

Gen1 Open Source Hand Work Instruction

by  TetherIA

Useful Tools

Tools:

1mm drill bit
2mm drill bit
2.1mm drill bit
Hand drill
Exacto Knife
Flash Cutters
File
Soldering Iron
Needle Nose Pliers
Phillips Driver
Torx Driver
Measuring Tape
Marker
Scissors

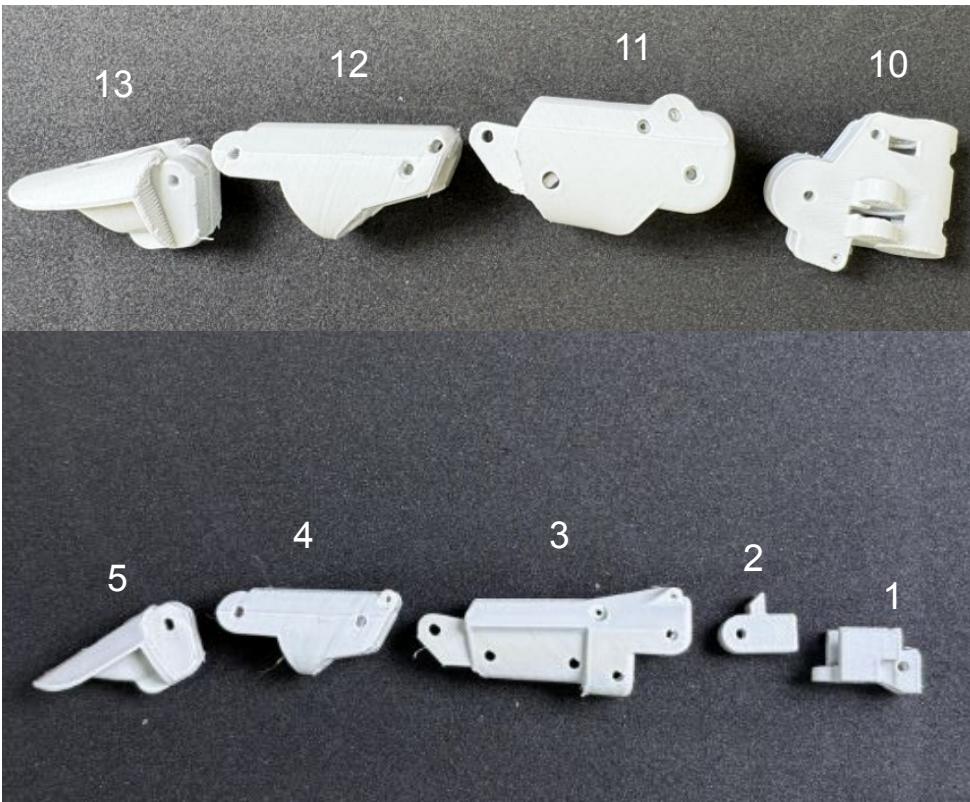
Consumables:

Super Glue
Loctite (blue 496)

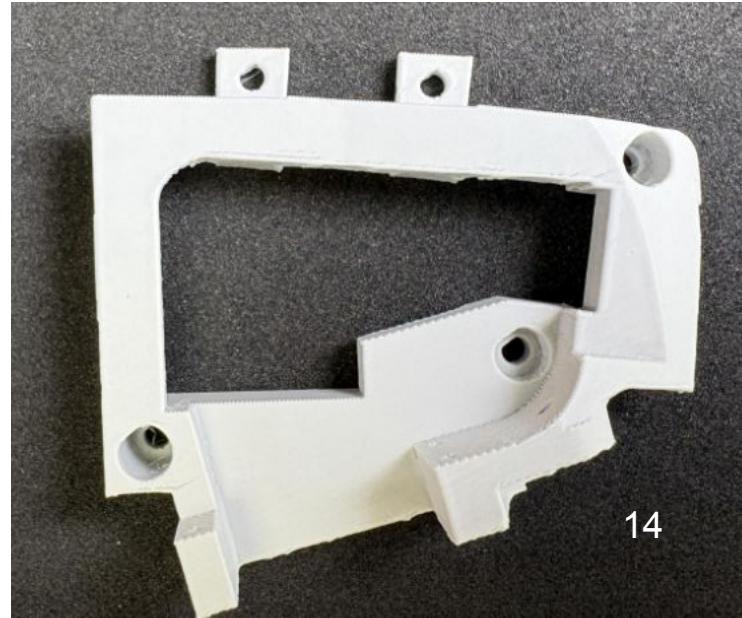
Optional:

2-Part Expansion Foam
Foam Molds
Mold Release Agent
Hot Glue
Finger Tip Silicone Cover
Protoboard
22awg solid core wire
Reset tactile button
Solder Flux
Solder
Hot Glue Gun
Heat Insert Tip
Molex 3pin female Connector
Palm Foam
Sandpaper

3D Printed Parts



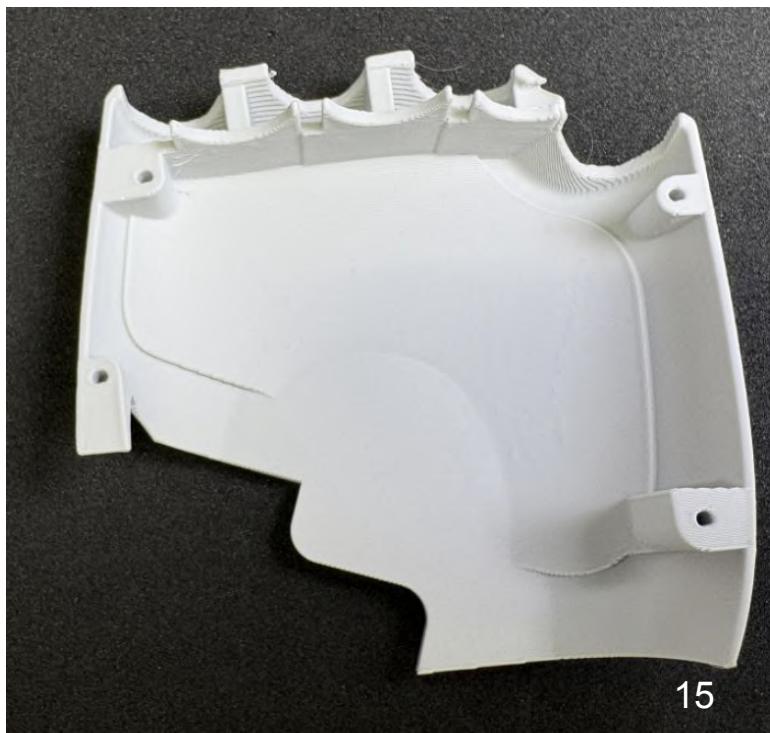
PN	Name	QTY
01	Finger Base	4
02	Finger MCP	4
03	Finger Proximal	4
04	Finger Medial	4
05	Finger Distal	4
10	Thumb CMC Base	1
11	Thumb MCP	1
12	Thumb Proximal	1
13	Thumb Distal	1



14



16



15

PN	Name	QTY
14	Servo Frame	1
15	Palm Front Frame	1
16	Palm Rear Frame	1

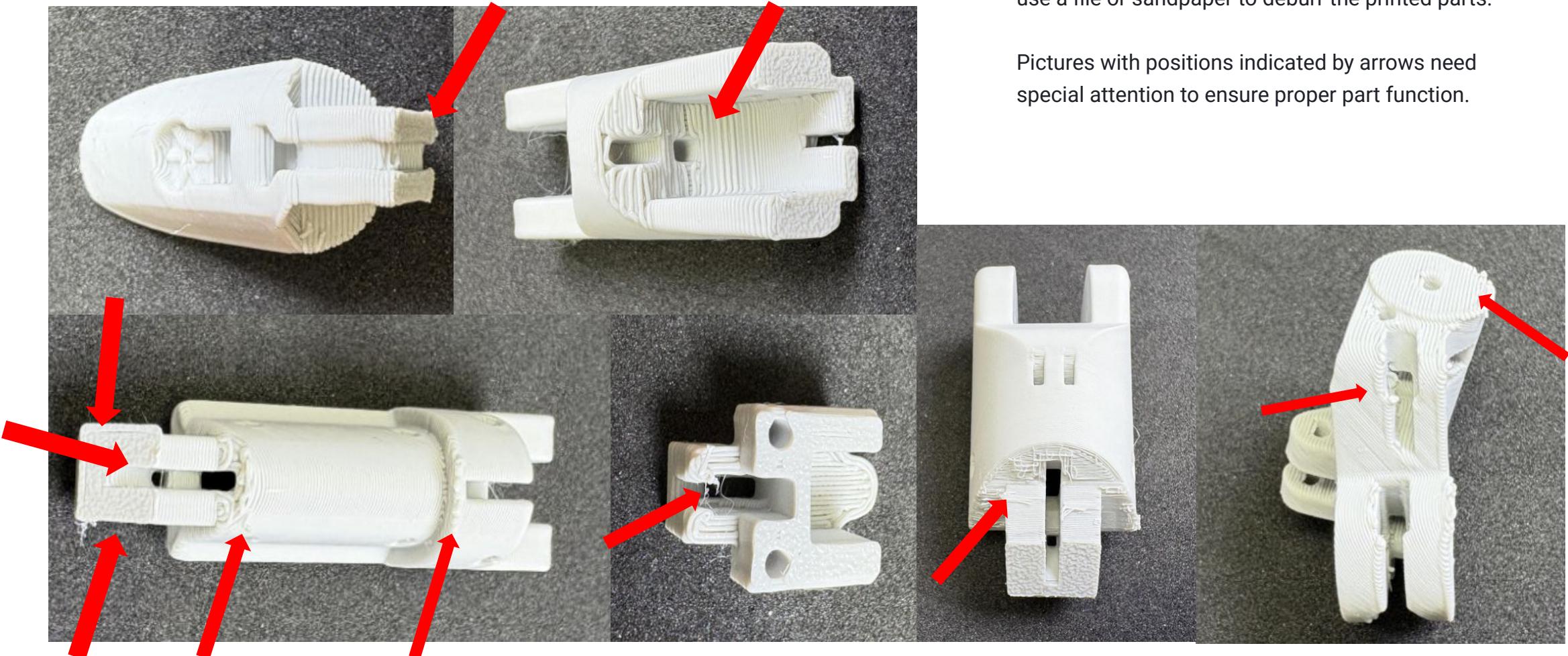
3D Print Cleanup

Tools:

File
Sandpaper
Flash Cutter
Hand Drill (1mm, 2mm, 2.1mm)

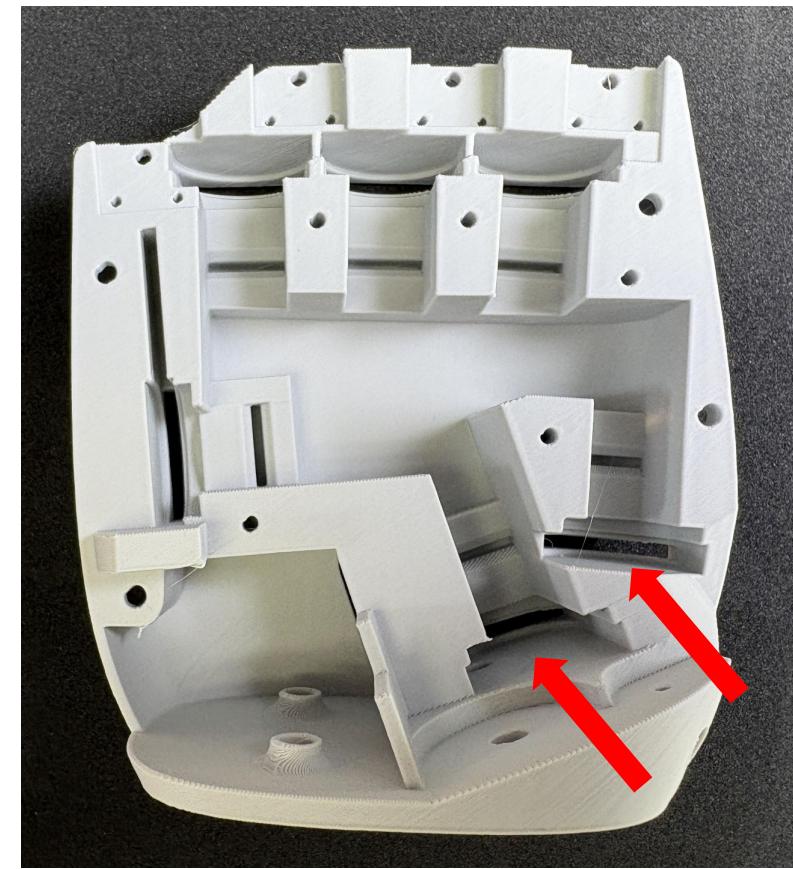
Name	Part Number	QTY
Finger Base	1	4
Finger MCP	2	4
Finger Proximal	3	4
Finger Medial	4	4
Finger Distal	5	4
Thumb CMC Base	10	1
Thumb MCP	11	1
Thumb Proximal	12	1
Thumb Distal	13	1
Servo Frame	14	1
Palm Front Frame	15	1
Palm Front Frame	16	1

Debur 3D Printed Components



Use a flush cutter to remove the supports. Then, use a file or sandpaper to deburr the printed parts.

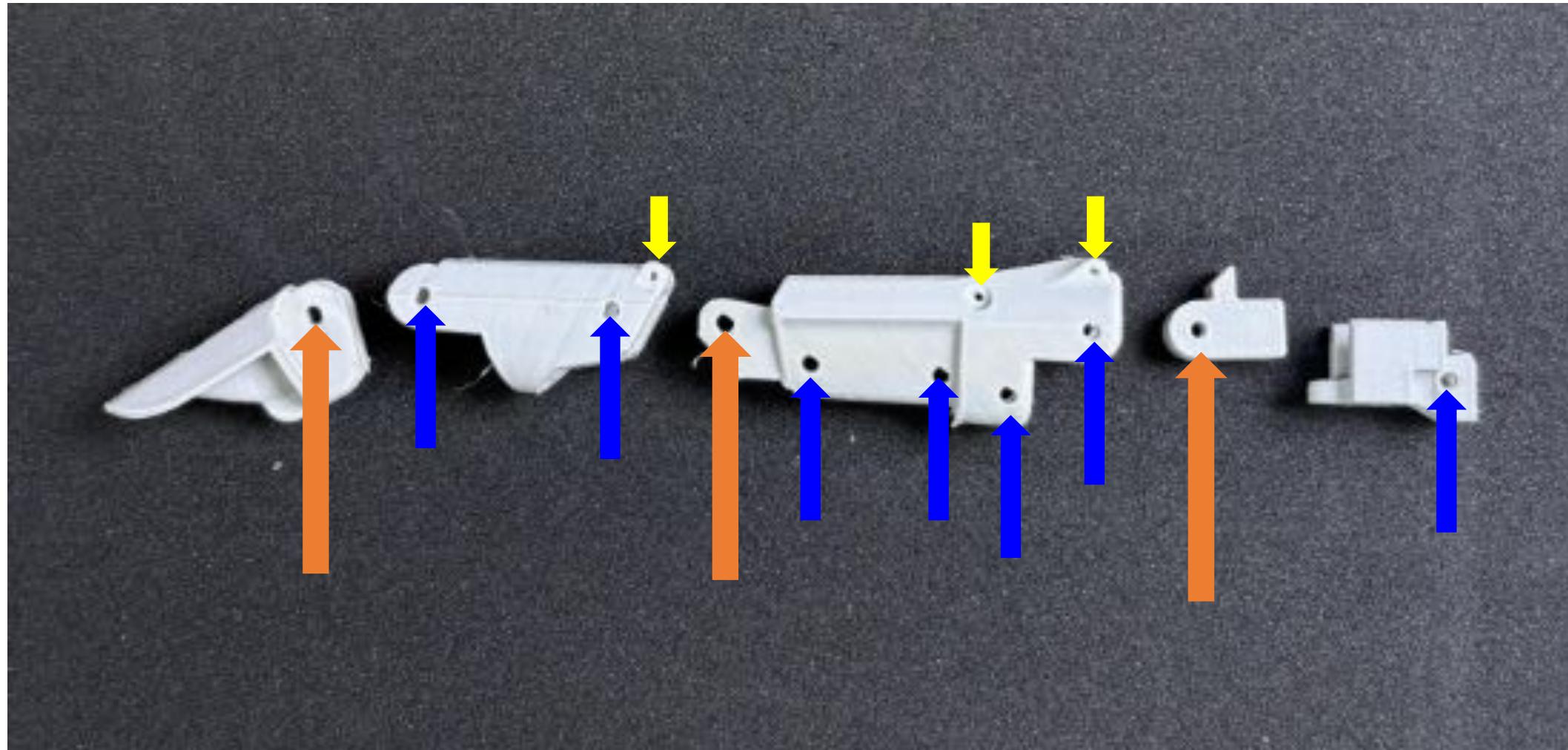
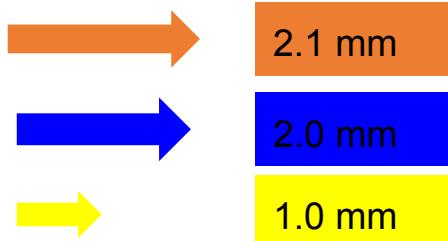
Pictures with positions indicated by arrows need special attention to ensure proper part function.



Drill

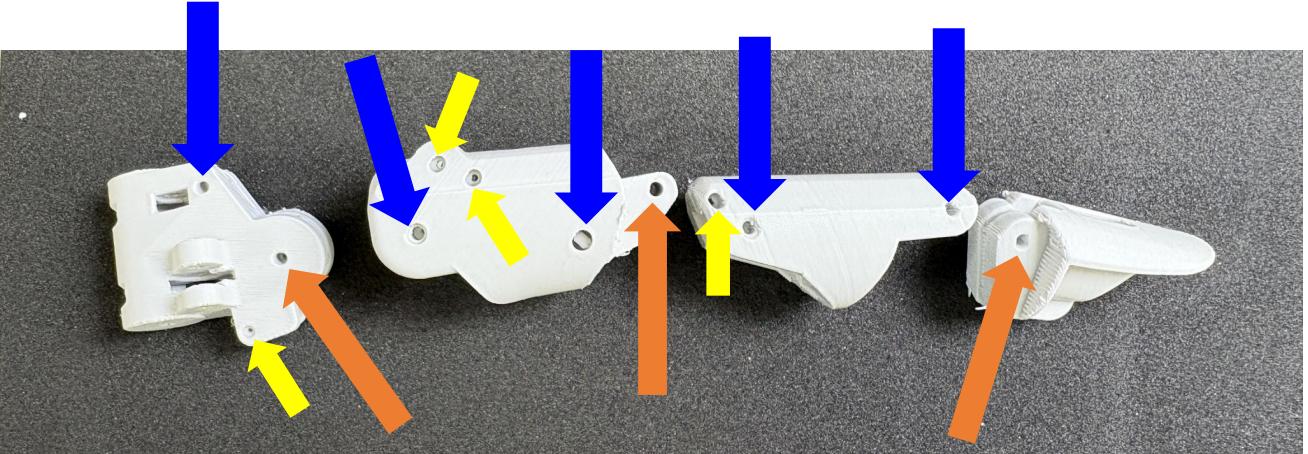
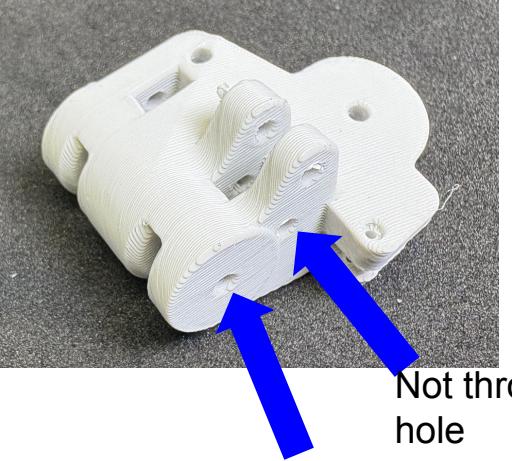
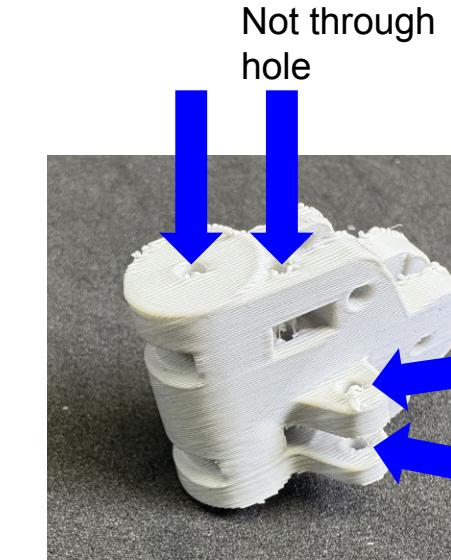
1. Drill out holes in finger joints for all four fingers

Note: All holes are through holes



Drill

1. Drill out holes in thumb joints



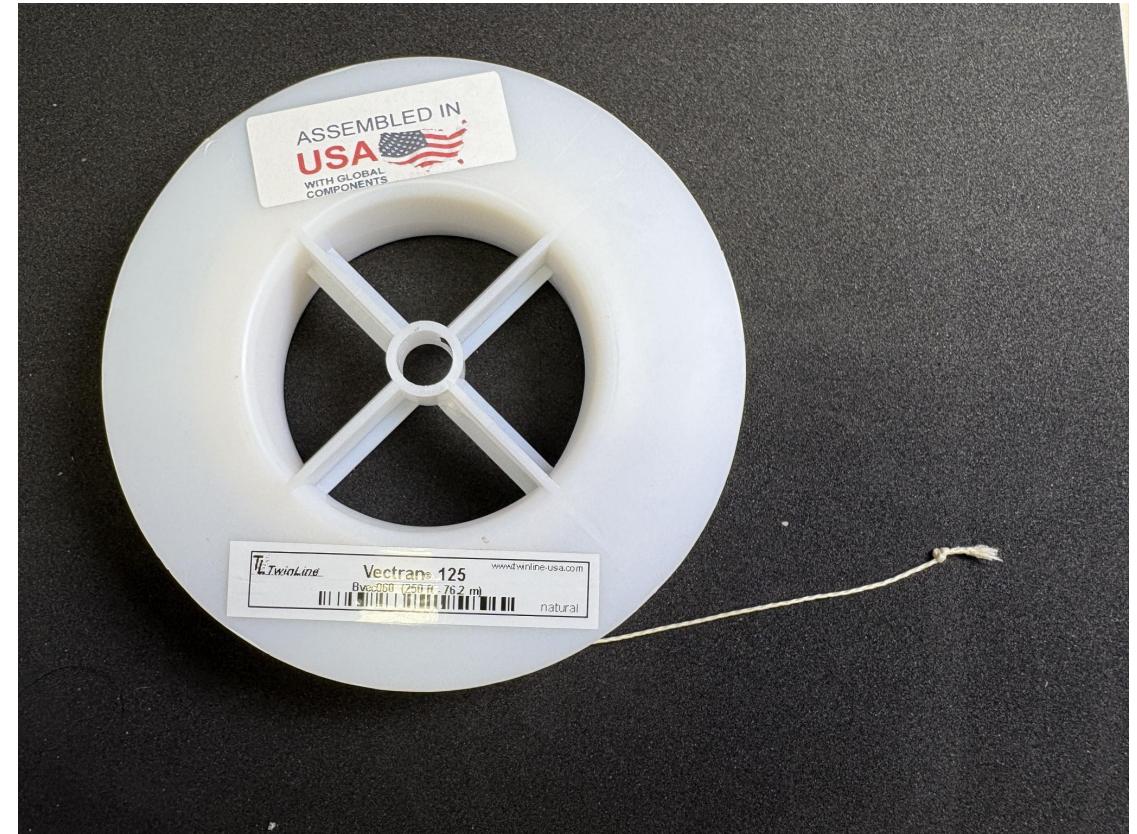
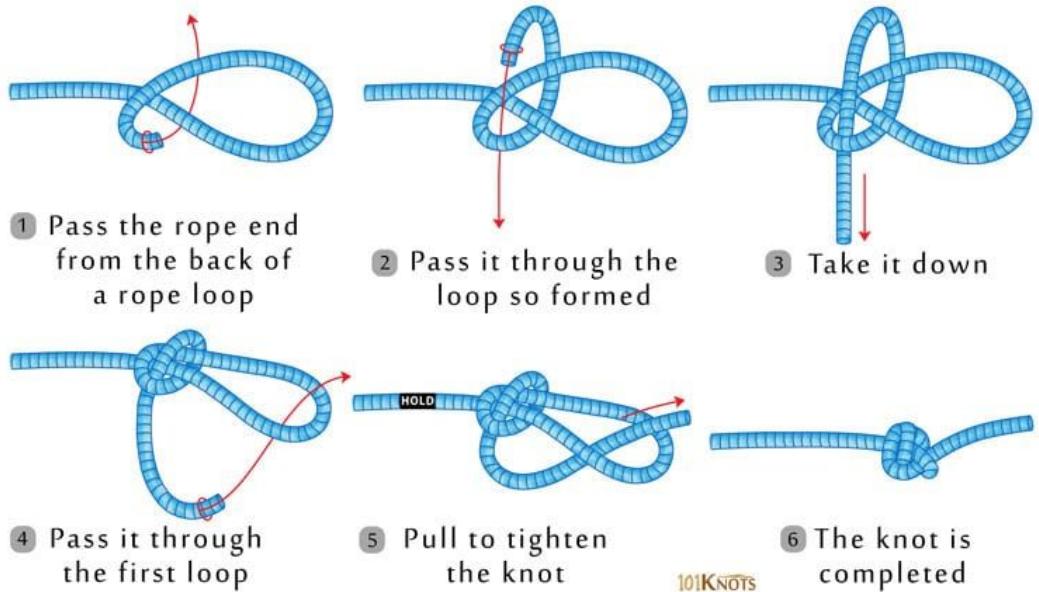
Cable Pre-assembly

Tools:
Scissors
Measuring Tape

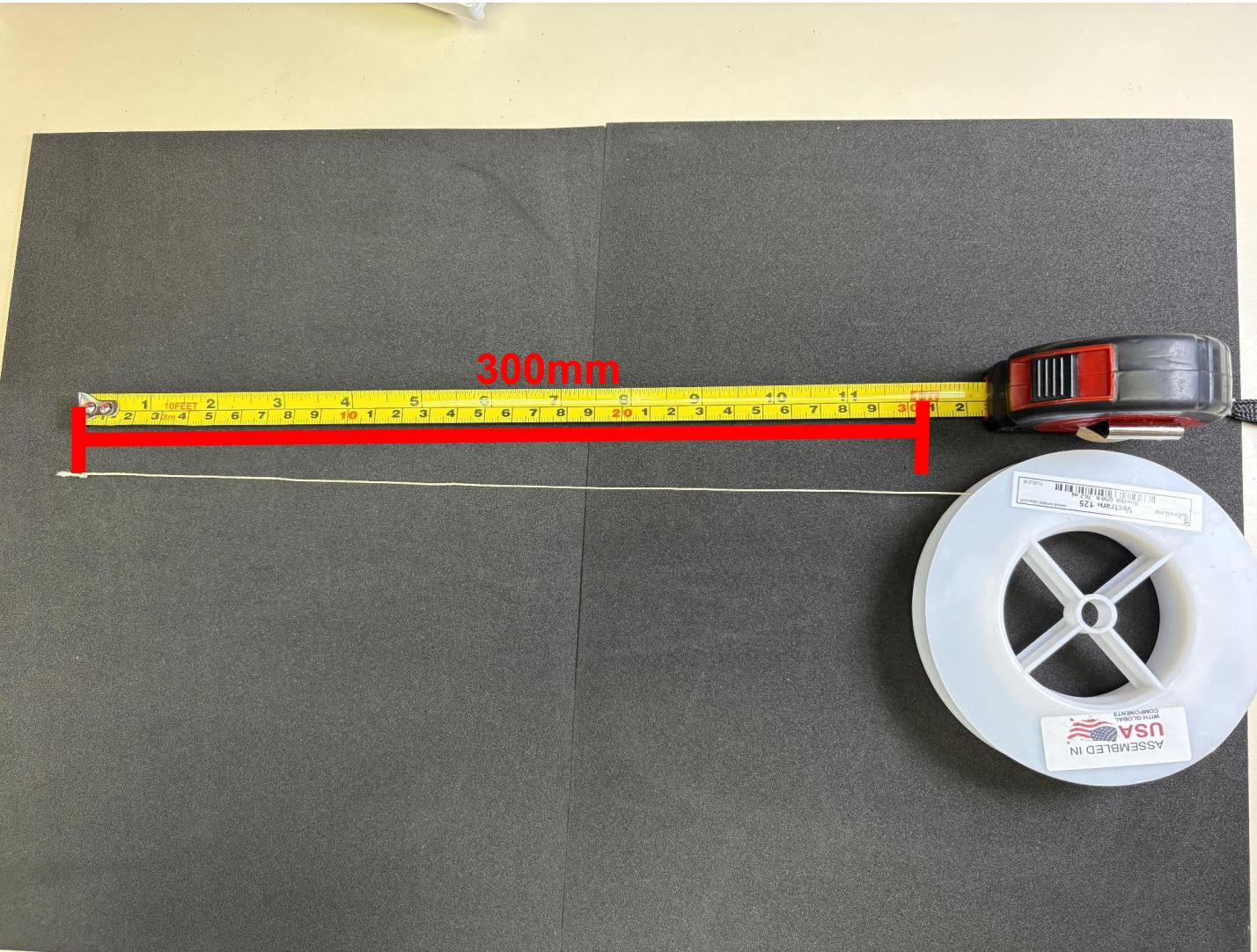
Name	Servoid #	QTY	Total Length (mm, from knot)	Marked Length (mm from spool exit)
Finger Pull Cable	3,4,5	3	300	130
Pinky Pull Cable	6	1	300	150
Finger Coupling Cable	NA	4	300	None
Thumb CMC Flex Cable	1	1	300	90
Thumb Pull Cable	2	1	300	150
Thumb Coupling Cable	NA	1	300	None

1. Tie ashley stopper knot on the end of vectran spool

Ashley Stopper Knot Instructions



2. Cut vectran 300mm from knot
3. Repeat 10 more times, creating a total of 11 cables



5. Trim the tail of the ashley stopper knot to <5mm
for all cables



Finger Assembly

Tools:

Threading Tool
Pliers
Torx Driver

Name	Part Number	QTY
Finger Base	1	4
Finger MCP	2	4
Finger Proximal	3	4
Finger Medial	4	4
Finger Coupling Cable	26	4
UNDERSIZED 2x10 Pin	32	16
2x5x2.5 bearing	30	16
1x10 Pin	31	12
M2x6 Flanged Torx Self Tapping Screw	38	4
Finger Proximal/MCP Return Spring	22	4
Finger Distal/Medial and Thumb Proximal/Distal Return Spring	21	4

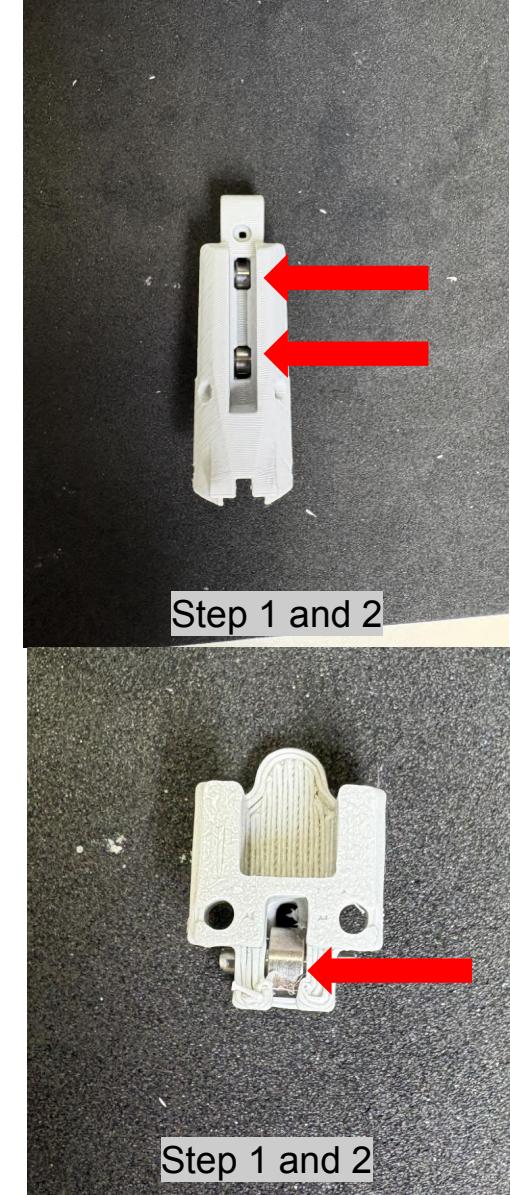
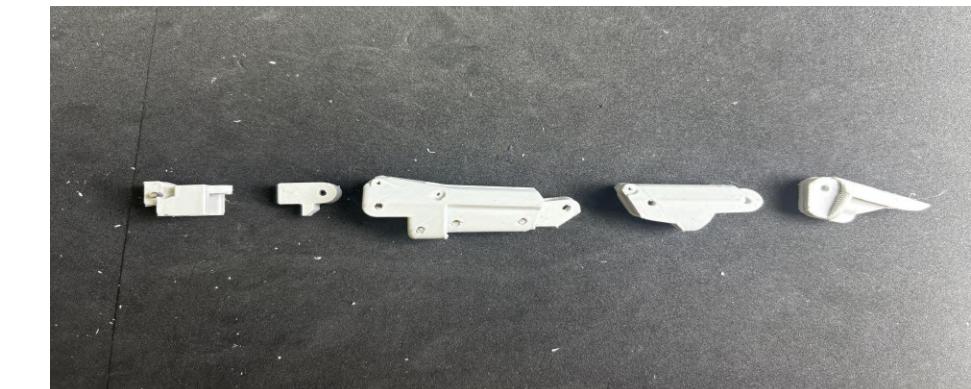
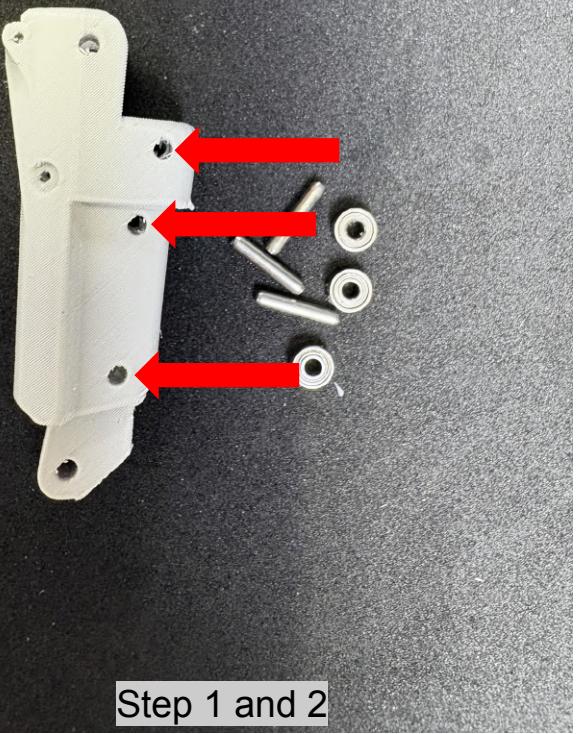
Bearings

1. Place four bearings (30) in finger proximal (3) and finger base (1) components

2. Secure using 2x10mm pins (32)

3. Repeat for all fingers

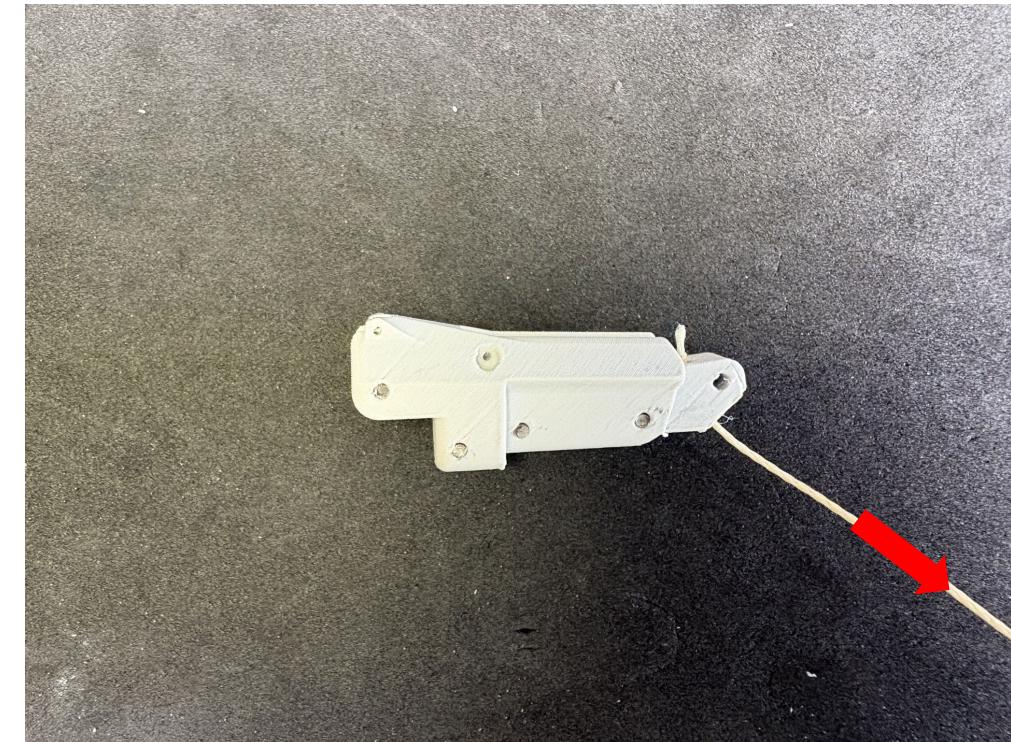
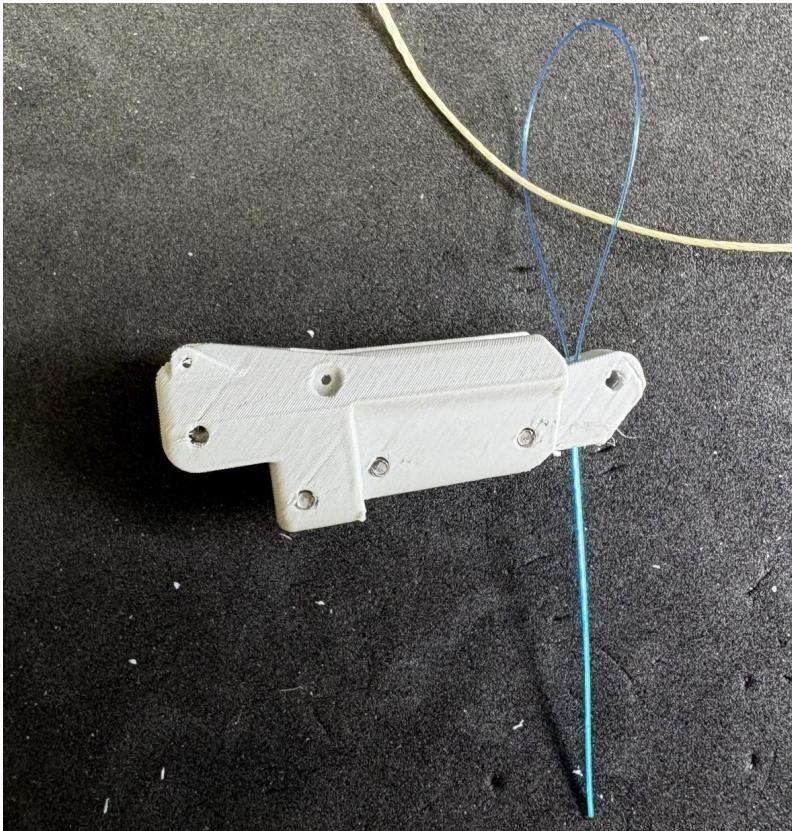
NOTE: Ensure all bearings spin, if not file/sand/deburr plastic



Finger Coupling Cable

4. Route a non-marked cable through hole at end of Finger proximal piece

5. Pull tight once routed to pretension/remove any slack that could be present in the ashley stopper knot

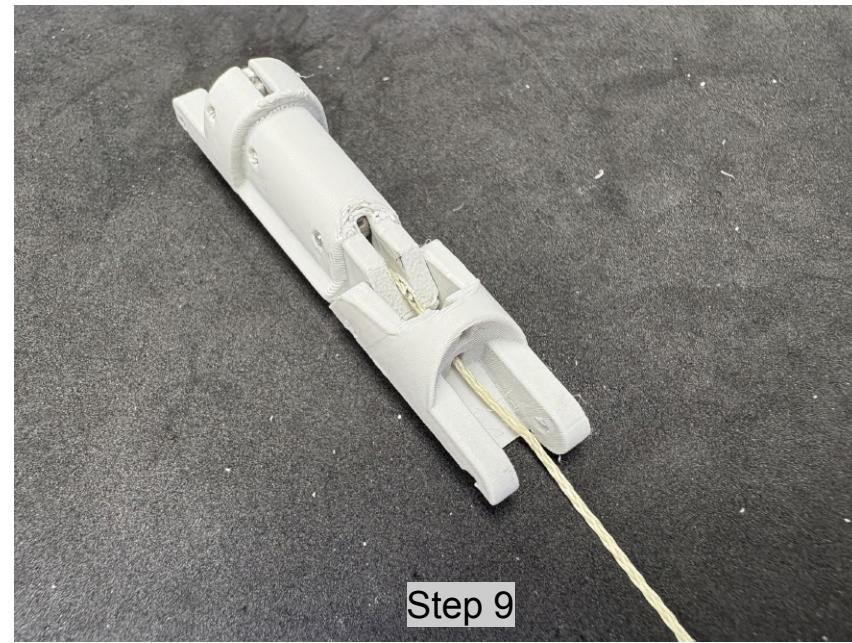
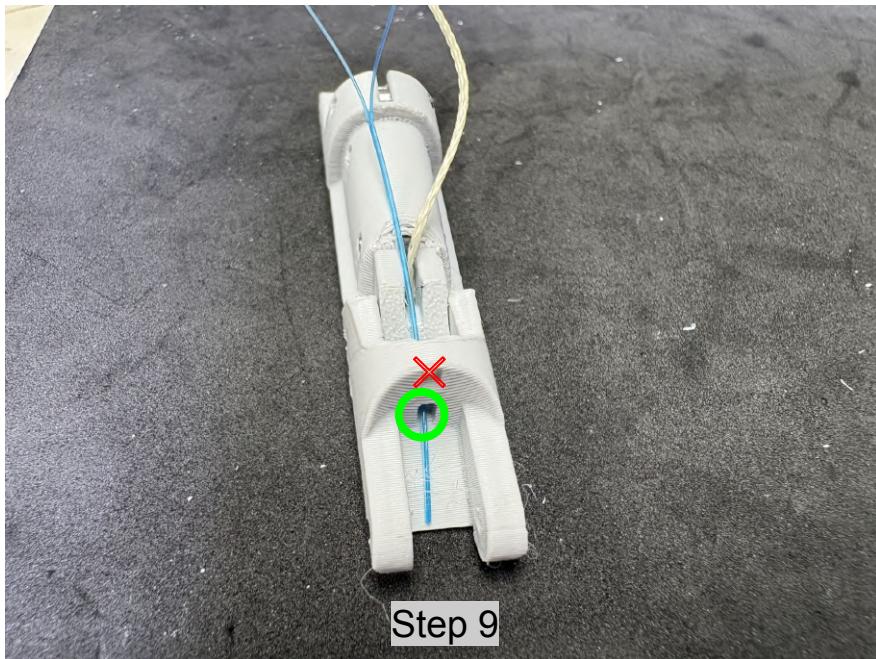
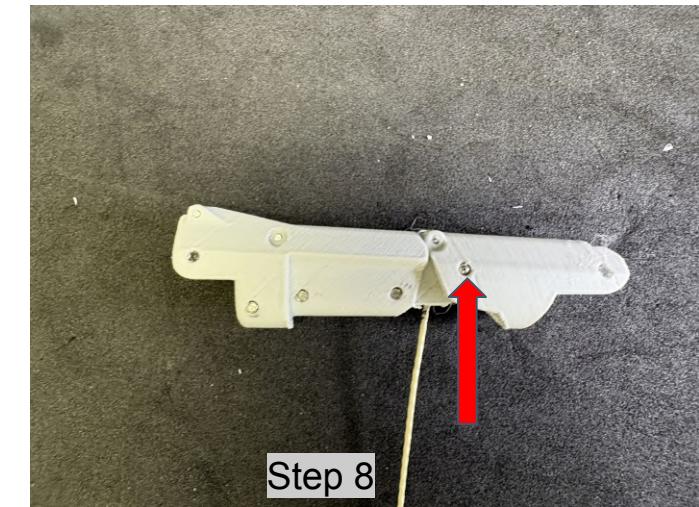
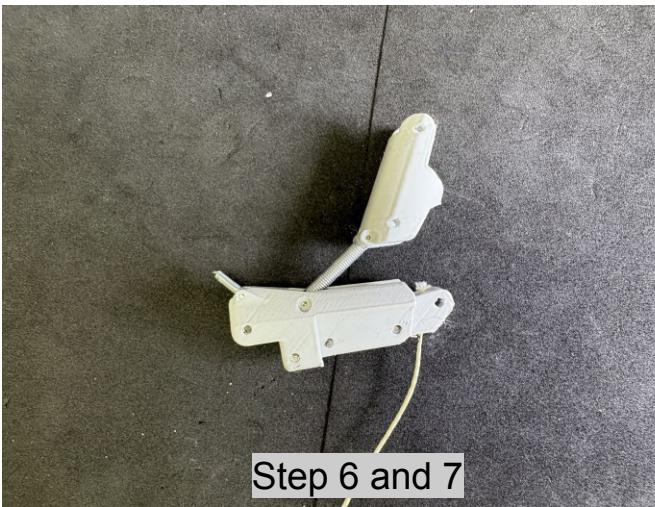


6. Install spring (21) connecting proximal (3) and medial (4) components using two 1x10mm pins (31)

7. Install spring (22) on base of proximal using one 1x10mm pin (31)

8. Connect proximal and medial sections using one 2x14mm pin (34)

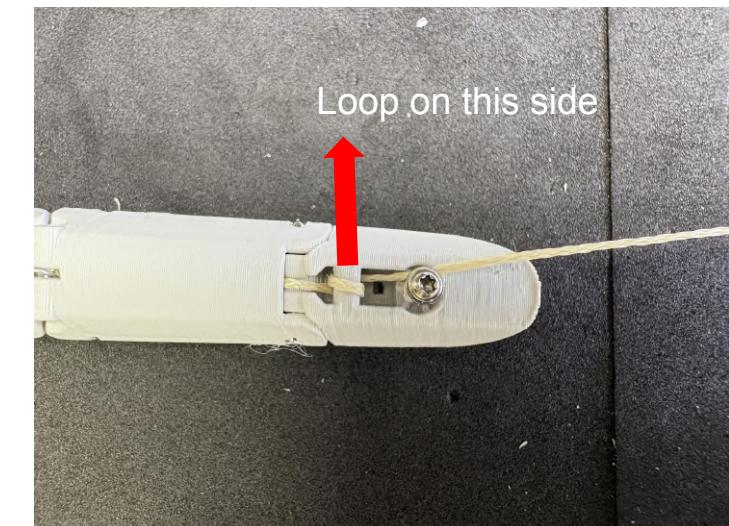
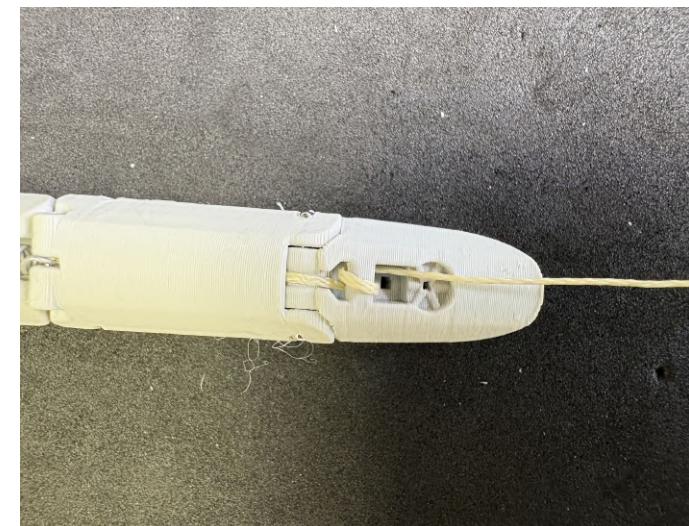
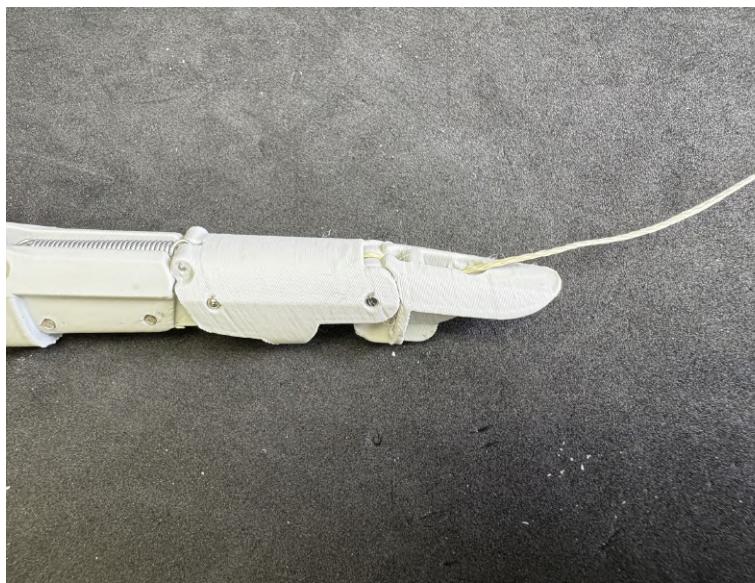
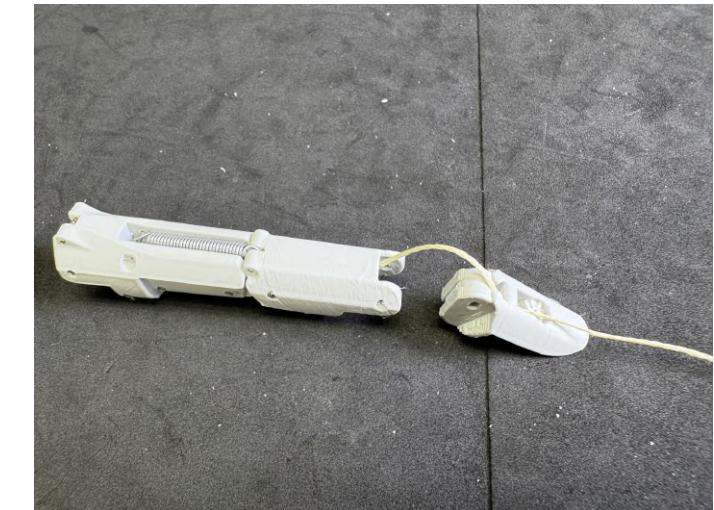
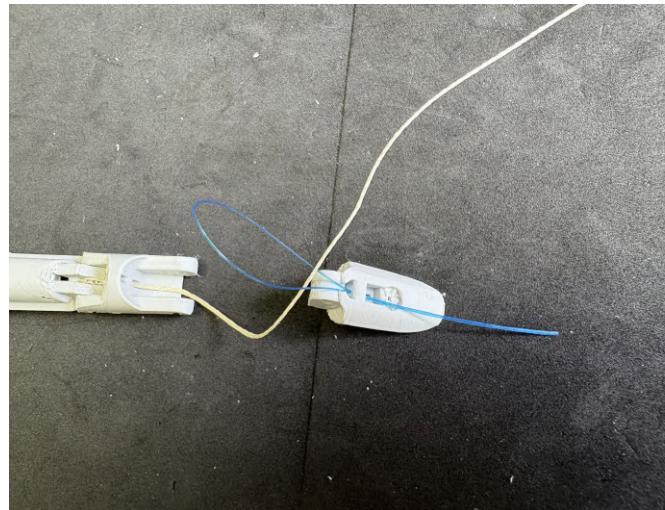
9. Thread coupling cable through bottom hole on medial section

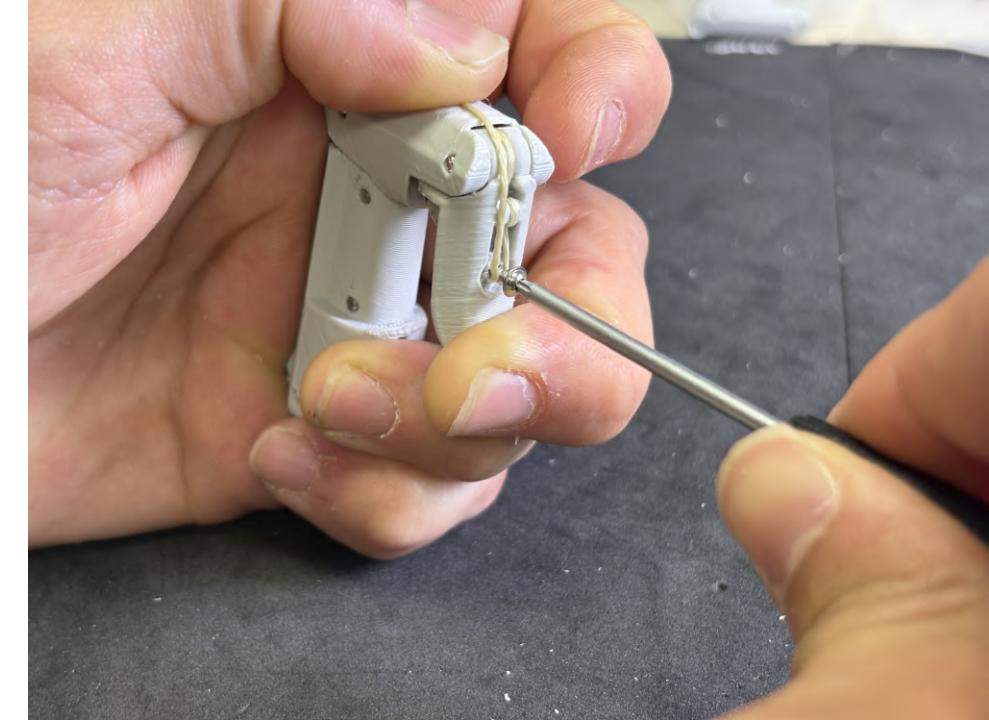
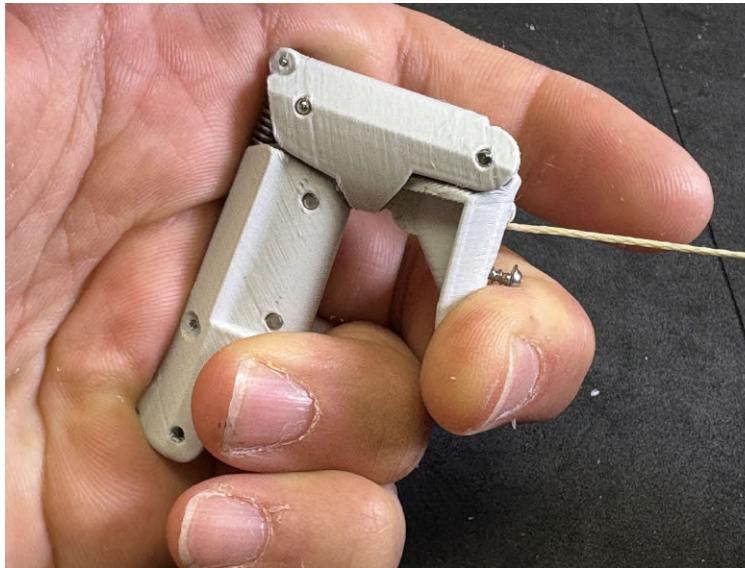
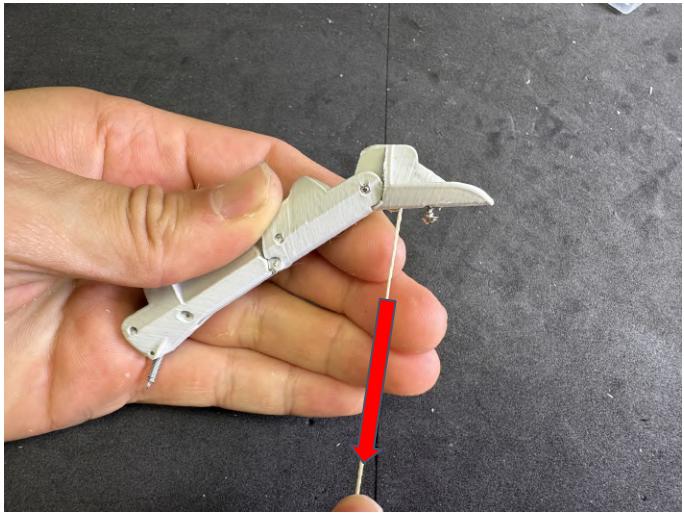


10. Route coupling cable underneath the bar on the distal section

11. Wrap coupling cable around bar once. Ensure that the cable wraps

12. Start to thread M2x6 Torx screw (38) into the distal section





13. Pull cable taut

14. Flex finger while maintaining tension

15. Tighten screw until cable is securely pinched

16. Distal/medial and medial/proximal angle should maintain the same angle when opening/closing the finger. See video

17. Repeat from step 1 for three remaining fingers

Name	Part Number	QTY
Thumb Abduction Upper Servo Disk	7	1
Thumb Abduction Lower Servo Disk	8	1
Thumb Abduction Linkage Bar	9	1
Thumb CMC Base	10	1
Thumb MCP	11	1
Thumb Proximal	12	1
Thumb Distal	13	1
Finger Coupling Cable	26	1
UNDERSIZED 2x10 Pin	32	5
2x5x2.5 bearing	30	5
1x10 Pin	31	2
M2x6 Flanged Torx Self Tapping Screw	38	1
Finger Distal/Medial and Thumb Proximal/Distal Return Spring	21	4
2x10 Pin	33	1
Servo Motor Mount Plate	43	1
Servo Motor Spline Screw M2.3x5	44	6
Servo Motor Plate Screw M2x4	45	1
Thumb CMC/MCP Return Spring	23	1

Thumb Assembly

Tools:

Threading Tool

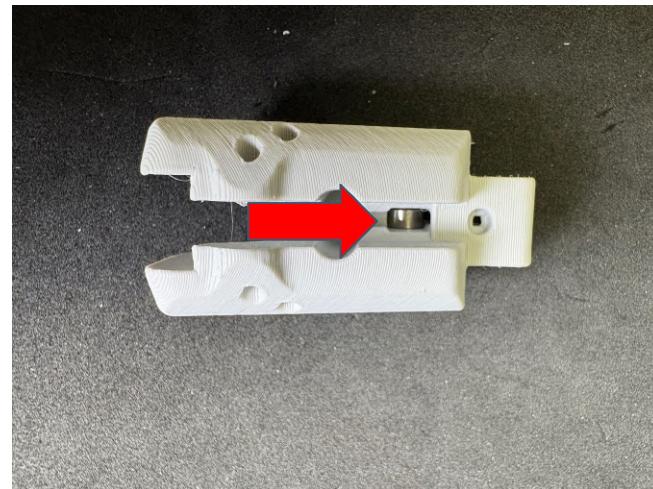
Pliers

Torx Driver

Loctite

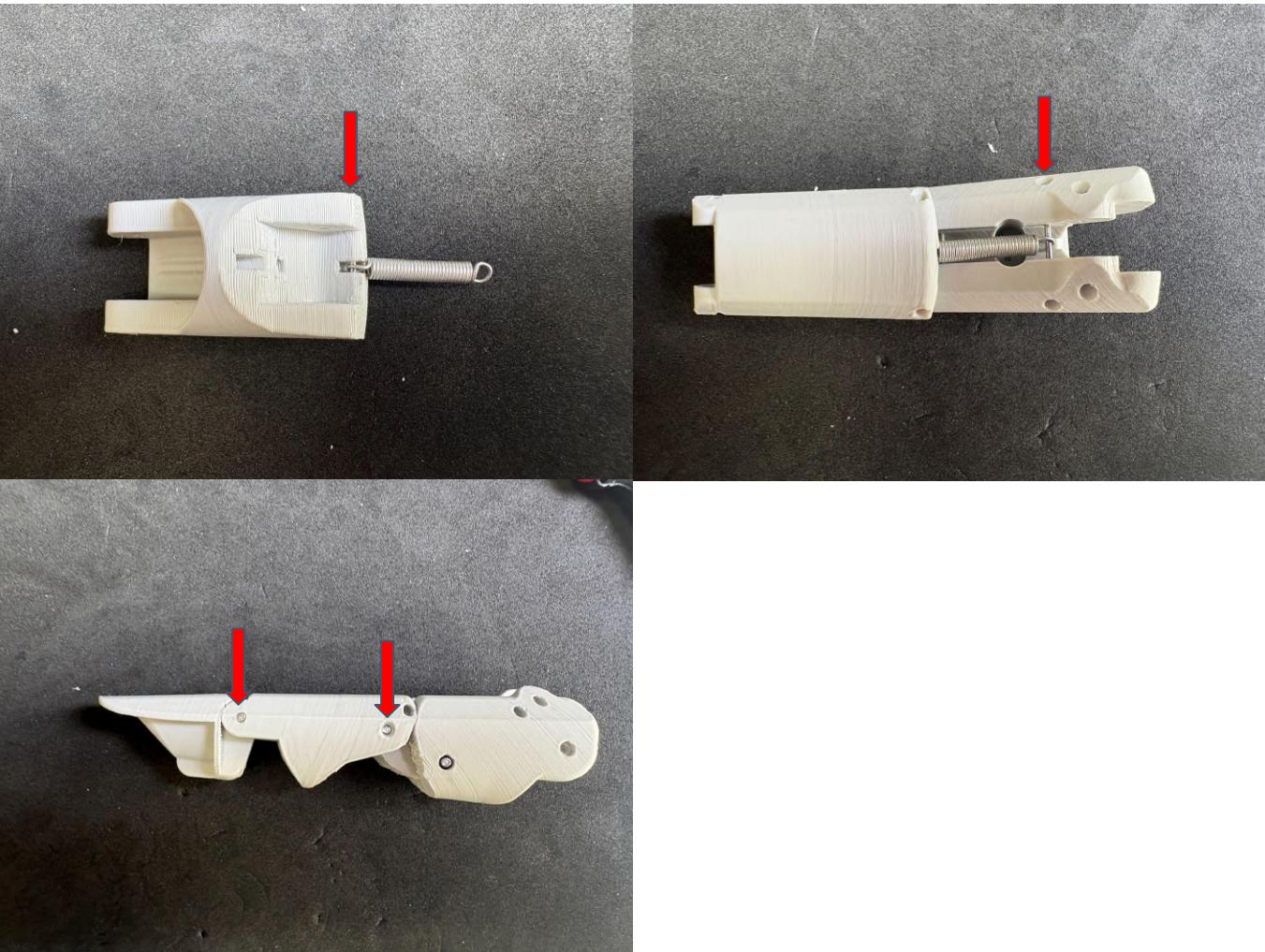
Thumb Bearings

1. Insert bearings into thumb base (10) and thumb MCP (11)
2. Secure using 2x10mm pins (32)

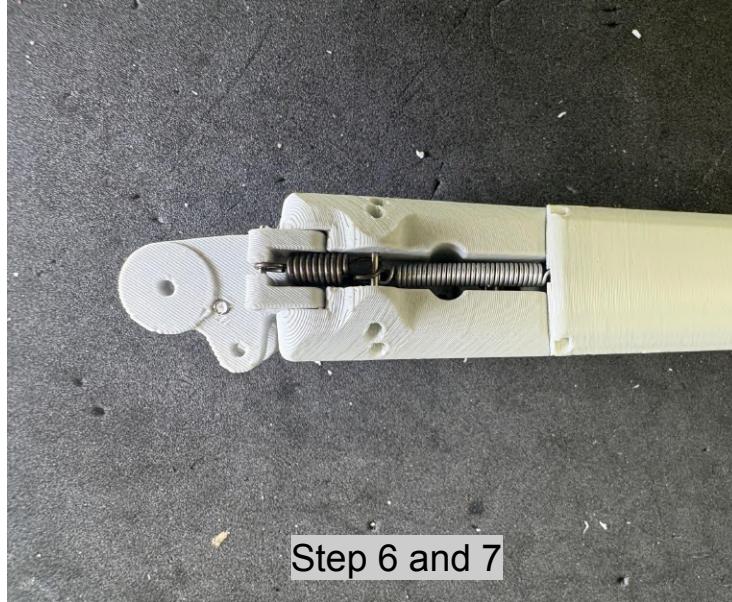
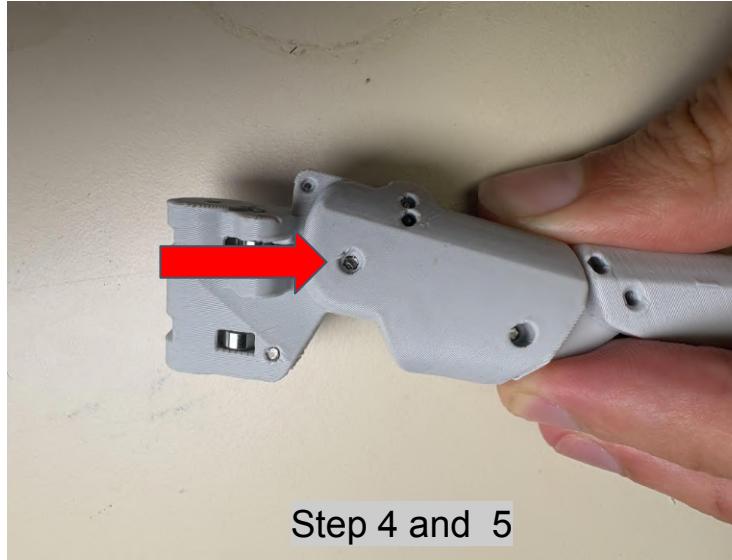


Thumb Assembly

1. Attach spring (21) with 1x10mm pin (31) to proximal
2. Attach other side of spring to MCP using 1x10pin (31)
3. Attach distal, proximal and MCP with 2x20mm pins (36)



4. Insert CMC into MCP. Add bearing between components
5. Secure using 2x20mm pin
6. Add thumb spring (23) between CMC and MCP
7. Secure using 1x10 pin



Thumb Coupling Cable

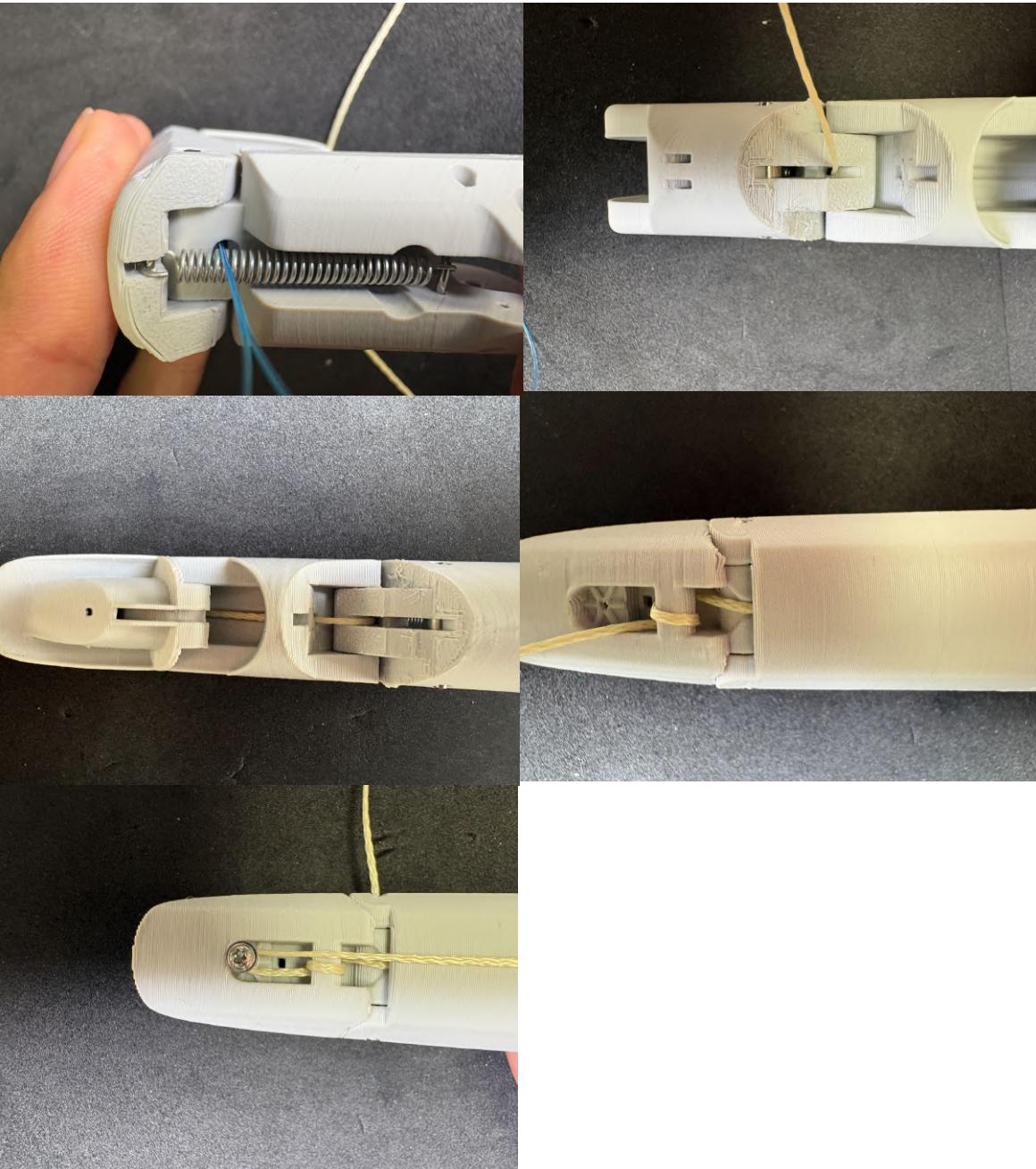
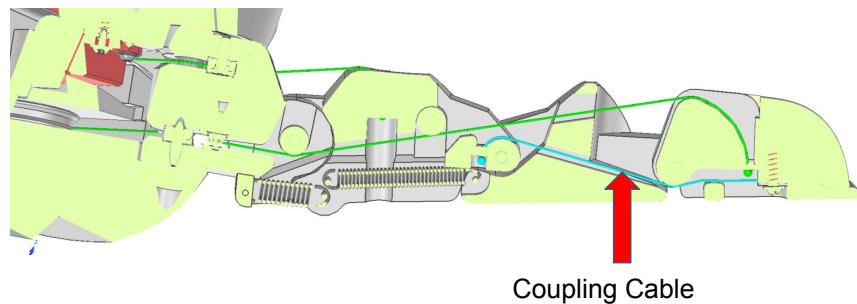
8. Thread a non-marked cable through in MCP

9. Pull taut

10. Thread through lower hole in proximal and over distal

11. Add loop on crossmember.
Note direction of loop

12. Tension and secure same as fingers with 2x6mm torx screw (38)



Linkage Assembly

13. Place aluminum disk (43) into thumb servo lower disk (7). Secure using M2x4 screws (45) with loctite
14. Add thumb servo upper disk (8) piece sandwiching the aluminum. Secure using M2x4 screws with loctite
15. Drill linkage holes in disks with 2mm drill (7 and 8)
16. Drill linkage hole in linkage bar with 2.1mm drill (9)
17. Place linkage bar between disks and secure using 2x10 pin (33). Note: direction of linkage is important. Reference image



Servo ID and Assembly

Tools:

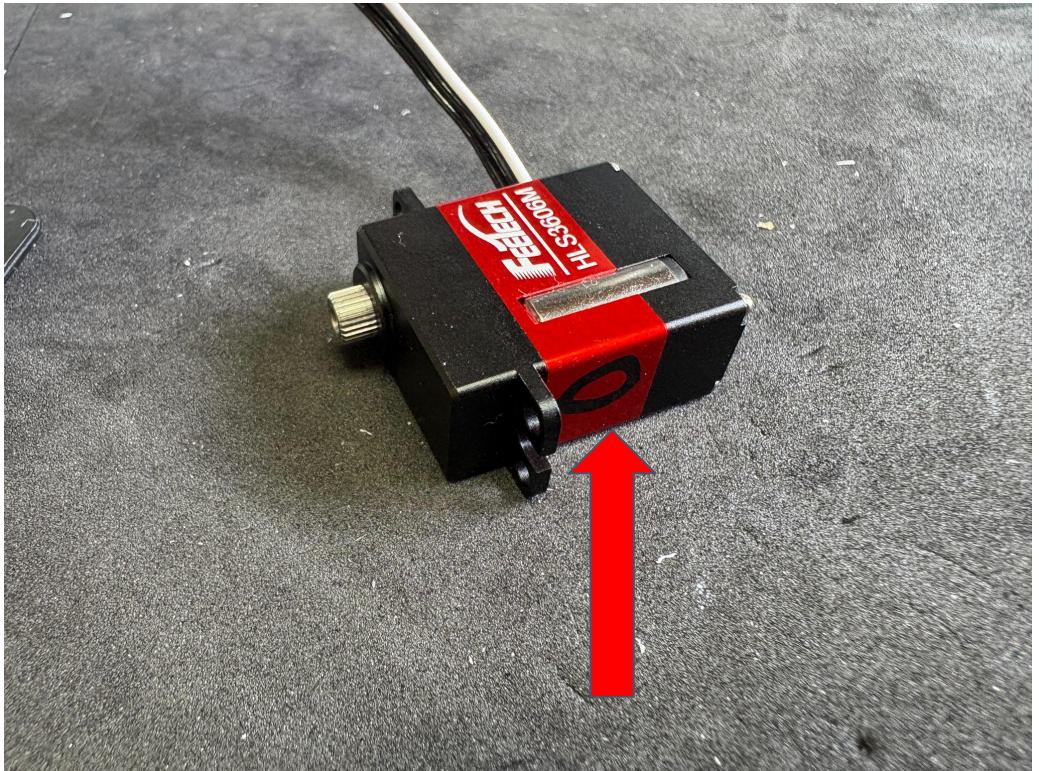
Computer
Breadboard
Marker
Molex Connectors
Soldering Iron
Protoboard

Name	Part Number	QTY
Servo Motor	42	7
Cable Spool	6	6
Finger Pull Cable	24	4
Pinky Pull Cable	25	1
Thumb CMC Flex Cable	27	1
Thumb Pull Cable	28	1
Servo Motor Mount Plate	43	6
Servo Motor Spline Screw M2.3x5	44	18
Servo Motor Plate Screw M2x4	45	6
Connection Cable	47	1

Label Servos

1. Label all 7 servos with a sharpie or paint marker with an individual number: 0, 1 ,2, 3 ,4, 5, 6

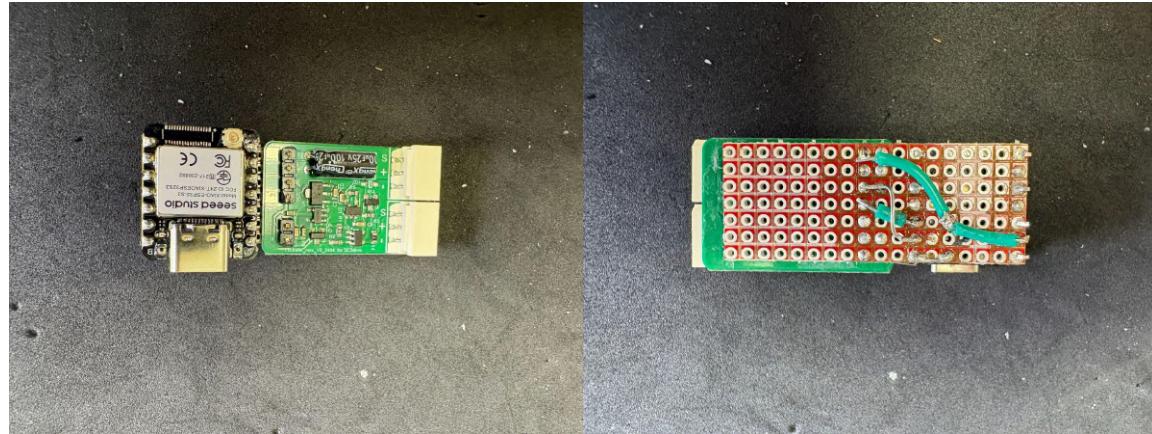
Reference image for location of label



Control Board

2. Build a control board using the electrical schematic

Board can be built on a breadboard (no soldering required), custom PCB (coming soon) or protoboard

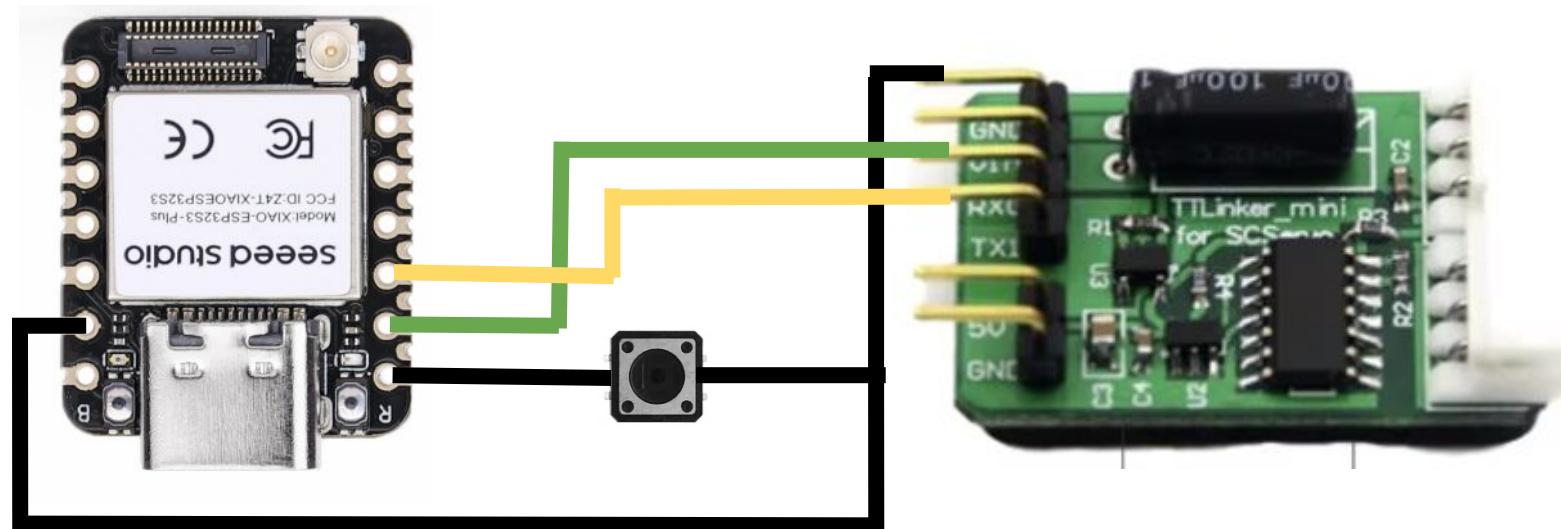


GREEN - RX

YELLOW - TX

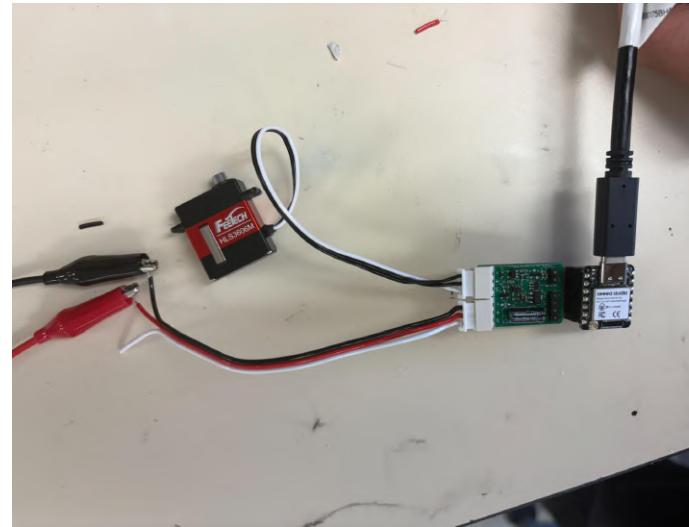
BLACK - GROUND

Example protoboard



Program Servos

3. Connect power (6vdc) to control board and esp32 to computer
4. https://docs.tetheria.ai/docs/getting_started/#setting-servo-ids
5. Follow steps to program and set ID for each servo

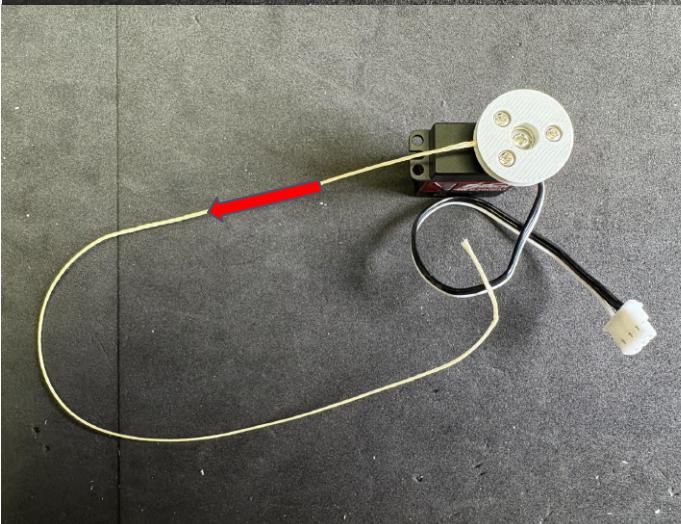


Servo Spools

6. Screw cable spool (6) into aluminum servo mount (43) using three screws (45). Apply loctite to threads before installing



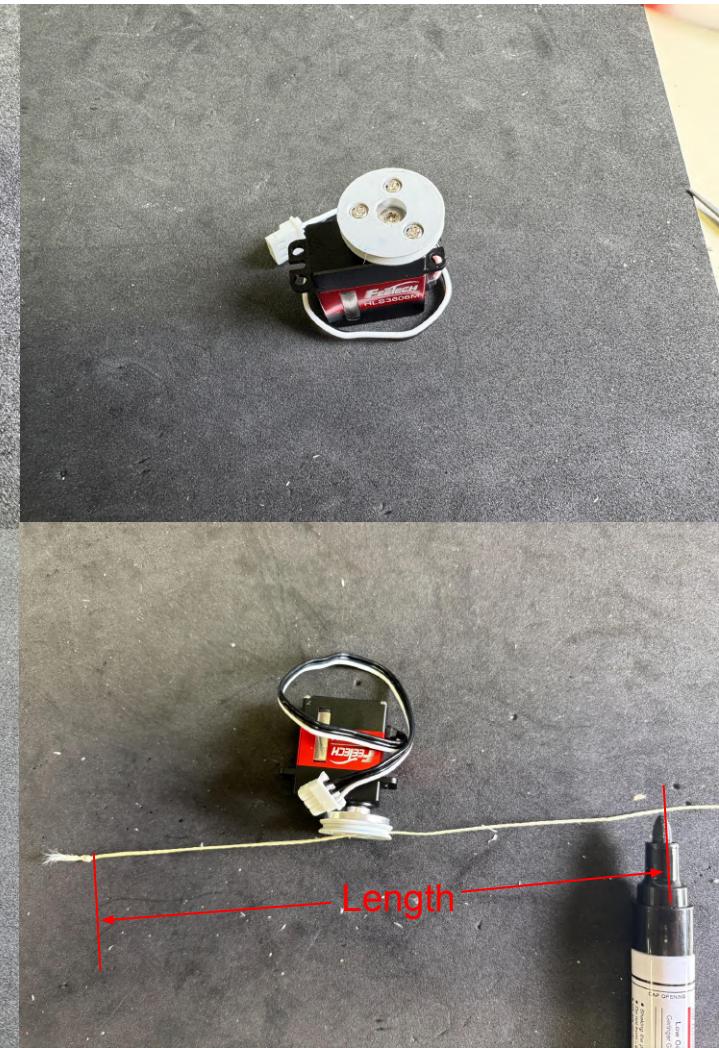
7. Attach mount to servo using large screw (44) and loctite



8. Thread a cable into servo

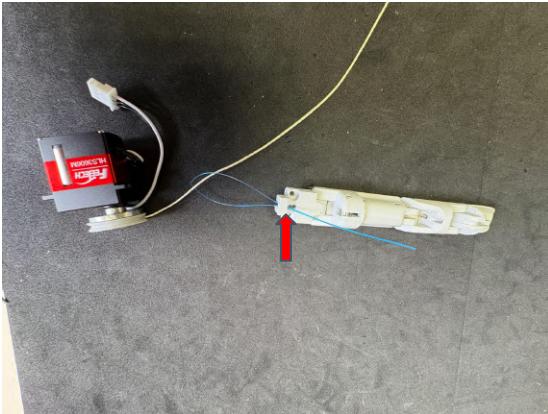
9. Mark length based on servo number (example: servo #1 = length 90mm)

10. Repeat for servos 1, 2, 3, 4, 5 and 6

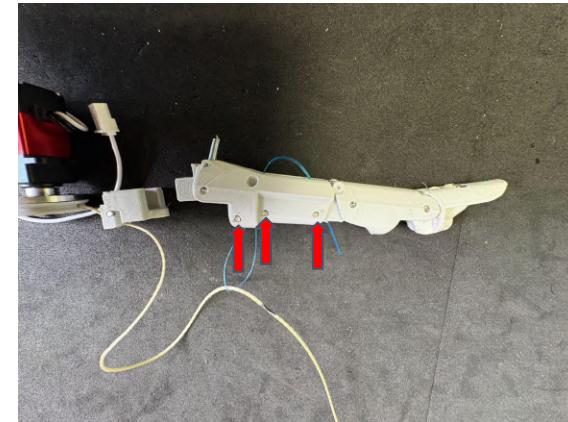


Thread finger servo cable

11. Thread the servo 14 cable through a finger base



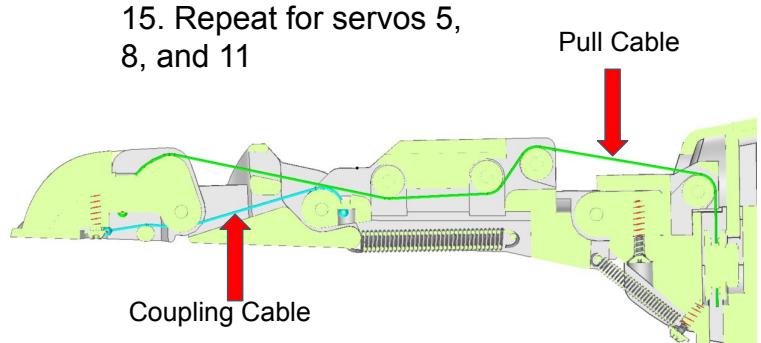
12. Thread between bearings on distal



13. Thread through top medial hole and distal



14. Tie ashley stopper knot at mark



15. Repeat for servos 5, 8, and 11



Servo Busbar

16. Cut 7x8 protoboard

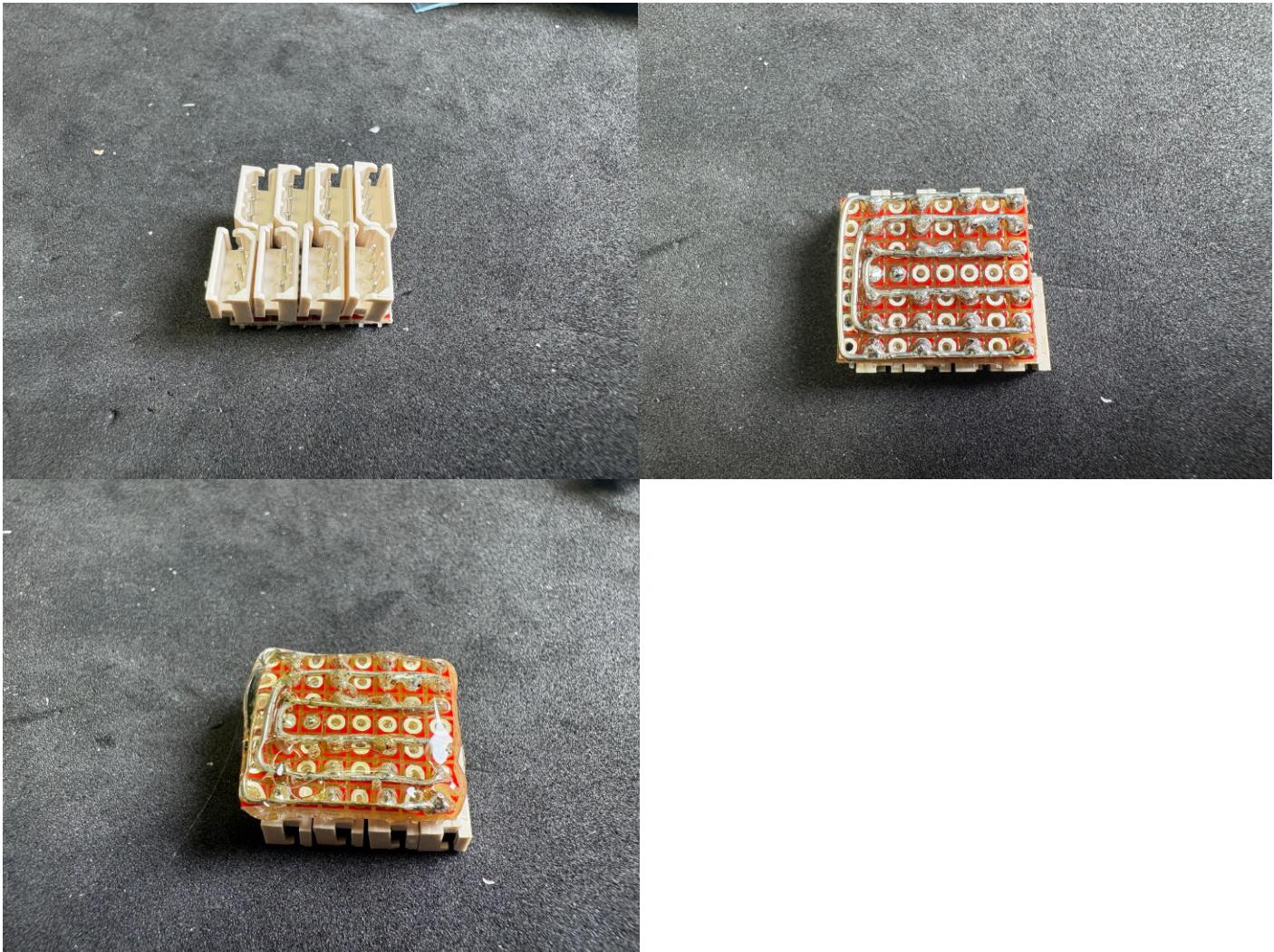
17. Place molex connectors as in image. Note orientation.

18. Solder together using 22awg solid wire as in image

19. Clean board to remove residual flux

20. Cover wires in hot glue or liquid electrical tape to protect against electrical shorting

NOTE: This step can be skipped by simply daisy chaining the servos together using the 3-way connects supplied with the servos



Hand Base

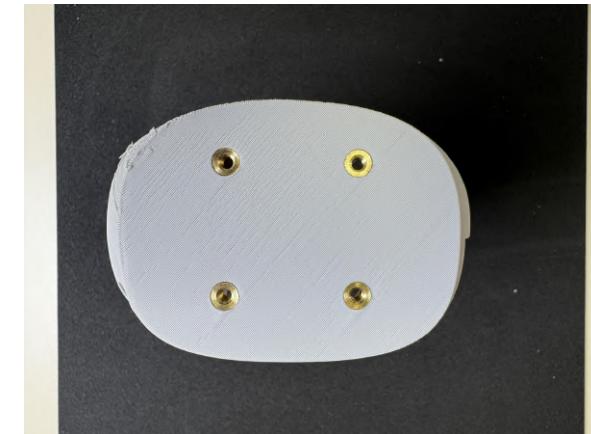
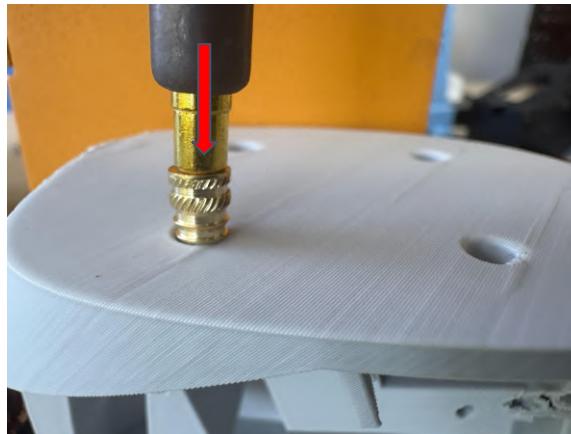
Tools:

Soldering Iron
Torx Driver
Philips Driver

Name	Part Number	QTY
Servo Frame	14	1
Palm Front Frame	15	1
Palm Rear Frame	16	1
M3x6.4 Heat set insert	41	4
M2x10 Countersunk Torx Self Tapping Screw	39	12
M2x6 Flanged Torx Self Tapping Screw	38	14
2x20 Pin	36	1
UNDERSIZED 2x30 Pin	37	1

Threaded Heat Inserts

1. Warm up a soldering iron with a heated insert tip
2. Gentle apply force on the heat insert using the iron
3. Make insert flush with surface of print



Install Finger Servos

4. Place servo 3 into pointer finger position with number side visible

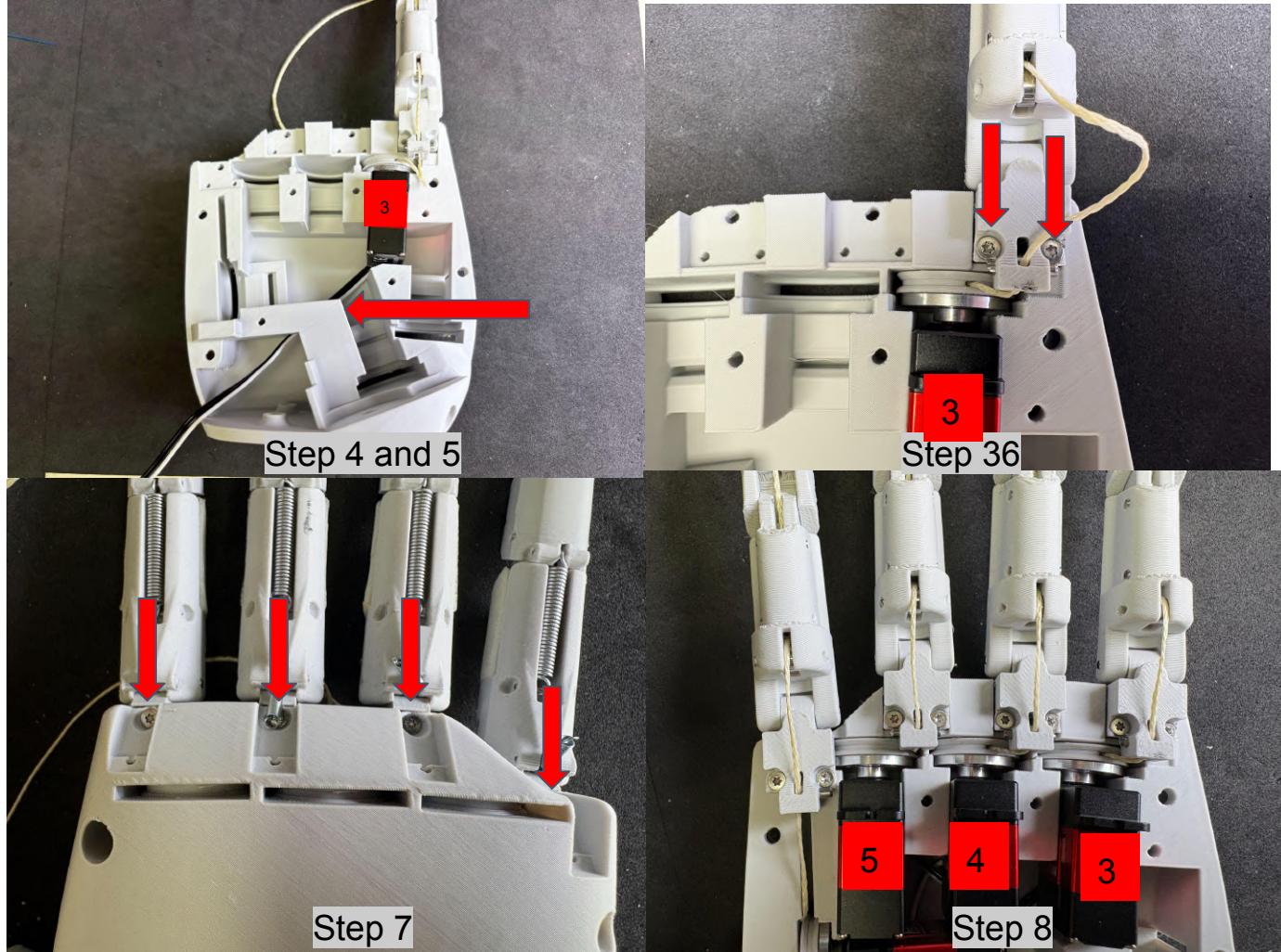
5. Feed wire under bar in palm hand (16)

6. Secure using M2x10 (39) countersunk screws

7. Flip hand over and secure finger with M2x10 countersunk screw

8. Repeat for servos 4, 5, and 6

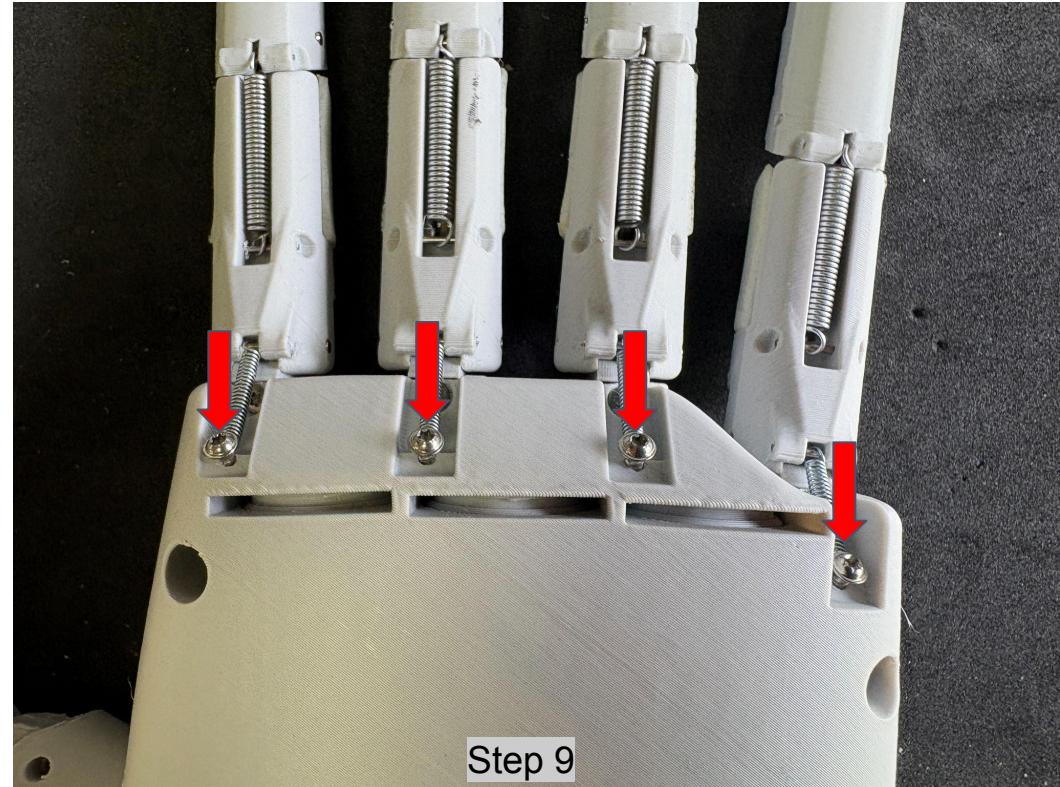
Note: for left hand, reverse servo sides



Distal Springs

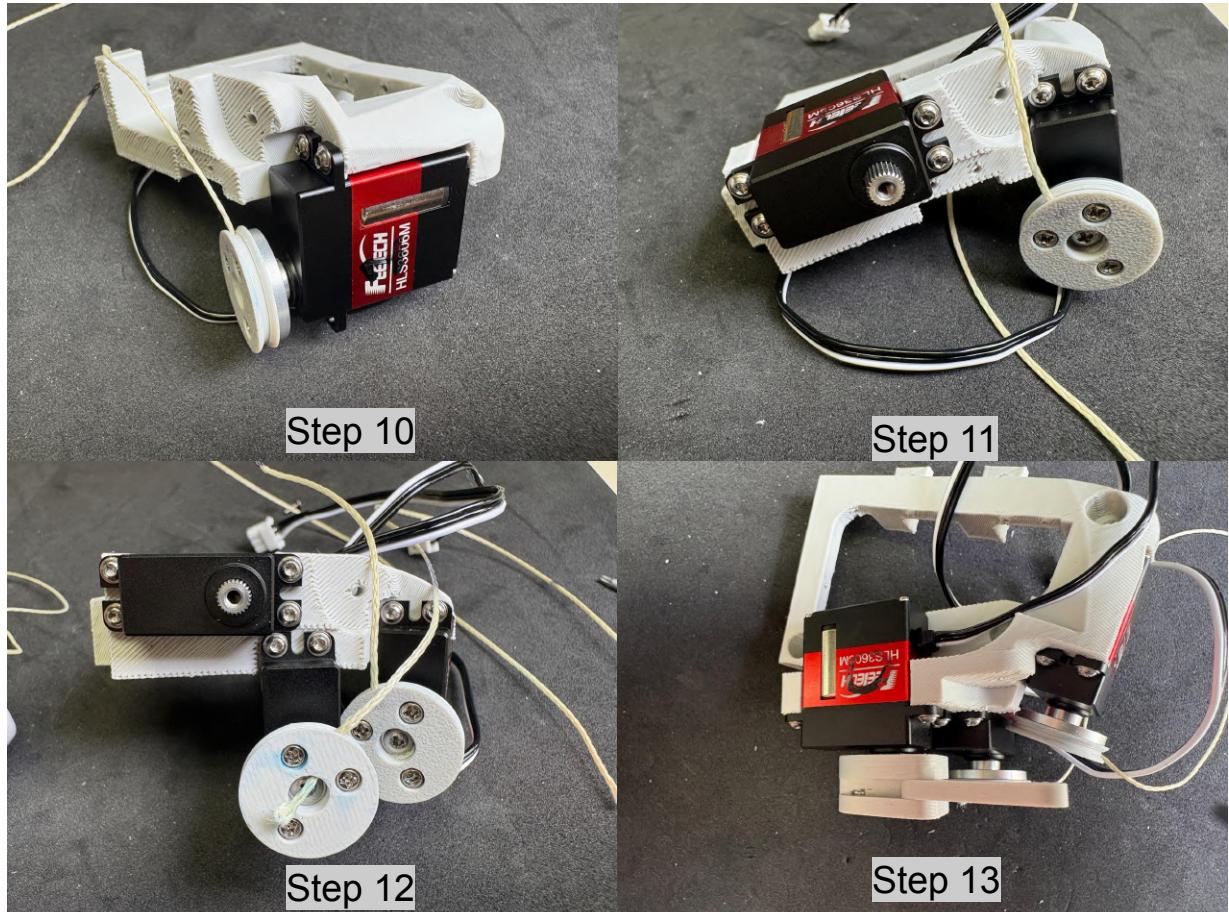
9. Secure springs (22) to rear palm using 2x6 self tapping torx (38)

Note: Do not over extend springs to avoid permanent deformation



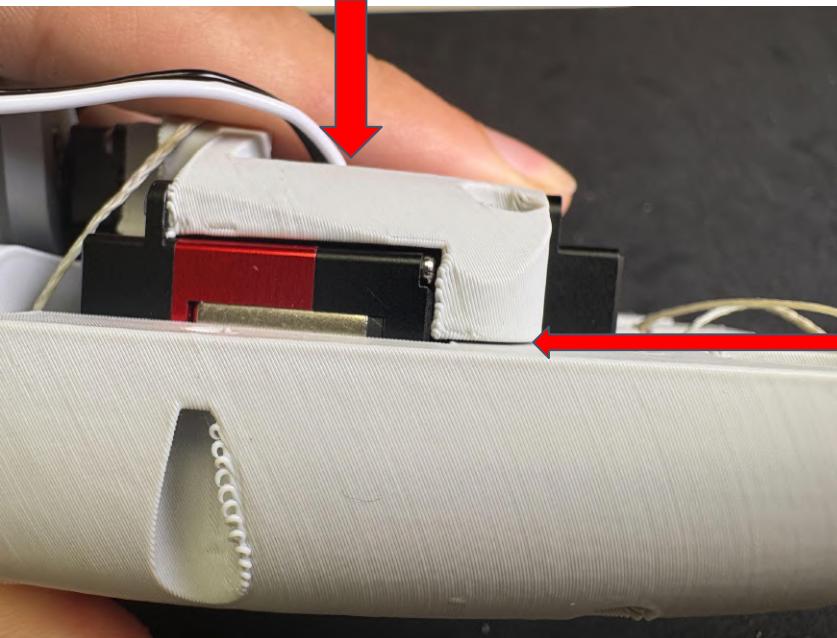
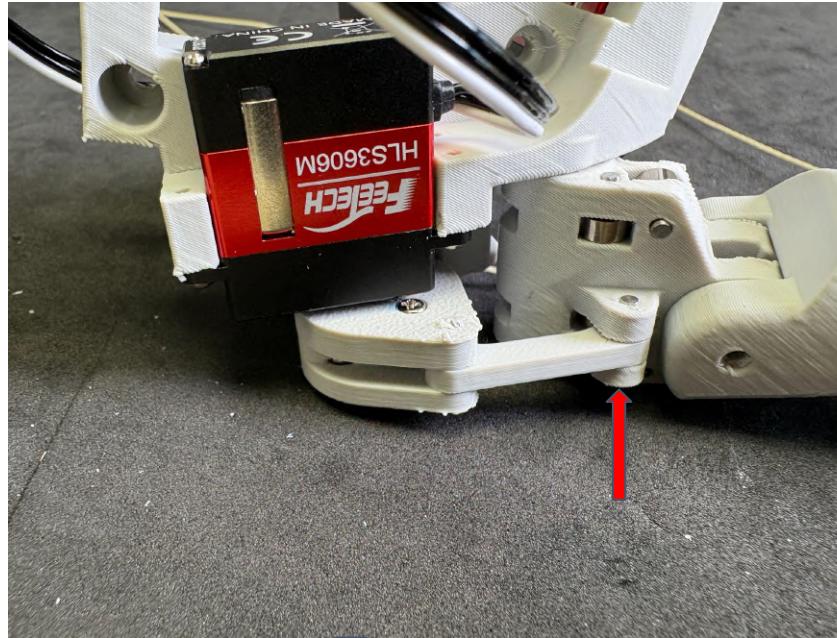
Servo Frame

10. Place servo 1 onto servo frame (14) and secure with two M2x6 self tapping screws (38)
11. Place servo 0 onto frame and secure with four M2x6 self tapping screws
12. Place servo 2 onto frame and secure with two M2x6 self tapping screws
13. Add linkage to servo 0 using screw (provided with servo) with loctite



Servo Frame Install

14. Insert 2x10 pin (34) between servo linkage and thumb CMC base (10)
15. Slide frame into hand
16. Ensure components are flush



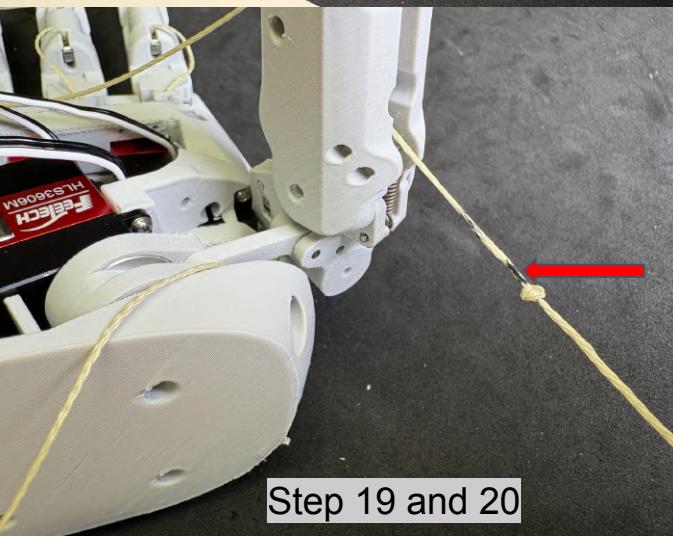
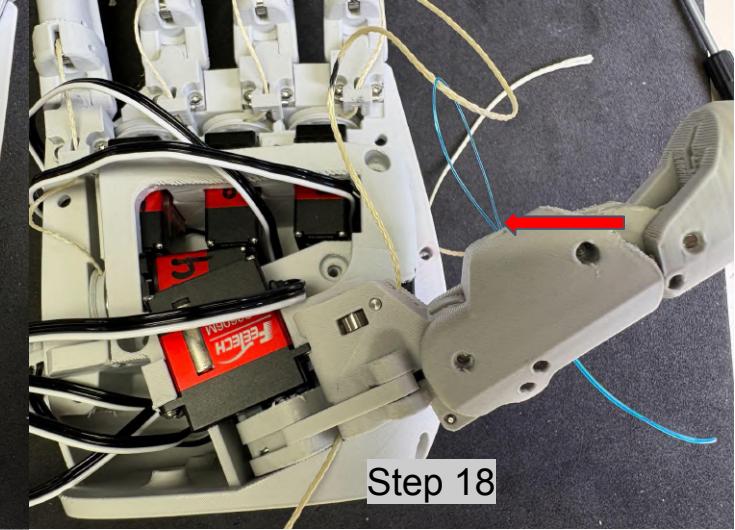
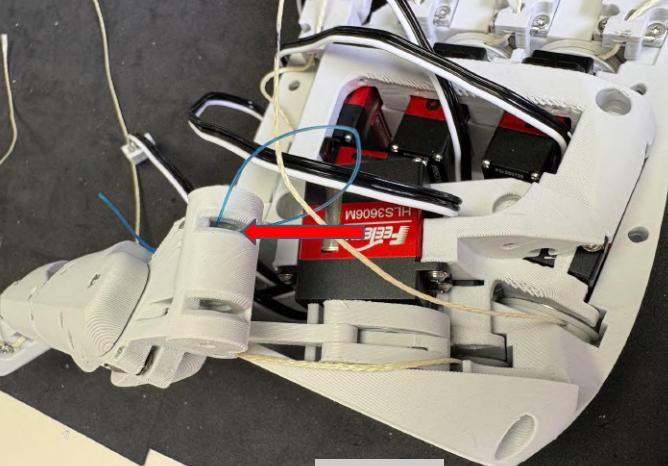
Thumb CMC Flex Cable

17. Thread cable from servo 1 as seen in image

18. Thread through hole closer to back of palm on thumb MCP (11)

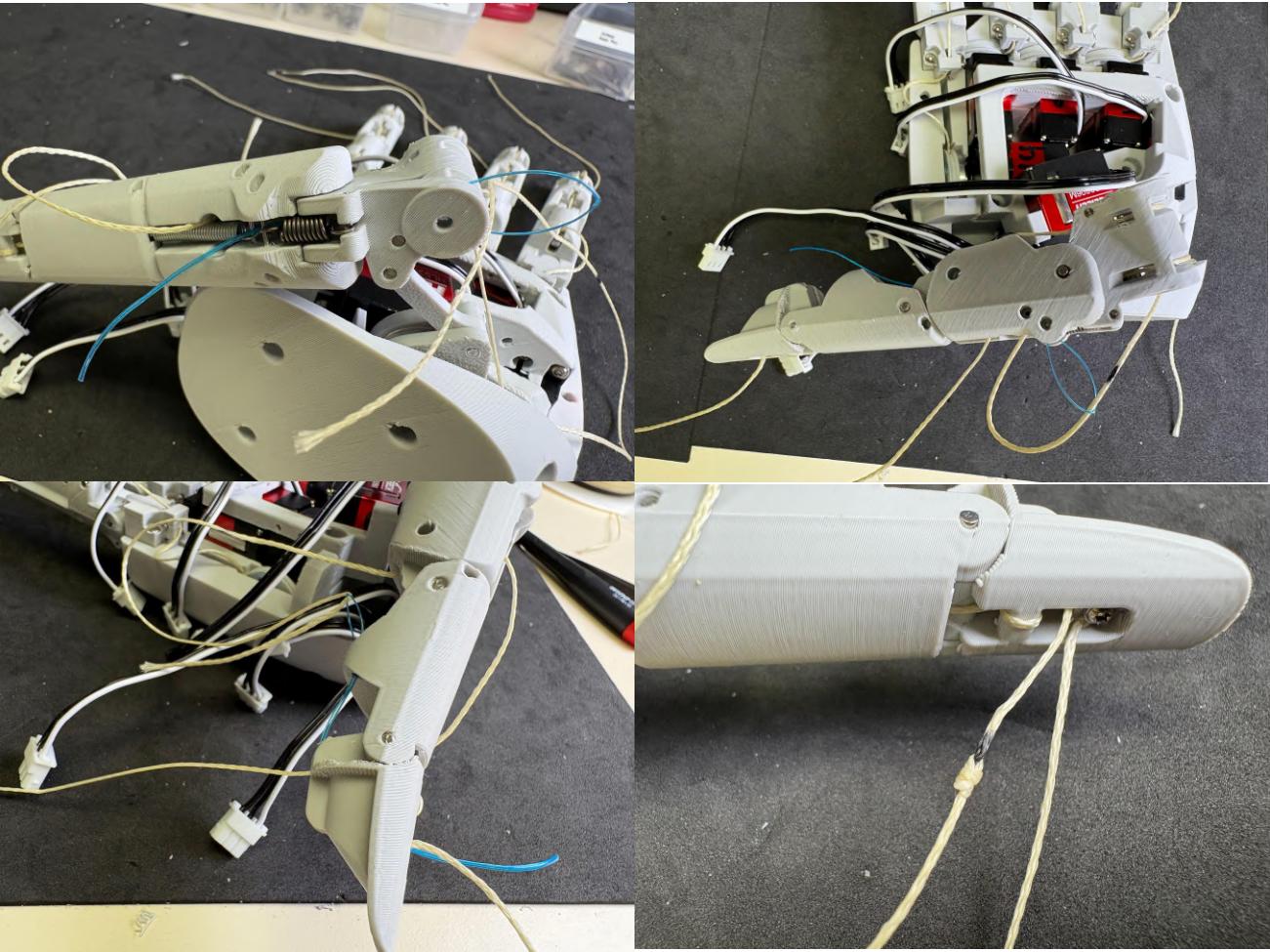
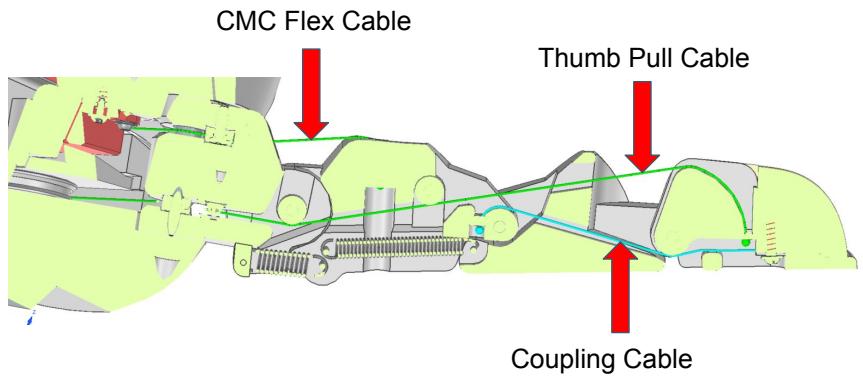
19. Tie ashley stopper knot at mark

20. Pull string tight



Thumb Pull Cable

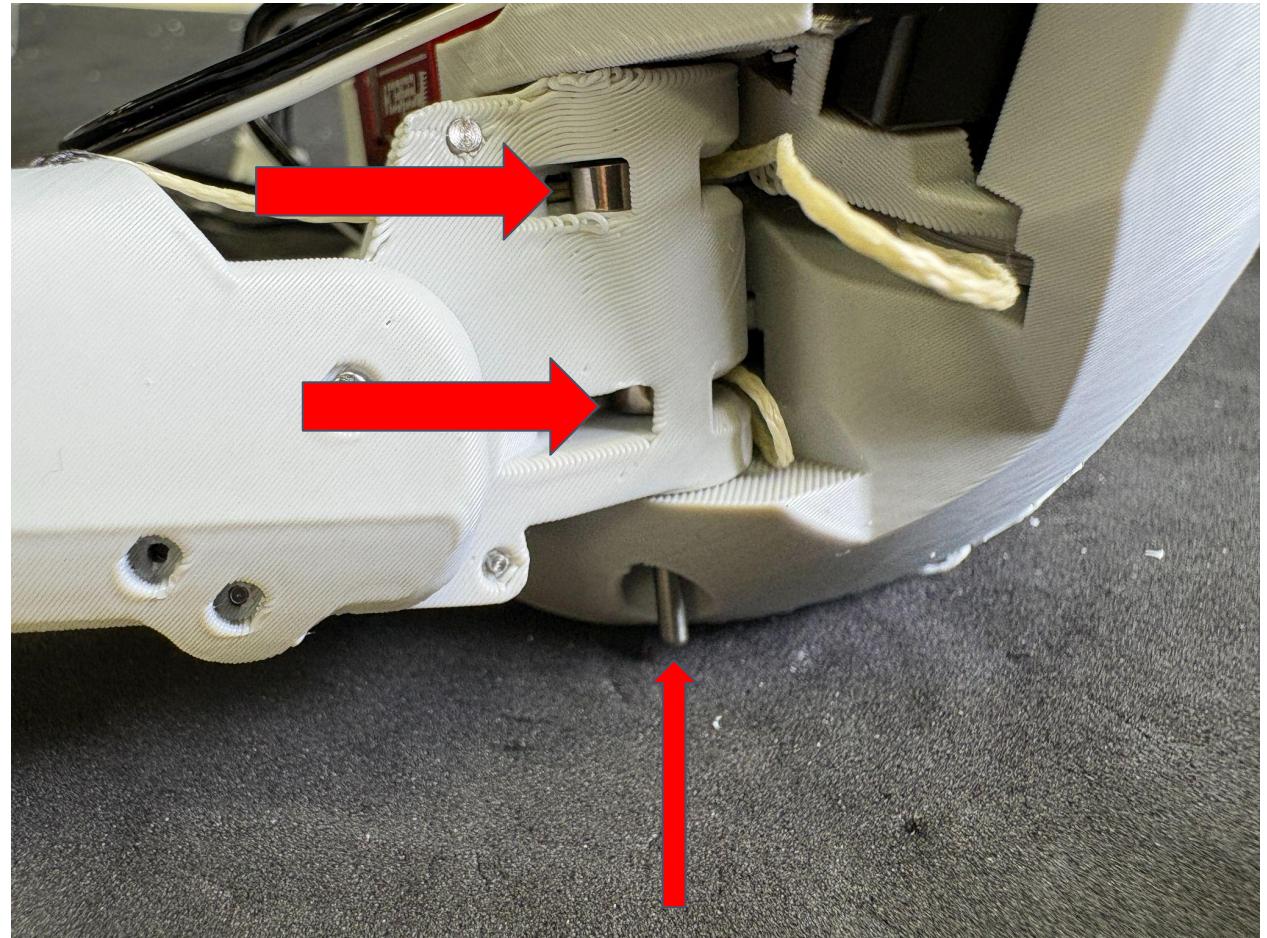
21. Thread cable from servo 2 as seen in image
22. Thread through MCP (10) around bearing
23. Thread through top hole in thumb proximal (12)
24. Tie ashley stopper knot at mark and pull tight



Thumb Bearings

25. Insert bearings (30) into CMC base and push in as far in as possible
26. Insert 2x30mm pin (37) from bottom until it is flush with the top surface

Note: applying pressure on bearings while installing pin will ensure they don't fall out



Final Touches

Tools:

Hot Glue
Super Glue

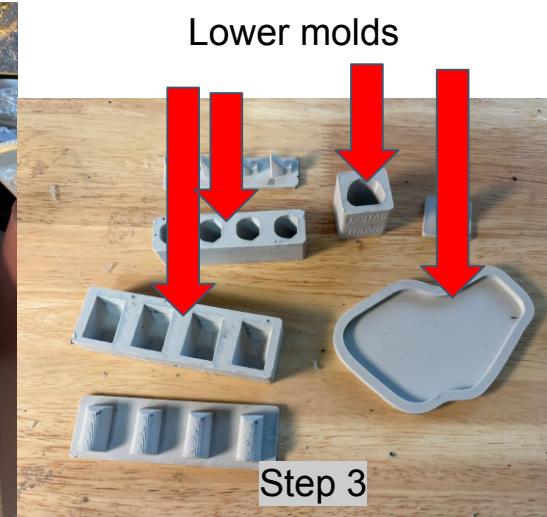
Name	Part Number	QTY
Palm Foam	20	1
3x10 self tapping	40	9
2x6 self tapping	36	8
M2x10 Countersunk Torx Self Tapping Screw	39	12
M2x6 Flanged Torx Self Tapping Screw	38	14
UNDERSIZED 2x30 Pin	37	1
Connection Cable	47	1
TTLinker	48	1

Silicone Inserts Molds (optional)

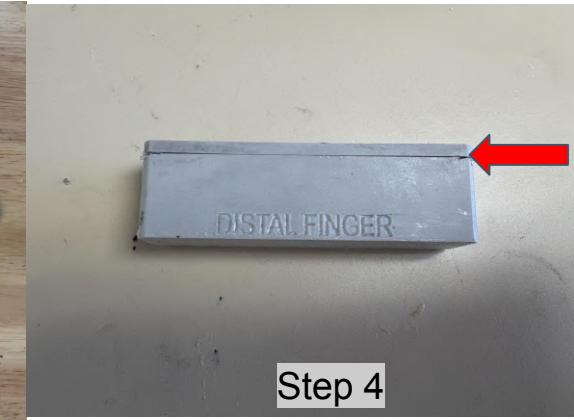
1. Place 3D printed molds on a flat/hard surface. Placing on a baking tray will make cleanup easier.
2. Mix a batch of silicone using instructions on bottles. 40grams total is enough to make one set of parts for a hand.
3. Fill lower molds ~80%. Let sit for 5minutes to allow bubbles to escape.
4. Add top half of mold to bottom half for distal and proximal molds. Push until flush. Silicone should leak out if filled correctly.
5. Let sit upright for 3h until fully cured. Then remove from molds.
6. Remove flash from edges of components



Step 2



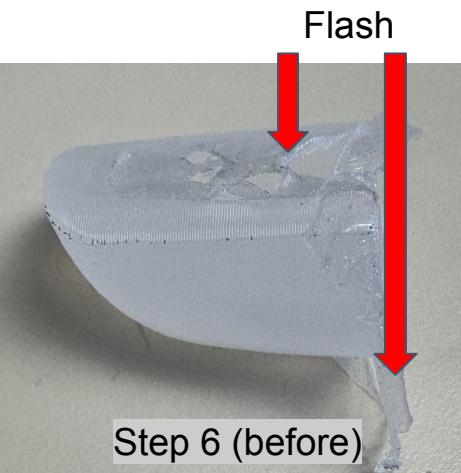
Step 3



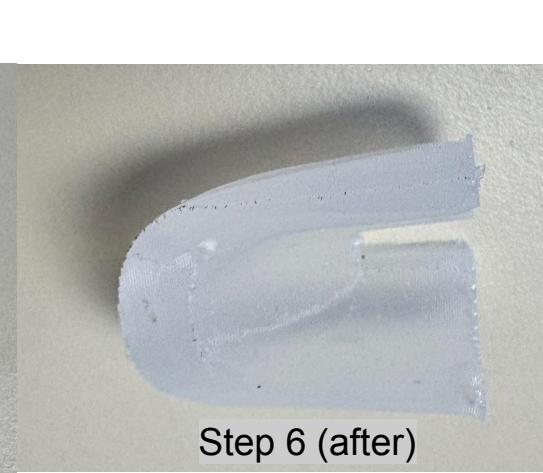
Step 4



Step 5



Step 6 (before)



Step 6 (after)

Silicone Inserts (optional)

7. Apply super glue to internal side of distal and proximal components

8. Spread around to create a uniform layer on the plastic

9. Gently press on foam and hold for 30seconds, until glue solidifies

10. Repeat for all fingers and thumb



Silicone Inserts (optional)

11. Apply even/thin layer of silicone adhesive to plastic. Spread to edges of offset surface.

12. Put on silicone pad to palm and gently apply force for 30seconds to allow to glue to cure



Step 11



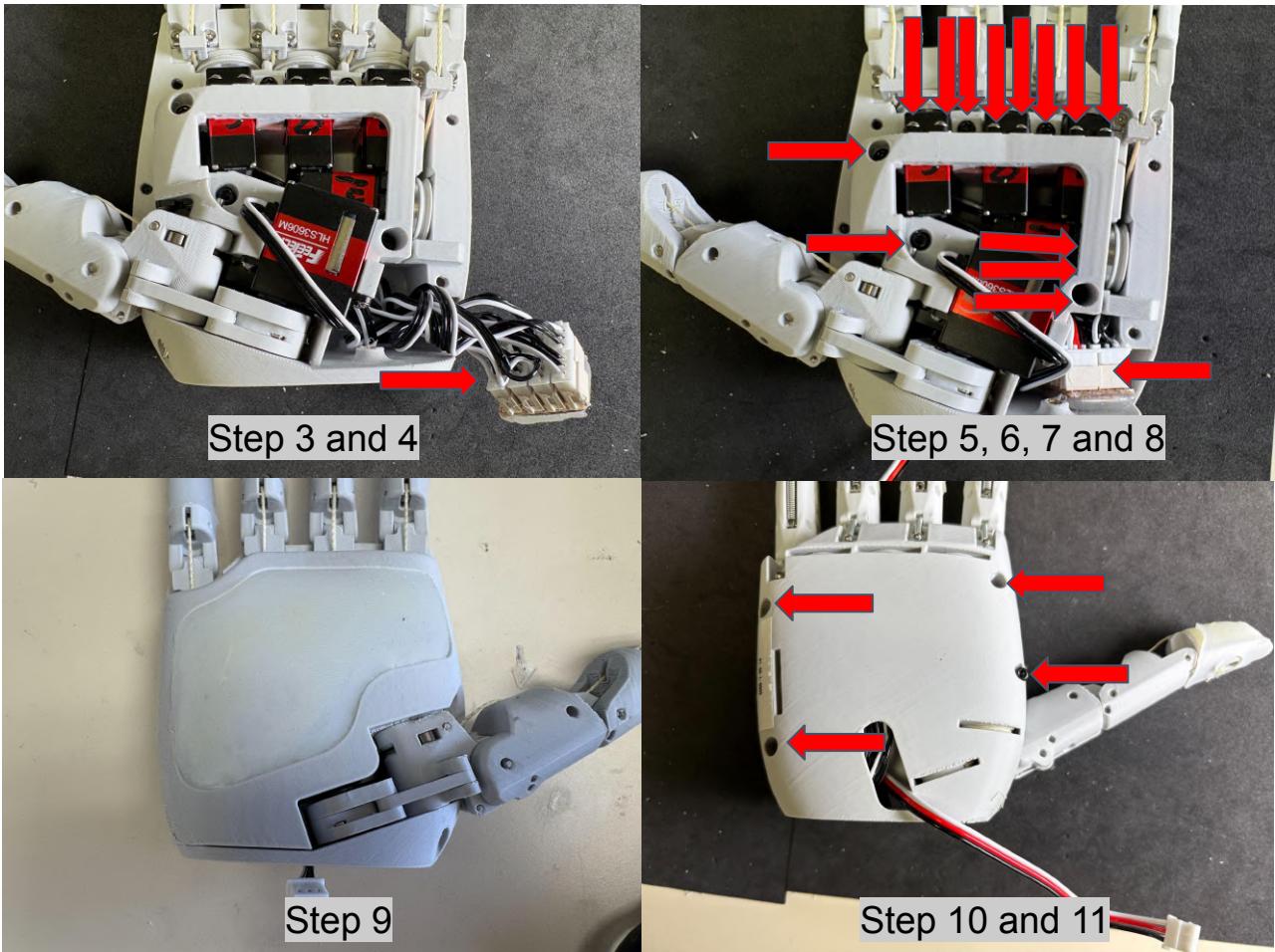
Step 11



Step 12

Servo Connection

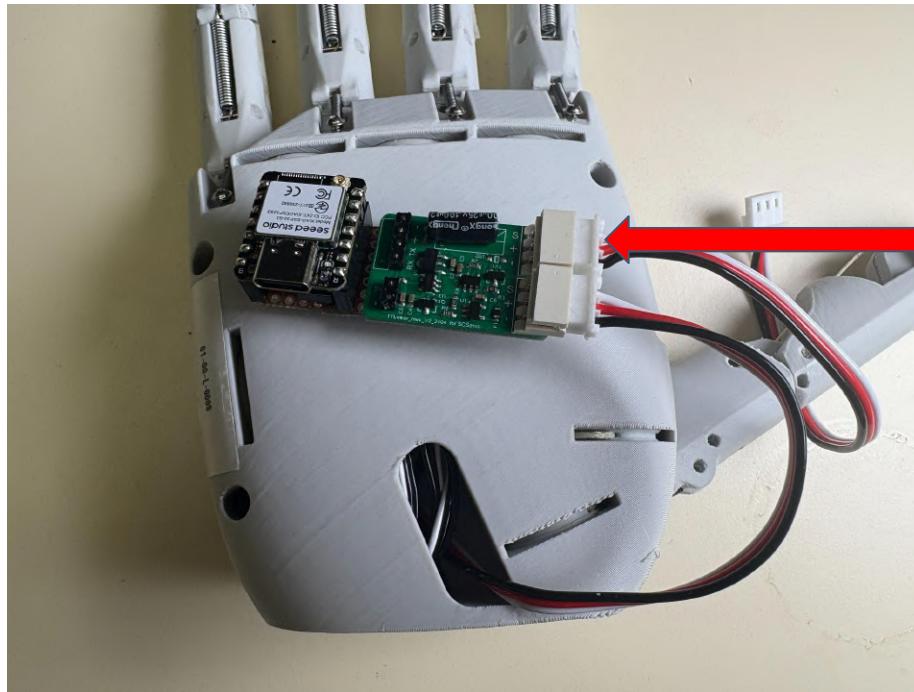
13. Route wires from servos 1, 2, 5, 8, 11, and 14 together through the hand and into the open area. This may require some rearranging
14. Connect all servos and one extension cable to the servo busbar
15. Push cables and busbar into space in the corner
16. Feed extension cable out of the back of the hand
17. Secure the frame using five 3x10 self tapping screws (40)
18. Secure servos 5, 8, 11, and 14 to servo frame using eight 2x6 self tapping torx screws (38)
19. Add front palm
20. Secure with four 3x10 self tapping screw on back of hand
21. Trim all cables 5mm from knot



Control Board

22. Installation location of TTlinker (48)
does not matter

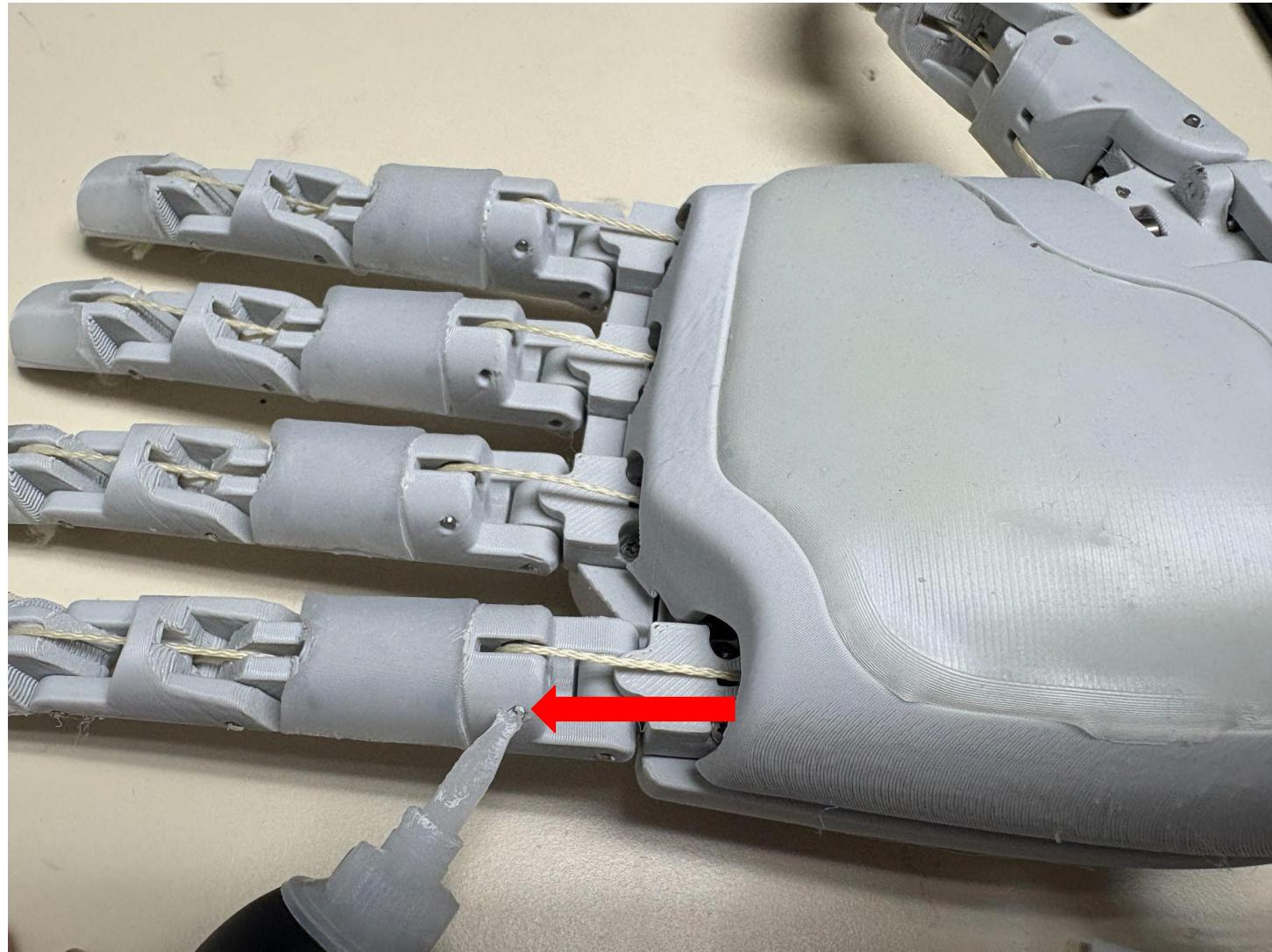
23. Connect a power cable (47) to the
second female connector on the driver to
power the servos



Power/Ground
Connection

High Cycling Protection (optional)

24. If using for high cycling >10,000 cycles per joint, apply superglue to every pin on both sides. This will secure them from sliding out.



Congratulations, you made it!

Your Aero hand is ready to meet the world. Let us know what you think of the hand.

<https://tetheria.ai>

