e-NABLE: Create a hold and release mechanism for hand designs

Design Matrix

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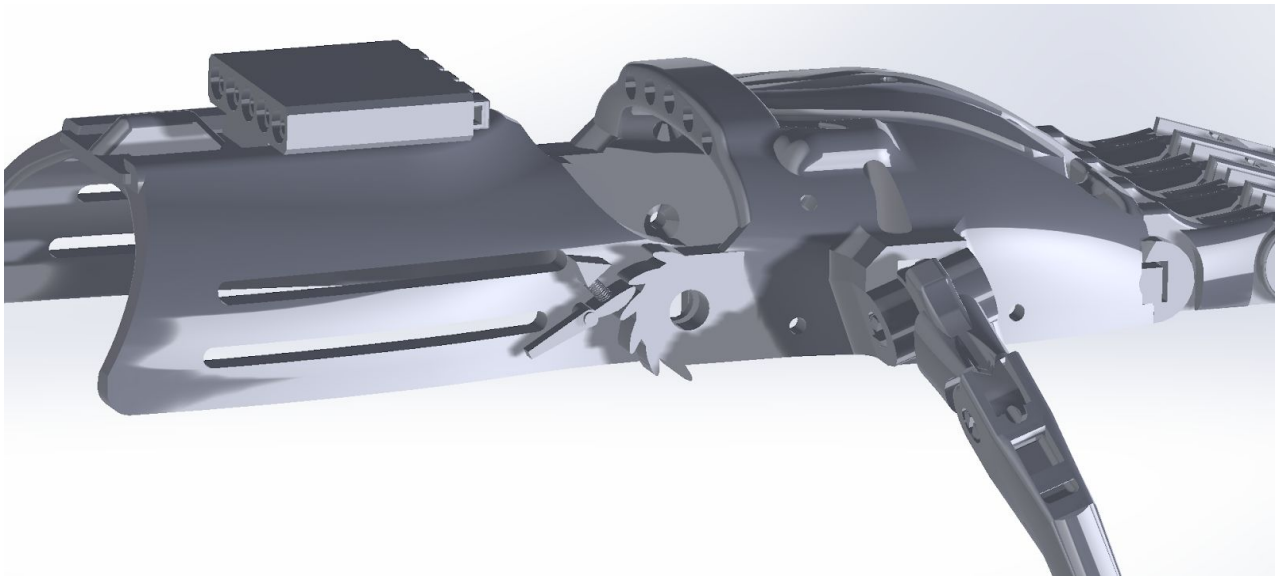
Date:

Key Features of Designs

Pawl Ratchet Mechanism

The pawl ratchet locking mechanism design is largely based on the original design with small modifications to the palm piece, gauntlet, and wrist joint. The gripping mechanism would still be operated wrist flexion, however a pawl ratchet mechanism would be implemented to lock the forward wrist movement in place. While the user would still have their wrist bent forward to close the hand, tension would be taken off of the wrist and remove the need for constant flexion. The gear head would be 3D printed as one piece along with the palm. The pawl and spring would be attached to the forearm gauntlet with a cover over the spring allowing the wrist to be locked in place. A simple lever would be used on the back of the pawl to release the mechanism.



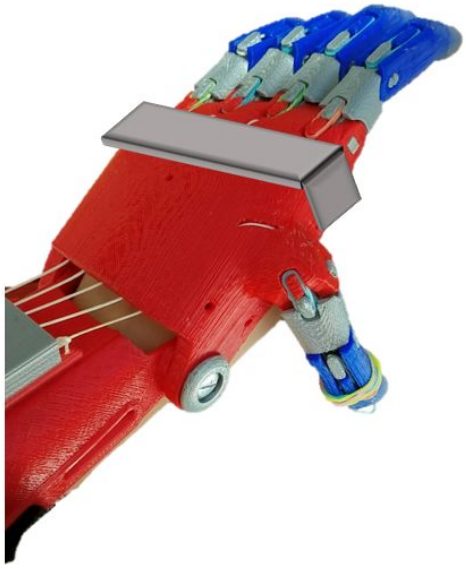
Gear Shift

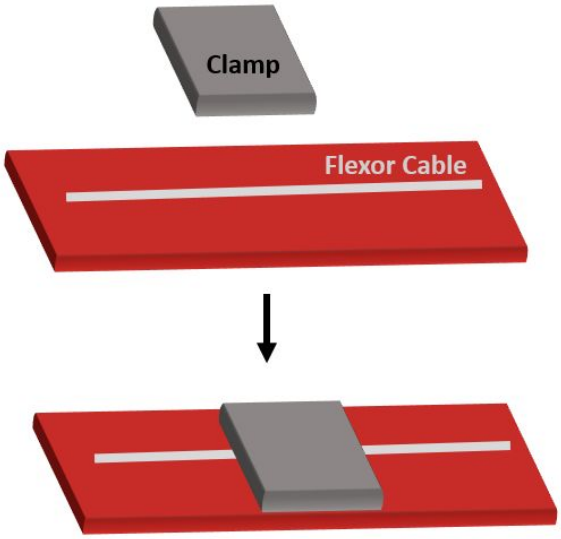
The gear shift design incorporates a sliding track and grooves that the tensioner component can lock into. This design allows the user to keep the option of flexing their wrist to close the fist, while adding a locking mechanism if desired. To utilize the locked grip, the user would pull the tensioner block to the desired position using their free hand, and then slide the block into the corresponding tilted groove. From here, tension in the flexor elastics is maintained by the increased distance of the elastics from their corresponding attachment points in each digit, which then cause the fist to close, thus shortening the distance. However, unlike the existing design, in which the user must maintain a force to counter the elastic force produced by the flexor elastics, in the Gear Shift design the elastic force is balanced by a reaction force produced in the groove of the design.

Hand Clamp

The hand clamp design incorporates a clamp on the top of the hand that would hold the flexor cables taut and prevent the fingers from extending. This design has many advantages: the locking mechanism can be engaged when wanted/necessary so the device can be used normally when locking is not needed, the user can freely flex/extend their wrist once the locking mechanism is employed, and it does not require any springs or metal. One potential issue with this design could be fully locking the flexor cables without slippage. Additionally, it could be difficult to source the materials necessary for the locking bar to work properly.

Hand Clamp Mechanism





Knob - Hand Ratchet Mechanism

The knob mechanism works with the same mechanics as the pawl ratchet. The difference being there is no longer a gauntlet that attaches to the arm of the user. The entire closing mechanism is on the back of the hand, with a knob that turns to wind up the tension cables. The mobility of this design is a bonus because the user now has full range of wrist motion. The downside is the only way to use the hand mechanism is to twist the knob on the hand with the users free hand, there is no way to have one-handed use. The release mechanism is the same as the pawl ratchet, with a push button that allows the knob to spin and release the tension.

Knob Rachet Mechanism

Design Criteria

Ease of Use: The ease of use grade was determined by the number of hands required to use the device for normal use, and prolonged holding usage. When holding an object for a prolonged period of time required two hands, it was given 1 point. Using one hand with the second assisting was 3 points. Only needing one hand was 5 points. Requiring extra or less hands for normal use and being able to flex or un-flex the wrist during prolonged use were bonus +/- points awarded as deemed appropriate. For example, the hand clamp design received 4 points, because 3 for one hand with assist plus the extra point for being able to use it with only one hand during normal use.

Hand Precision: Hand precision was defined as the ability for the fingers to grip multiple sized objects. Currently when the wrist is flexed the fingers close around the object and grab it. When we make the new design, the goal is to maintain as much of this flexibility as possible. The ratings for the designs are based off the ability to theoretically grab multiple sized objects. The hand clamp design wins this category because you close the wrist normally, and then choose to apply the brake after the size has been determined. The other designs using ratchets scored lower because you are only allowed as much precision as there are ratchet positions. The gear

shift design received the least points because there is a limited number of stops possible for shift feature to work with.

Sourcing/Cost: Sourcing and cost are concerns for eNABLE devices. These prosthetics are often sent to third-world countries, so it is important that any materials used can be easily found (for both assembly and replacement parts. Additionally, given the target-population, these devices should be as low-cost as possible (~$12-20). The designs were evaluated based on the cost and perceived sourcing of extra parts needed for each device beyond current eNABLE prosthetics.

Ease of Assembly: For eNABLE devices, it is important that the prosthetics can be easily assembled. On the eNABLE website, they even show a ten year old and a one-handed man assembling their devices. Therefore, this category was defined as the expected difficulty to assemble our design as compared to existing devices.

Safety: Safety was defined as the potential for failure within a device. For example, if one of the locking mechanisms were to slip, the object being held by the user would fall and potentially cause injury.

Design Matrix:

	Pawl ratchet Mechanism		Gear Shift Mechanism		Hand clamp - (put on the breaks)		Knob - Hand Ratchet Mechanism	
Ease of use (30)	18	3/5	12	2/5	24	**4/5**	6	1/5
Hand precision (25)	15	3/5	10	2/5	25	**5/5**	20	4/5
Sourcing/ Cost (20)	16	4/5	20	**5/5**	8	2/5	16	4/5
Ease of assembly (15)	12	3/5	15	**5/5**	12	4/5	9	3/5
Safety (10)	8	**4/5**	8	**4/5**	4	2/5	8	**4/5**
Total (100)	69		65		**73**		59	

Conclusion

Based on the criteria outlined in the previous section the hand clamp design was determined to be the best design by a narrow margin over the pawl ratchet mechanism. The hand clamp design would be the easiest to use and more ergonomic than the other designs as it allows for normal one handed use of the device but then additionally allows for the option to lock the grip and once the hand is closed and locked, the user still has wrist movement. It also would have the highest hand precision out of the designs considered because it does not rely on the hand grip to match up with a gear teeth. The Hand Clamp will need a couple of new materials including some sort of rubber for the break and a specific type of cable- rather than fishing line which is sometimes used- to ensure the clamping mechanism does not break it. Other designs rated higher because there would be minimal, if any, extra materials required. Once the new parts are printed there will not be a significant increase in assembly difficulty because there are no springs or complex pieces in this design. Lastly, the Hand Clamp rated low in safety because of the anticipated potential for slippage failure more than other devices.