs. For the Pliers design, he computed the force analysis equation to be $\frac{F_a}{F_d} = \frac{r_d}{r_a}$. For the Internal Expansion design, he determined the force analysis equation to be $\frac{F_a}{F_d} = \frac{r_c}{r_a}\tan\theta$. Using a desired distracting force of 2000N (safety factor of 2) and a grip force of 300N (a slightly lower value than Alexis cited as an additional safety factor), he calculated the equation $r_a = 6.67r_d$ for the Pliers design and $r_a = 6.67r_c\tan\theta$ for the Internal Expansion design, where r_a refers to the required length of the handles. Christian's mathematical work depicting these equations can be found in Appendix B.

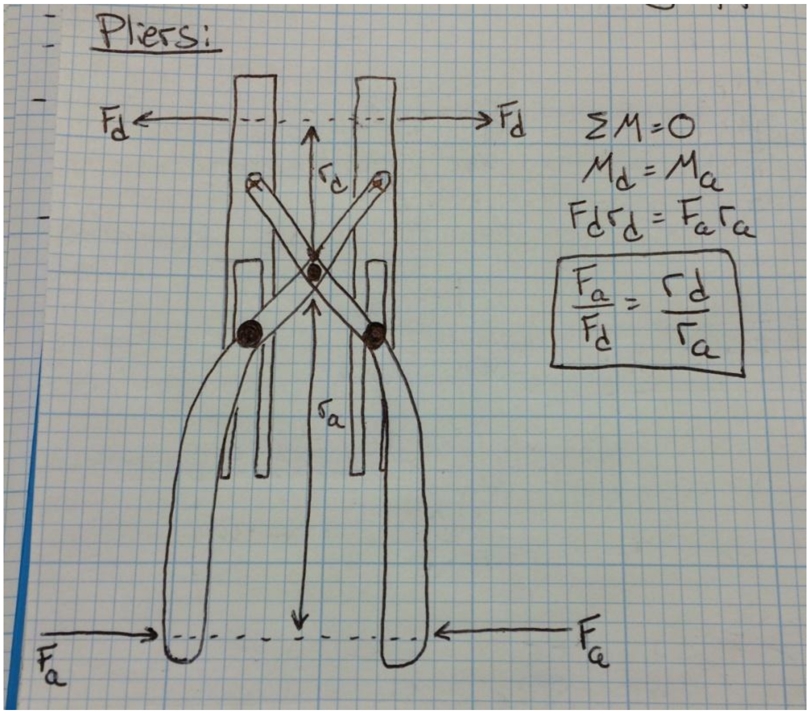


Exhibit 1 Force Analysis of Pliers Design

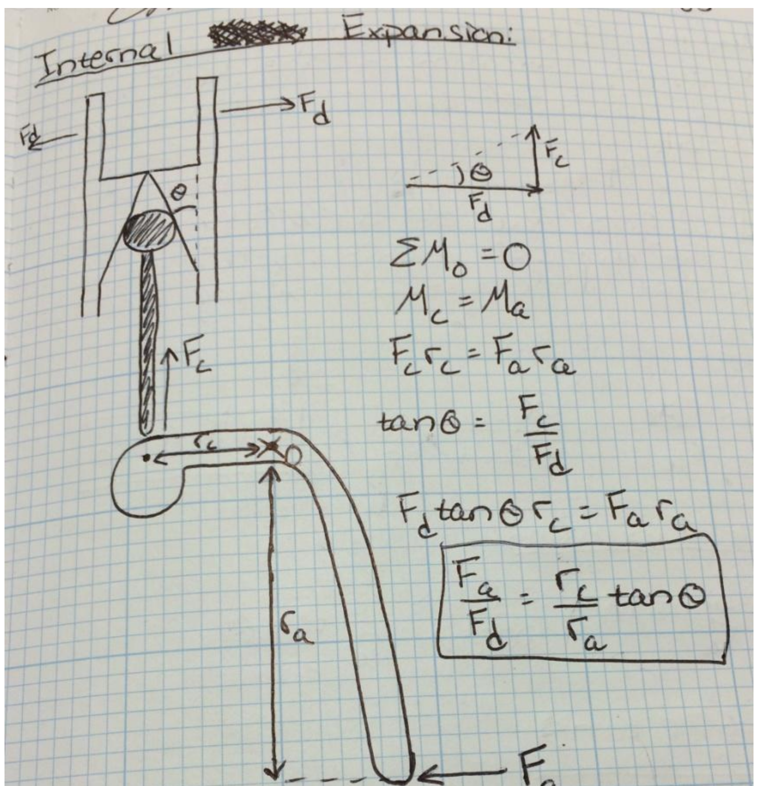


Exhibit 2 Force Analysis of Internal Expansion Design

3. Christian also sketched an embodiment of a measurement system for the Internal Expansion design. The sketch entails a "window" in the distraction

handle that exposes the internal ratcheting system. The gear train of the ratchet system translates with the actuation of the lever/handle to numbers on the gears corresponding to the distraction widths which can be seen through the window. This window will also act as an opening to improve sterilizability of the internal components of the distractor. This idea is depicted in Exhibit 3.

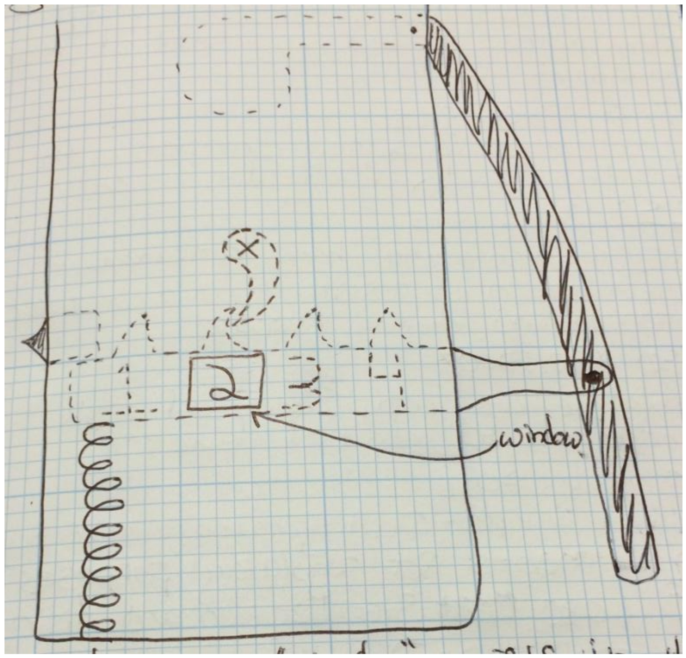


Exhibit 3 Measurement System for Internal Expansion Design

4. Jadon ordered parallel pliers from McMaster Carr to give us a better visualization of how the Pliers and Pliers-S designs function. A picture of the parallel pliers is included in Appendix C.

5. Cassie O. began working on the cost estimates of the three designs. She looked at various online retailers to familiarize herself with the parts and detailing of those parts that are available.

6. I began thinking of paddle connect systems so surgeons can efficiently interchange the various paddles to the instrument. I 3D modeled the design I am referring to as Slit-and-Lock on Autodesk Inventor. The idea consists of the interchangeable paddle having a small extruded square that slides though a track in the complementary face at the end of the distractor. The CAD models of the interchangeable paddle and the complementary face are shown in Exhibits 4 and 5, respectively.

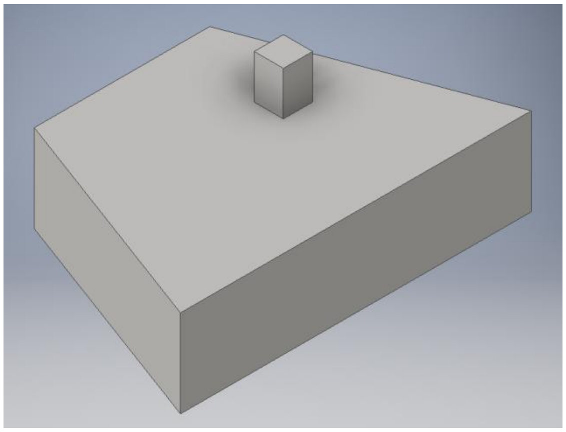


Exhibit 4 Interchangeable Paddle Design for Slit-and-Lock Design

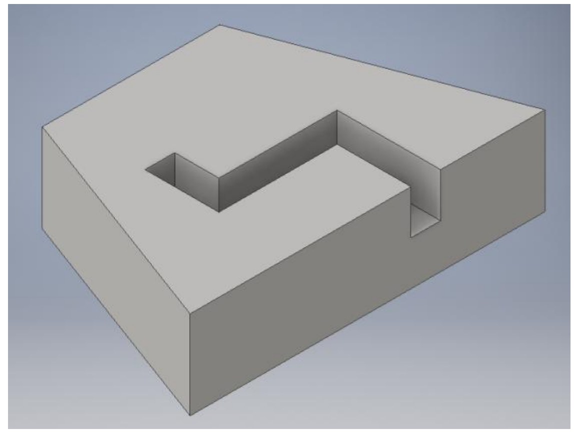


Exhibit 5 Complementary Face to Interchangeable Paddle for Slit-and-Lock Design

7. We were concerned about various components of the three distraction method designs having difficulty being sterilized due to their complexity or location within the distractor, so I researched common sterilization techniques in hospitals. I found steam sterilization to be the most common method and that the steam in the autoclave must be able to make contact with all surfaces of the device in order to sterilize the instrument. This information will affect how we rate the sterilizability of our designs and may cause us to make some changes to our designs, such as adding ventilation holes to the box in Internal Expansion.

Next Steps

1. Using the research we have conducted the last several weeks, we will be deciding which distraction mechanism to pursue on Wednesday, April 27th. After which, we will delve into paddle designs, the paddle connect system ideas, and impaction handle attachment concepts.
2. Cassie O. will continue to make progress on the cost estimates of our three distraction method designs.
3. Brian and Jadon will continue investigating ratchet systems to create designs to be used for our distractor.
4. Christian will research the size of vertebrae to establish the ideal area of the paddle to alleviate stress concentrations that may occur from inserting the distractor.
5. I will 3D print my Slit-and-Lock paddle connect system design, as well as continue to generate ideas for the paddle connect system.

Project Related Questions

1. Do you have any knowledge on ideal geometry and sizing of the paddles?

References

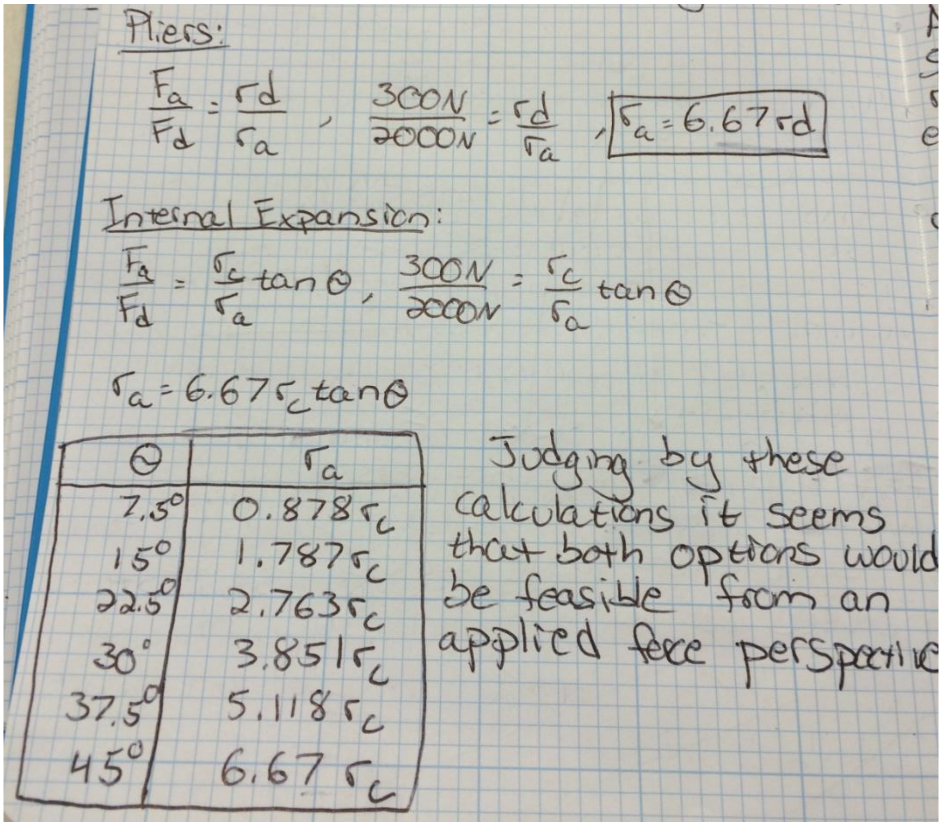
1. Astin, Angela DiDomenico. "Finger Force Capability: Measurement and Prediction Using Anthropometric and Myoelectric Measures." Thesis. Virginia Polytechnic Institute and State University, 1999. Print.

<u>Appendix A:</u> Grip Strength of Three Age Groups

Table 4. Summary of strength and variability in each of the finger couplings and for simple grip classified by age.

Age	Measure	Poke	Press	Pull	Lateral	Chuck	Palmar	Grip
	Mean (N)	44.27	41.60	57.57	78.93	77.88	51.95	359.91
18-29	Standard Deviation (N)	18.12	18.54	23.77	28.96	28.42	17.76	114.55
(n=61)	Coeff. of Variation (%)	40.93	44.58	41.29	36.69	36.49	34.18	31.83
	Mean (N)	48.69	44.35	63.76	85.49	86.06	59.32	449.45
30-39	Standard Deviation (N)	16.09	16.89	23.87	27.06	30.02	14.85	104.53
(n=19)	Coeff. of Variation (%)	33.04	38.08	37.44	31.65	34.88	25.04	23.26
	Mean (N)	48.46	46.24	64.28	82.69	79.45	56.01	328.64
40+	Standard Deviation (N)	18.40	19.84	30.73	27.40	30.24	24.48	109.51
(n=20)	Coeff. of Variation (%)	37.96	42.92	47.80	33.14	38.06	43.70	33.32

<u>Appendix B:</u> Christian's Mathematical Work for Establishing Force Analyses Equations



<u>Pliers:</u>

$$\frac{F_a}{F_d} = \frac{r_d}{r_a}, \quad \frac{300N}{2000N} = \frac{r_d}{r_a}, \quad \boxed{r_a = 6.67 r_d}$$

<u>Internal Expansion:</u>

$$\frac{F_a}{F_d} = \frac{r_c}{r_a}\tan\theta, \quad \frac{300N}{2000N} = \frac{r_c}{r_a}\tan\theta$$

$$r_a = 6.67 r_c \tan\theta$$

θ	r_a
7.5°	$0.878 r_c$
15°	$1.787 r_c$
22.5°	$2.763 r_c$
30°	$3.851 r_c$
37.5°	$5.118 r_c$
45°	$6.67 r_c$

Judging by these calculations it seems that both options would be feasible from an applied force perspective

<u>Appendix C:</u> Pliers from McMaster Carr