Open Parametric Hand Build Guide
Version 1

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github.com/kg398/100_fingers

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Contents

Introduction

A more comprehensive build guide to accompany the basic instructions in README.md and video guide.

Summary of files

- /OpenSCAD: scripts for generating hands with OpenSCAD. parameters.scad for demo use and parameters for generating example hands
- /STLs: 3D files for 3D printable parts
- /STLs/hands: three example hands generated from parameters.scad and example generated for visualisation (no_lig)
- /STLs/actuation_box: 3D files for three examples of modular actuation (1 degree-of-freedom(dof)/synergy, 2 dof/synergy, 1 dof with switching modulation)
- /STLs/manual_handles: 3D files for manual lever actuation and handles for 1 and 2 dof actuation boxes
- /media: images from publication (in progress)
- /build_guide: build guide PDF and videos

List of publications

- Gilday, K., Sirithunge, C., Iida, F., & Hughes, J. (2025). Embodied manipulation with past and future morphologies through an open parametric hand design. Science Robotics, 10(102), eads6437. /10.1126/scirobotics.ads6437 (arxiv: /10.48550/arXiv.2410.18633)
- Carlet, R., Gilday, K., & Hughes, J. (2025, April). Behaviour Range Optimization of the Dexterous Robotic Open Parametric Hand. In 2025 IEEE 8th International Conference on Soft Robotics (RoboSoft) (pp. 1-7). IEEE. /10.1109/RoboSoft63089.2025.11020976
- Gilday, K., Pyeon, D., Dhanush, S., Cho, K. J., & Hughes, J. (2024). Exploiting passive behaviours for diverse musical playing using the parametric hand. Frontiers in Robotics and AI, 11, 1463744. /10.3389/frobt.2024.1463744

0 Getting Started

The build guide follows the assembly of the default anthropomorphic hand (4 fingers, 1 thumb), single DoF actuation box, and manual handle. The exact version used in this guide is ?release_v?[1].

0.1 Bill of materials

Table 1: Full list of materials for default hand, 1 DoF actuation box, and manual hand.

Part	Description	Quantity
Polypropylene filament	Single-piece printed hand	80 (g)
M2x4 countersunk bolts	Tendon anchors	21
Braided fishing line, ∼0.2 mm diameter, >20 kg load	Tendons	10 (m)
PLA filament	Actuation box printed parts	50 (g)
Extension springs (l: 10–15 mm; k: 0.1–1 N/mm)	Passive tendon mounting and SEA	26
15x5x4 mm flanged bearing (flangeD/ID/W)	Actuation pulley mounting	2
50x4 mm smooth rod	Passive tendon bearing surface, e.g. aluminium	3
60x1.5mm smooth rod	Passive tendon pins, e.g. fibreglass	3
Braided fishing line, ∼1 mm diameter, >80 kg load	Actuation tendon	0.3 (m)
M2x4 countersunk bolts	SEA spring mount	5
M2x4 caphead	Box assembly, passive tendon anchors, t-select	3+21+1
M2x8 caphead	Box assembly and active tendon anchors	6+6
M2x10 caphead	Box assembly and SEA pins	2+2
M2 nut	Passive and active tendon anchors	21+5
M3x6 caphead	Box assembly, wrist and handle mounting	6+4+4
M4x12 grub screw	Hand mount	2
M5x16 caphead	Pulley shaft	1
PLA filament	Manual handle printed parts	100 (g)
140x4 threaded rod, steel	Tendon anchor and lever backbone	1
M4x25 caphead	Anchor locking pin	1
M4 nut, square	Tendon anchor	4
M5x25 caphead	Lever shaft	1

0.2 Printing files

Hand printing

Hands can be printed via commercial FDM printers (Prusa/Creality/Craftbot/Raise3D tested). General printing requirements are: large build volume and semi-flexible materials. Ideal hand properties with dual extrusion nylon filament and support material. Nylon printing is challenging for most printers, therefore polypropylene (PP) printing is recommended for good living hinge properties and relative ease of printing with a single extruder and standard temperatures. Print orientation is critical (palm should face down with fingertips closest to build plate and all ligament pairs flat relative to the build plate). Tree/organic support is recommended for easy removal around delicate ligaments. Minimal post-processing is needed to ensure pulleys are all clear of material. See Fig. i for example in Prusa Mk3/4.

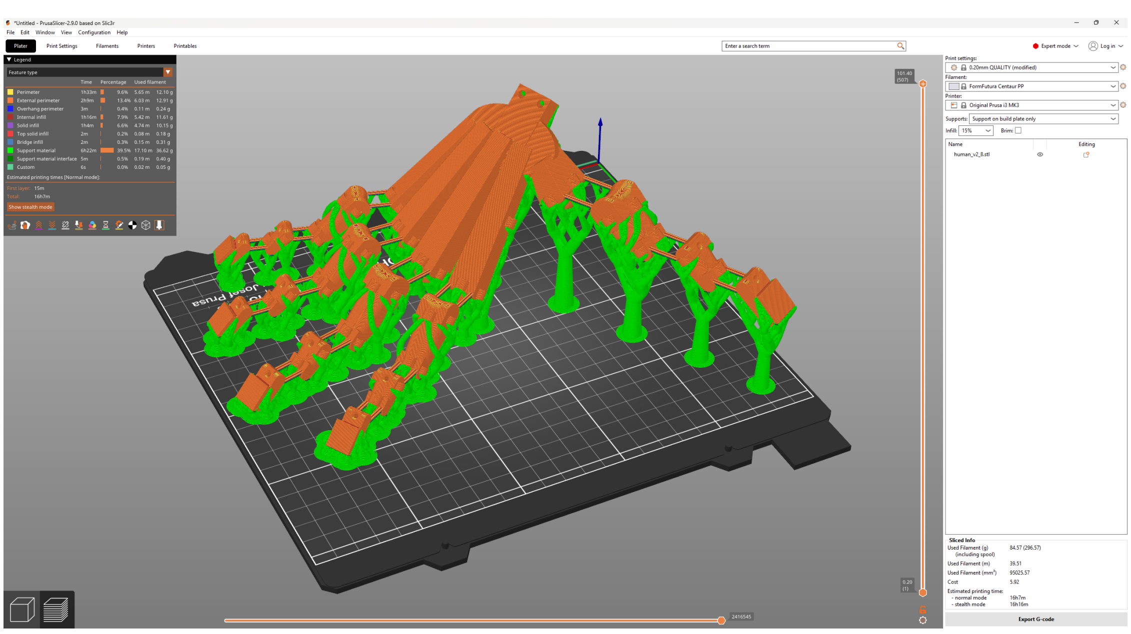

Figure i: Single-piece hand. Note ligaments oriented in x-y plane. Red = hand. Green = organic support.

[1] 2 DoF, switching, and 2 DoF handle are not updated in this release

SLS printing is also suitable. Only polyamide (PA2200) has been tested, resulting in stiffer bones than polypropylene and a cleaner print. Orientation is less critical.

Polypropylene printing tips

PP offers superior properties compared to standard 3D printing materials for this application with high toughness and excellent layer adhesion. PP adheres poorly to everything except itself, including most printer build plates. First layer adhesion issues are overcome by placing a layer of tape containing PP (most clear packaging tapes) on the build plate.

Follow manufacturers guidelines for printing PP, generally: 220–240°, bed 60°, 100% cooling, no heated enclosure.

Support material and bridge settings may need tuning depending on filament and printer model. Some test prints of single fingers or joints are recommended to find a balance of print quality and ease of support removal. Organic/tree type support is recommended. Lower print temp and denser support gives less warping and more reliable ligament printing.

Actuation printing

Actuation box and handles are printed with standard profiles in PLA. See Fig. ii for example in Bambu X1C.

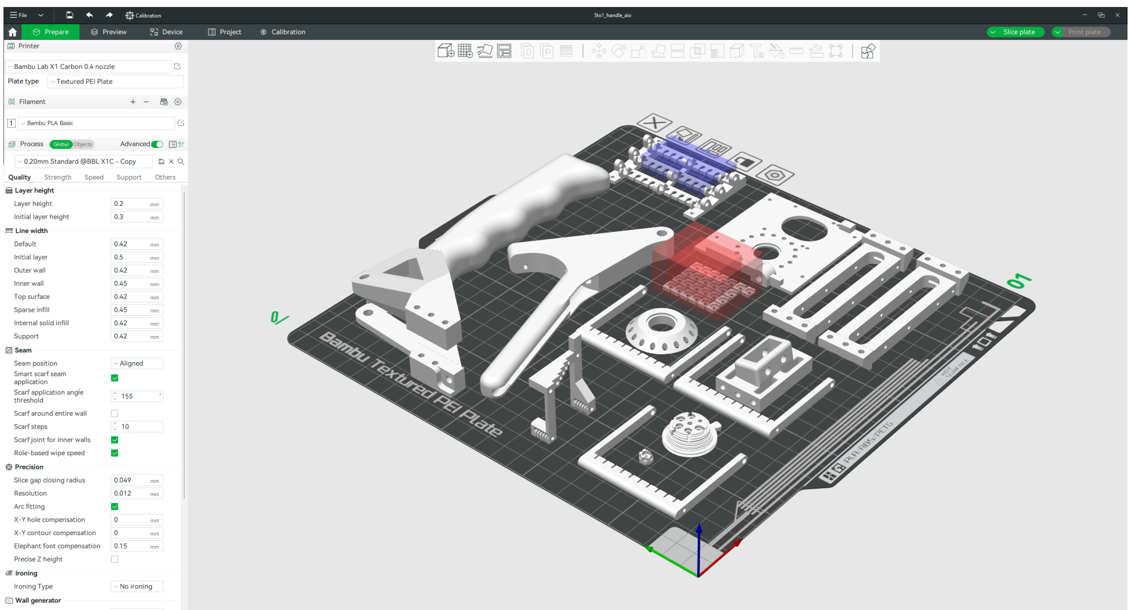

Figure ii: Actuation box and manual handle parts. Note part orientation. Red = support blocker. Blue = support enforcer.

1 Hand

Sections 1–4 cover assembly of the default hand with 1 degree of actuation driven manually, but should contain the necessary detail for reproduction of other versions. For support, contact via github or directly at kieran.gilday@epfl.ch.

Figure 1a: Hand assembly needs one printed part, 21 M2x4 countersunk screws, approx. 10 m of tendon which can support >20 kg and CA glue.

Hand assembly needs the following parts from section 1 of Table 1:

- PP printed hand (e.g. here),
- 21 M2x4 countersunk screws,
- approx. 10 m of tendon which can support >20 kg,
- CA glue.

Hand assembly is aided by the following tools:

- side cutters,
- tape measure,
- sharp knife or tendon cutter,
- screwdriver for M2x4 screws,
- tweezers (optional, can help tendon routing),
- needle (optional, can help tendon routing).

1.1 Support material

Figure 1.1: Breaking away support with sidecutters.

Step 1.1: remove support material. Organic support should peel away mostly by hand, use sidecutters to break away the rest. Take care not to overstress the ligaments. If any tendon pulleys are warped or blocked with support material you may have to open them with a drill and 1.5 mm bit.

Note: It is possible to repair ligaments by ironing with a soldering iron. If there is excess material around the ligament it can be gently heated and spread, otherwise cut a small piece of PP filament to use as a patch.

1.2 Cut tendons

Figure 1.2: Measuring and cutting tendons.

Step 1.2: cut 10x60 cm tendons for the extensors and 11x30 cm for the flexors and thumb opposition. A sharp box cutter is ideal or quality sidecutters. Tendons can be trimmed later so cut in excess of given lengths rather than too short.

1.3 Anchor bolts

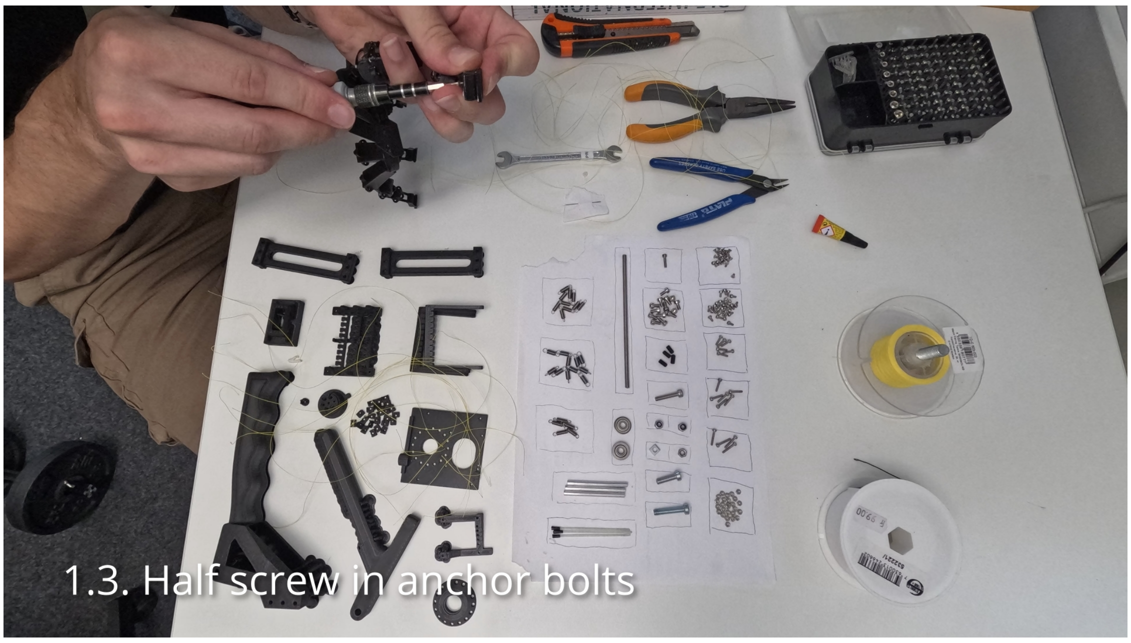

Figure 1.3: Leave at least 1 mm unscrewed.

Step 1.3: prepare hand for tendon routing by screwing in M2x4 bolts halfway. There are 4 anchor holes per finger (2 in each distal and intermediate bone) and a 21st hole in the thumb proximal for the opposition tendon.

Note: for a stronger anchor, longer bolts can be used (M2x6) if the bones are thick enough. CA glue or epoxy can also reinforce anchors at the expense of ease of repair.

1.4 Knot and route tendons

Figure 1.4: 4 lines and anchors per finger (5 tendons) + 1 for the thumb, 5 fingers for 21 lines (26 tendons).

There are 3 extensor tendons (using 2x60 cm) and 2 flexor tendons per finger (2x30 cm). Figs. 1.4a–1.4d cover the extensor routing.

The first 60 cm connects to the rear of the intermediate bone and forms 2 of the 3 extensor tendons. A single knot in the center fastens it to the anchor and the two ends route over the PIP extension and MCP abduction/adduction (Fig. 1.4a inset left).

The second 60 cm line connects to the rear of the distal bone and forms the 3rd extensor tendon. A single knot in the center for anchoring, and the 2 ends routed over DIP extension, PIP either side, reforming through MCP extension (Fig. 1.4a inset right).

Figure 1.4a: Form a small loop with a single knot for anchoring the 2 routings shown in inset.

Step 1.4a: form a small loop approx. 1 cm diameter by tying a loose single knot in the center of the 60 cm tendon.

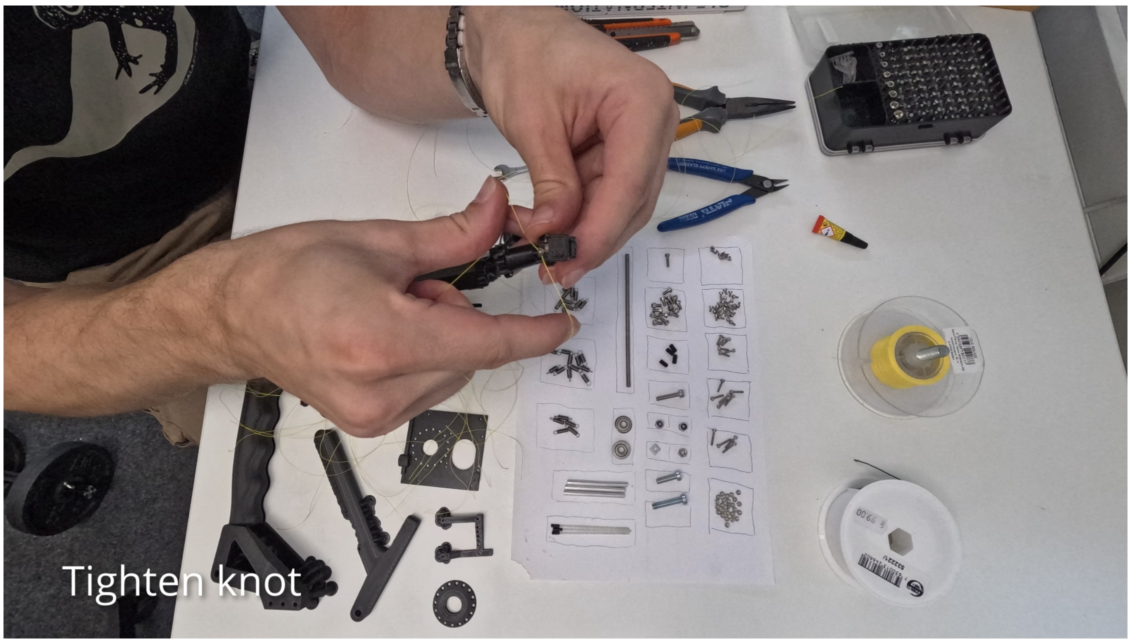

Figure 1.4b: Pull tight over anchor bolt.

Step 1.4b: tighten the loop onto the partially screwed in anchor bolt.

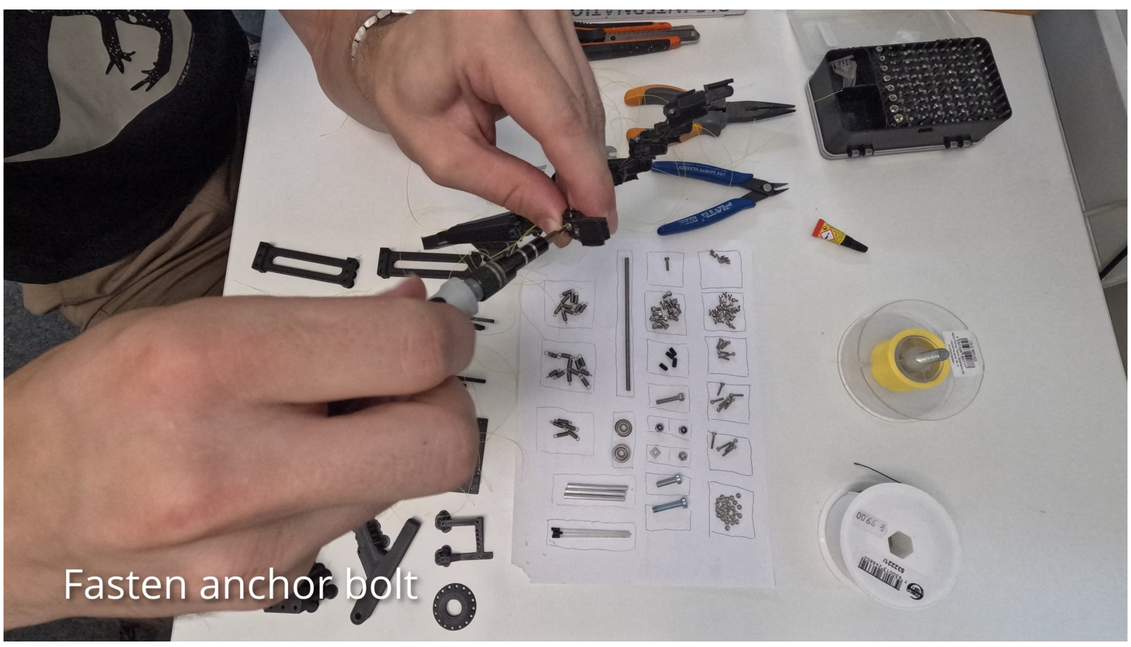

Figure 1.4c: Fix down.

Step 1.4c: fully fasten the anchor bolt while firmly pulling the tendon in the direction of routing.

Figure 1.4d: Route by hand, with tweezers to assist, or needles if needed.

Step 1.4d: repeat for the 2 routings given in Fig. 1.4a inset.

Note: if tendon ends too frayed or pulleys too rough internally, a sewing needle works the best for completing the routing.

Figs. 1.4e–1.4g cover the flexor and opposition tendons.

Figure 1.4e: Sliding knot loop self tightens over palmar side tendon anchor.

Step 1.4.e: form a small loop with a sliding knot in one end of the 30 cm line. Leave 1 cm extra length. Loop this over palmar side anchor and pull tendon to tighten sliding knot.

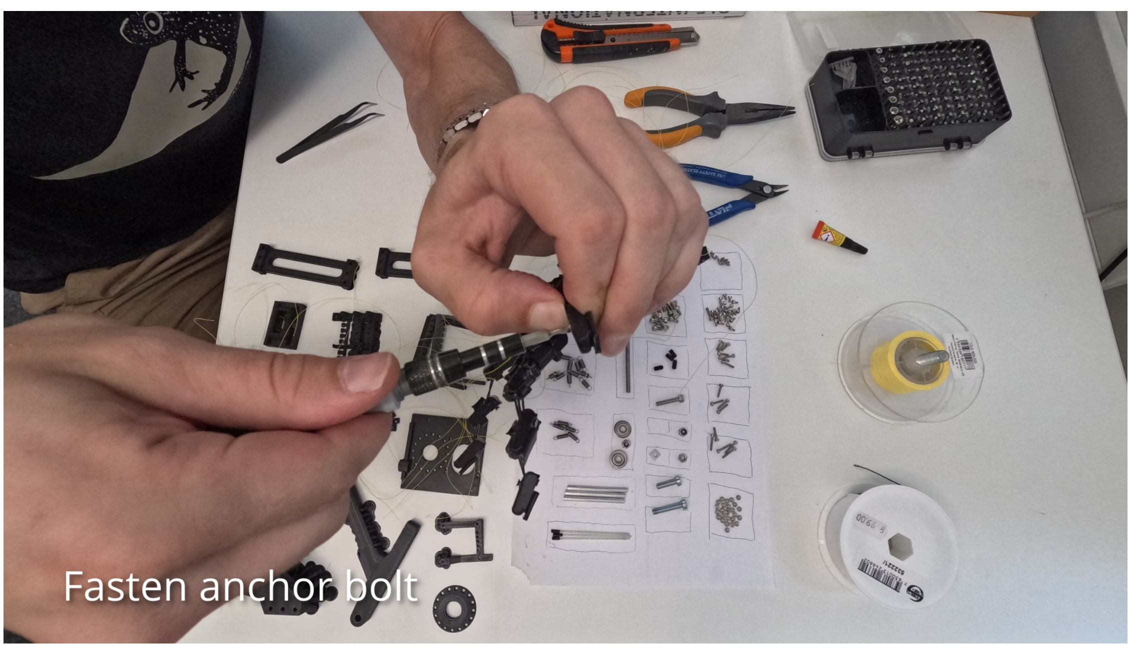

Figure 1.4f: Hold tendon tight with thumb while securing anchor screw.

Step 1.4f: fully fasten the anchor bolt while firmly pulling the tendon in the direction of routing.

Figure 1.4g: Tendons can remain loose by the palm. Pulling tendons should seat joints nicely into their sockets.

Step 1.4g: repeat for the 2 routings given in Fig. 1.4e inset, then repeat for each finger.

Note: the 11th 30 cm tendon is for thumb opposition. Follow same anchoring as Fig. 1.4e–1.4f, using anchor bolt in thumb proximal (metacarpal in standard human anatomy convention), 1st pulley on thumb proximal and 2nd pulley on index metacarpal.

Figure 1.4h: Wicking glue into the excess tendon by the anchor is effective for preventing knot unraveling.

Step 1.4h: for more permanent tendon anchoring, small amounts of CA glue can be applied to the knot or excess tendon by each anchor.

2 Actuation Box

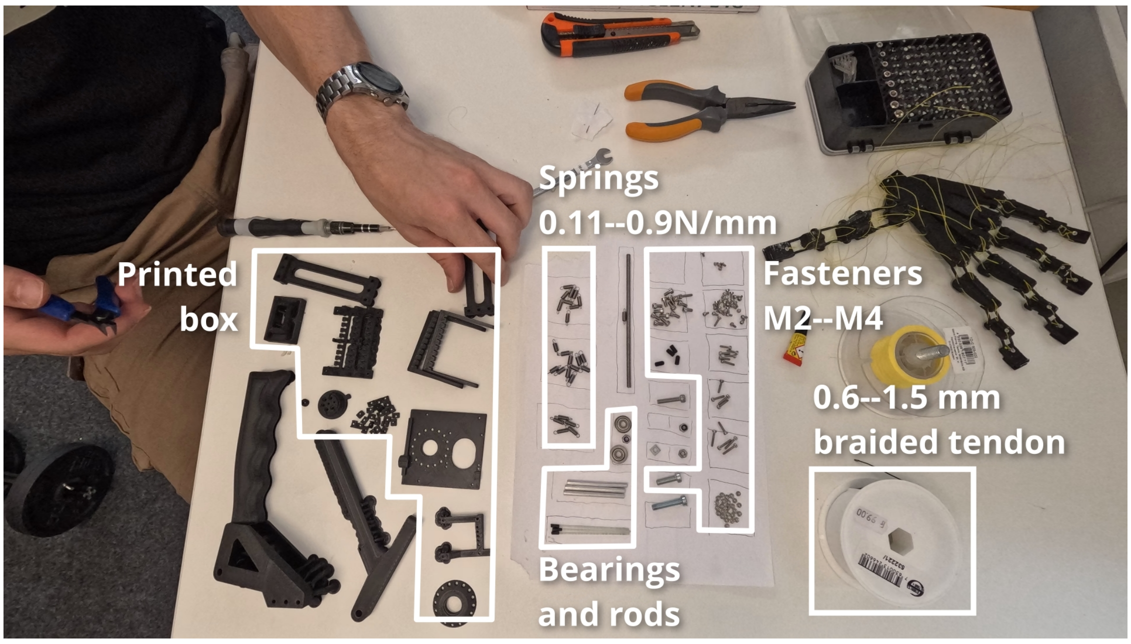

Figure 2a: Actuation box assembly needs one set of printed parts, a variety of extension springs, smooth rod, screws and stronger tendon.

Actuation box assembly needs the following parts from section 2 of Table 1:

- PLA printed parts (here),
- extension springs (d:2–5 mm, l: 10–15 mm, k: 0.1–1 N/mm), e.g. 10 k:0.15, 11 k:0.3, 5 k:0.9 (26 total springs),
- flanged bearings 15x5x4 ODxIDxW (13x5x4 ODxIDxW non-flanged),
- smooth rod, e.g. aluminum/steel pins, 4 mm diameter for tendon bearing, approx. 1.5 mm (should have a friction fit in racks) for tendon pins,
- <1 m braided fishing line rated to approx. x5 hand tendon load,
- screws from M2–5 and M2 nuts.

Box assembly is aided by the following tools:

- side cutters,
- tape measure,
- sharp knife or tendon cutter,
- screwdriver for M2–M5 screws,
- pliers,
- tweezers.

2.1 Support material

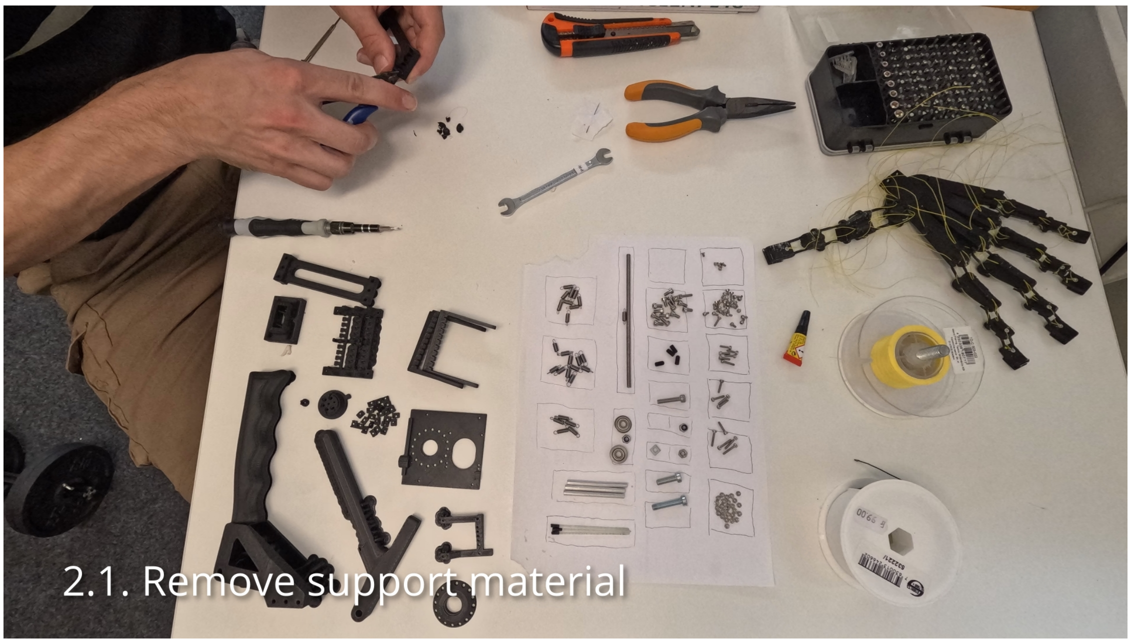

Figure 2.1: Take note of print orientations in Fig. ii.

Step 2.1: remove support material. Organic support should peel away mostly by hand, use sidecutters to break away the rest.

2.2 Hand connector and spring racks

This step takes the printed parts: *side_panels* x2, *rack_mount*, *rack* x3, *wrist*, and uses 2 M2x8, 2 M2x10, 10 M3x6 screws.

Figure 2.2a: Assembled passive tendon side first for easier access to routing.

Step 2.2: assemble the *rack_mount* to the *side_panels* with the 4 M2 screws. The taller end of the *rack_mount* should be flush with the lip of the *side_panel*. Then fasten the *wrist* to the *side_panels* with 4 M3x6 bolts, leaving the center holes free. If using the 10degree *wrist*, ensure it is swept backwards towards the rack. Finally, mount spring *racks* with 6 M3x6 screws. Do not over-tighten any screws

2.3 Spring anchors

This step takes the printed parts: *tendon_hook_v4* x21, and uses 21 M2x4 caphead screws, M2 nuts, and extension springs (two different spring rates, approx. different by a factor of 2).

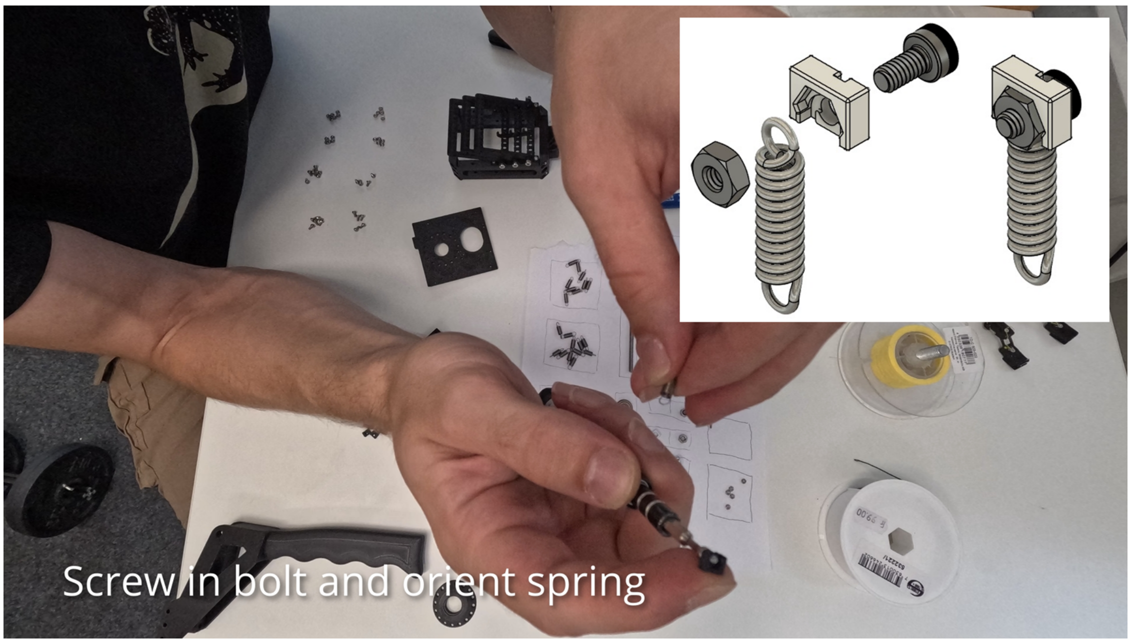

Figure 2.3a: Partially assembly anchor and assembly inset.

Step 2.3a: the M2x4 screw should be a friction fit but not threaded in the printed hook. Screw this in first and overtighten to strip any formed thread. Next place the spring over the screw thread protruding from the hook, the spring loop orientation over the thread is important and should match th e inset in Fig. 2.3a.

Note: the spring loop is oriented so when the bolt is tightened, the loop is closed. This prevents deformation of the spring.

Figure 2.3b: ..

Step 2.3b: add the nut and fully tighten. There should be no gap between the nut, spring loop and printed hook. In preparation for attaching the tendon, the screw can be unfastened, leaving approx. 1 mm gap. Then repeat steps 2.3a and b for all 21 passive spring anchors.

2.4 Hand mounting and passive tendons routing

This step takes the assembled hand, partially assembled box, M4 headless (grub) screws, 21 spring anchors, and x3 1.5 mm smooth rods for pinning spring anchors.

Figure 2.4a: Connect hand to wrist.

Step 2.4a: push hand into wrist until holes are aligned. M4 headless screws lock these together.

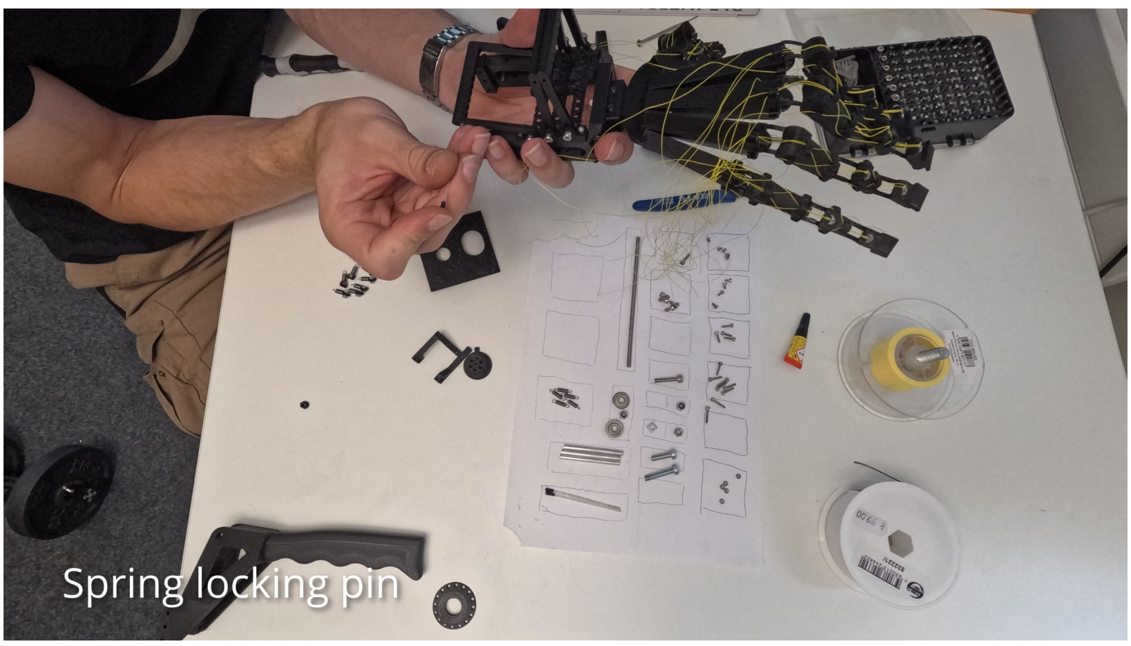

Figure 2.4b: Inserting pin in one rack.

Step 2.4b: locking pin should be able to freely slide all the way through the rack. Wrap 5 mm of one end in tape to form a grip (optional).

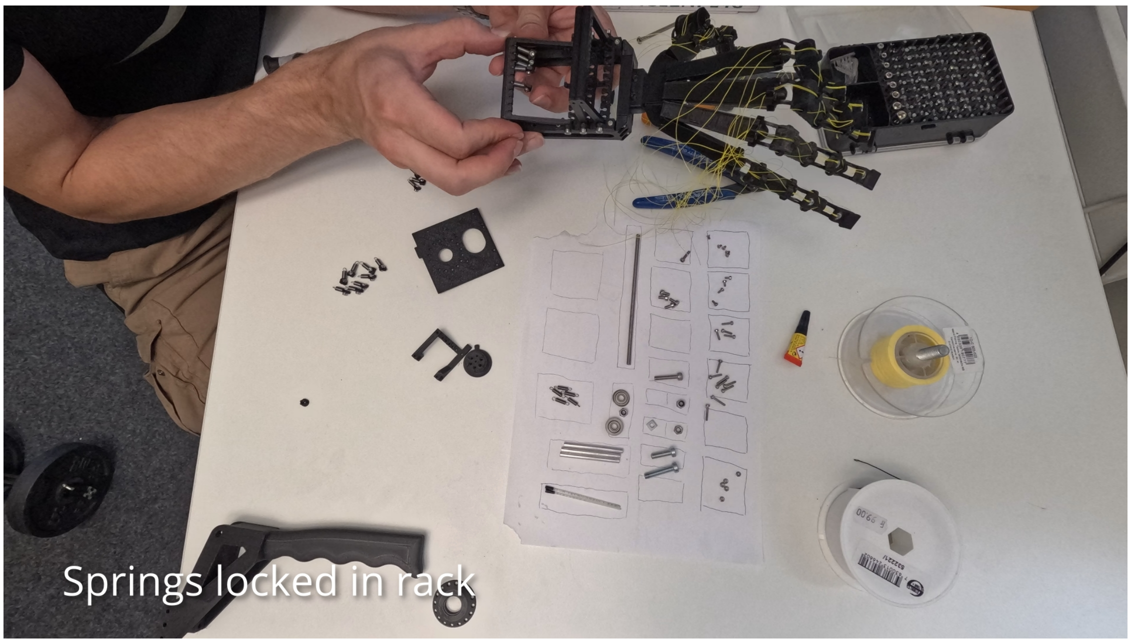

Figure 2.4c: 5 spring anchors pinned on one rack.

Step 2.4c: passive tendon spring configuration is arbitrary, but consistent placement aids future adjustments. I use: 5 thumb tendons on the lowest rack, then the 4 of each index and little finger on the next, then the 4 of each middle and ring on the last. The tendons or each finger should also be placed consistently, I use (from left to right): left abductor (low k anchor), right abductor (low k), extensor (high k), intermediate flexor (high k), and—in the case of the thumb—opposor (high k).

Note: two different spring stiffness are recommended to balance forces more evenly over joints making for easier adjustments. Low stiffness is only used for abductors as the stiffness is additive when the two tendons per finger meet at the PIP joint. Otherwise spring rates are arbitrary. Higher overall stiffness give more stable behaviours and stronger pinching, though requires more force to actuate.

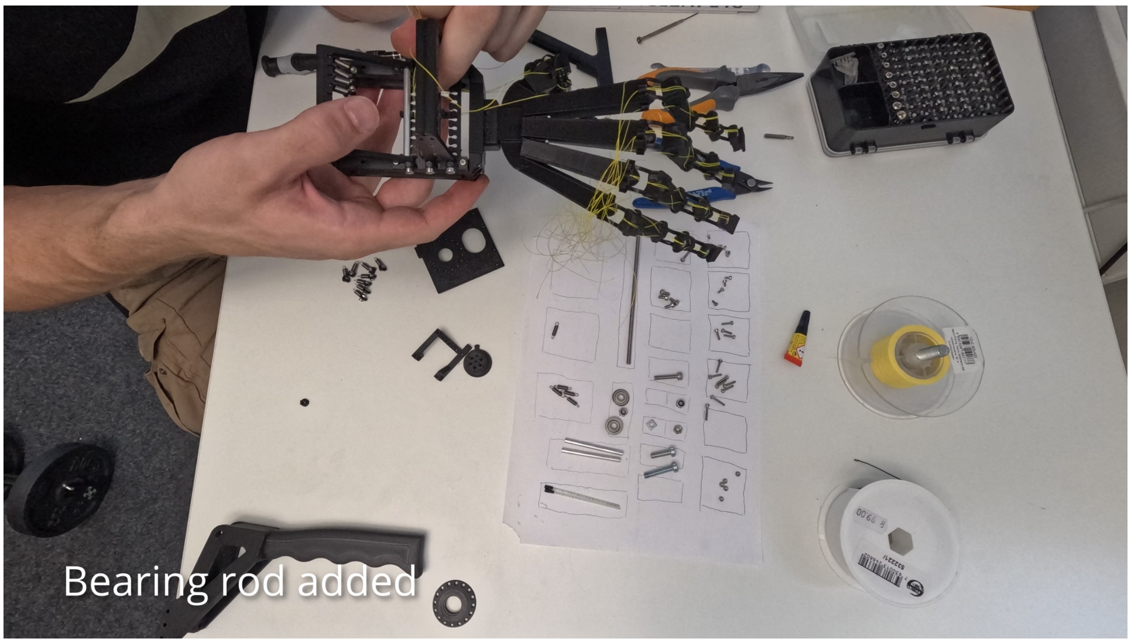

Figure 2.4d: Bearing rod locks tendons in there slots opposite from spring anchors.

Step 2.4d: for one rack, route tendons through the wrist slots and to the *rack_mount* slots opposite the chosen spring configuration. Take as direct tendon path as possible for reduced friction. Once all rack tendons are in their slots, press fit the 4 mm bearing rod into the *rack_mount* to lock them in place.

Figs. 2.4e–2.4g cover anchoring individual tendons.

Figure 2.4e: Tendon only needs looping approx. 180 degrees. Tendon towards hand should align with slot in Fig. 2.3a.

Step 2.4e: before starting ensure one of the M3 rack mounting screws is partially loosed so a tendon can be wrapped in the space between the head and printed part for a temporary friction hold. Then loop the tendon over the head of its corresponding spring anchor. The loop should be anti-clockwise with the tensioned end aligning with the small printed slot (Fig. 2.3a inset).

Figure 2.4f: Wrapping tendon underneath M3 screw head temporarily holds it in place.

Step 2.4f: pull free end to remove tendon slack, then wrap free end around a slightly loose M3 rack bolt to temporarily hold in place.

Note: the first tendon for each finger has more slack and can be pulled more than expected, significantly curling the finger up. Each subsequent tendon has less slack to remove.

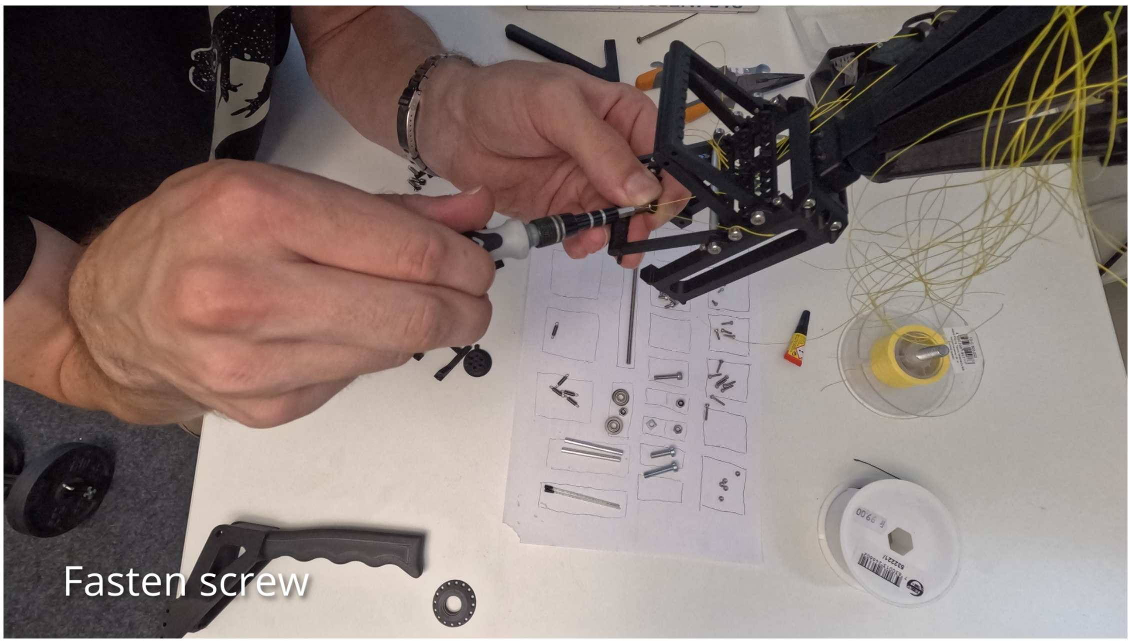

Figure 2.4g: Clamp tendon with spring anchor screw while roughly held in place.

Step 2.4g: firmly tighten screw so tendon is securely clamped between plastic hook and screw head.

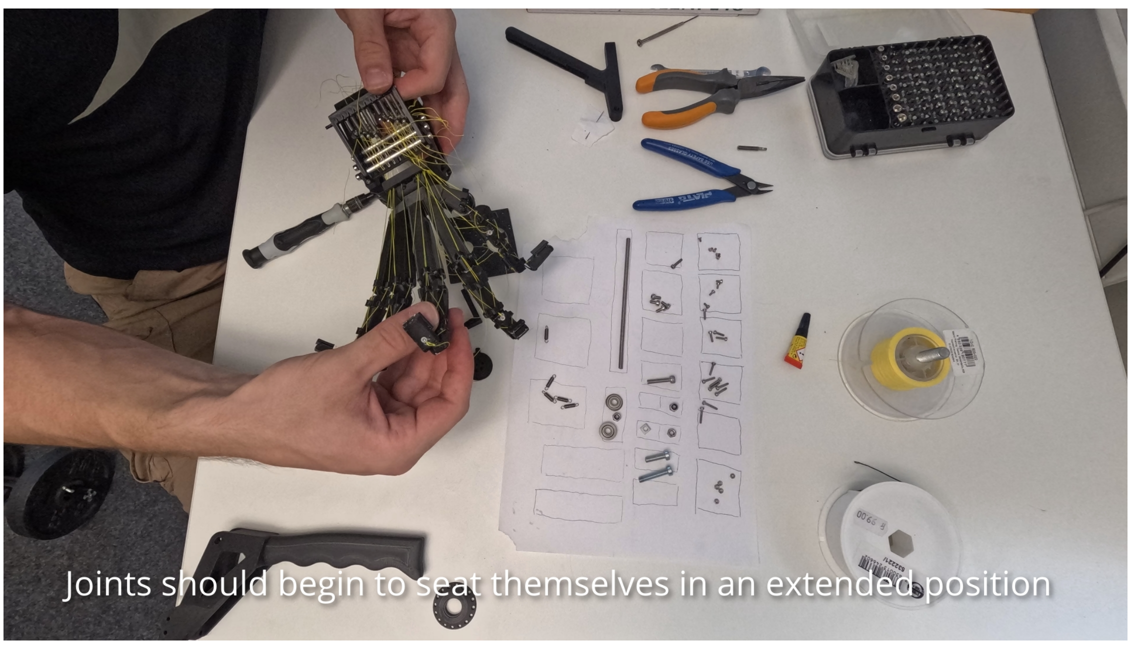

Figure 2.4h: Joints in extended positions except hyperextended DIP with unconnected flexor tendons.

Step 2.4h: repeat for each passive tendon. If following default configuration, this is all tendons except for distal flexors (Fig. 1.4e inset left). Each joint should start to seat in its socket in the extended position except for the DIP. If not, tendon tensions can be adjusted now or along with active tendon tuning later.

2.5 Active tendon base components

This step takes the printed components: *pulley_base*, *sea*, *bearing_block*, *pulley/parametric_pulley*, and *pulley_tselect*; other parts include 1 m strong braided fishing line, 2 15x5x4 flanged bearings, 4 M2x4, 10 M2x8, 2 M2x10, and 1 M5x16 caphead screws, 5 M2x4 countersunk screws and 5 M2 nuts.

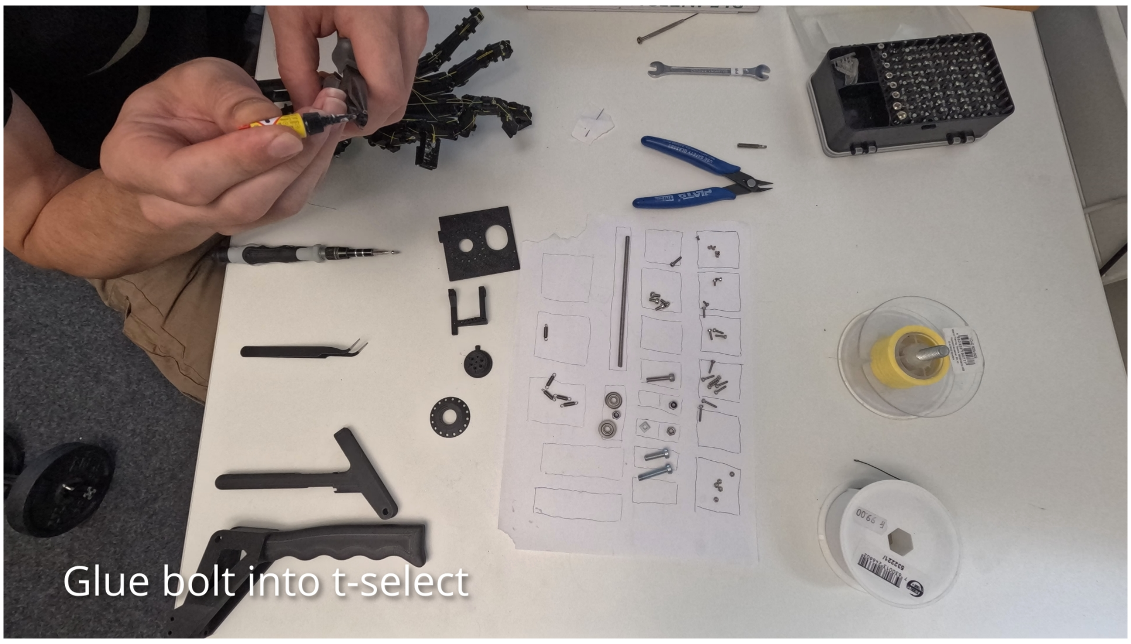

Figure 2.5a: *pulley_tselect* will allow active tendon tension adjustment.

Step 2.5a: prepare pulley tendon tensioning selector by CA gluing the head of an M2x4 caphead screw into the *pulley_tselect*.

Figure 2.5b: Pressing bearings into *pulley_base* and *bearing_block* together.

Step 2.5b: align *pulley_base* and *bearing_block* so both bearings can press fit and join parts together with flanges facing outwards. Use a clamp or vice to ensure flush fit.

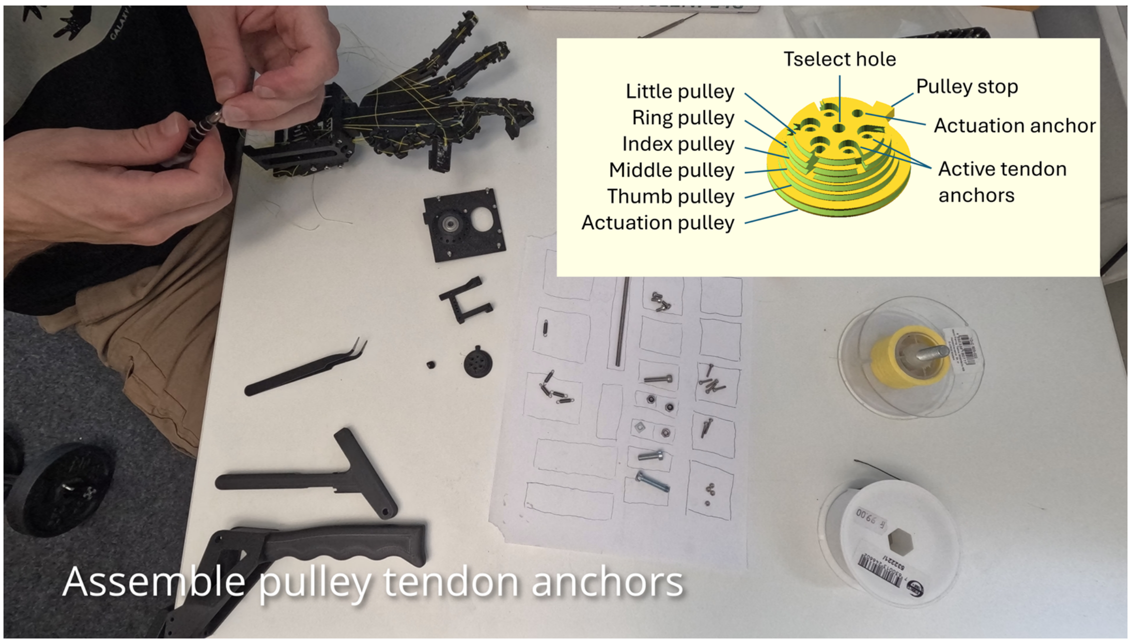

Figure 2.5c: Fully screw nut onto M2x8 screw and push into the 5 active tendon slots. Inset of labelled pulley features.

Step 2.5c: prepare the 5 active tendon anchors by fully tightening an M2 nut on each of 5 M2x8 caphead screws. These should then press into the 5 active tendon anchor holes (Fig. 2.5c inset) without screwing. If the holes are too tight, they can be opened up with a 2 mm drill bit.

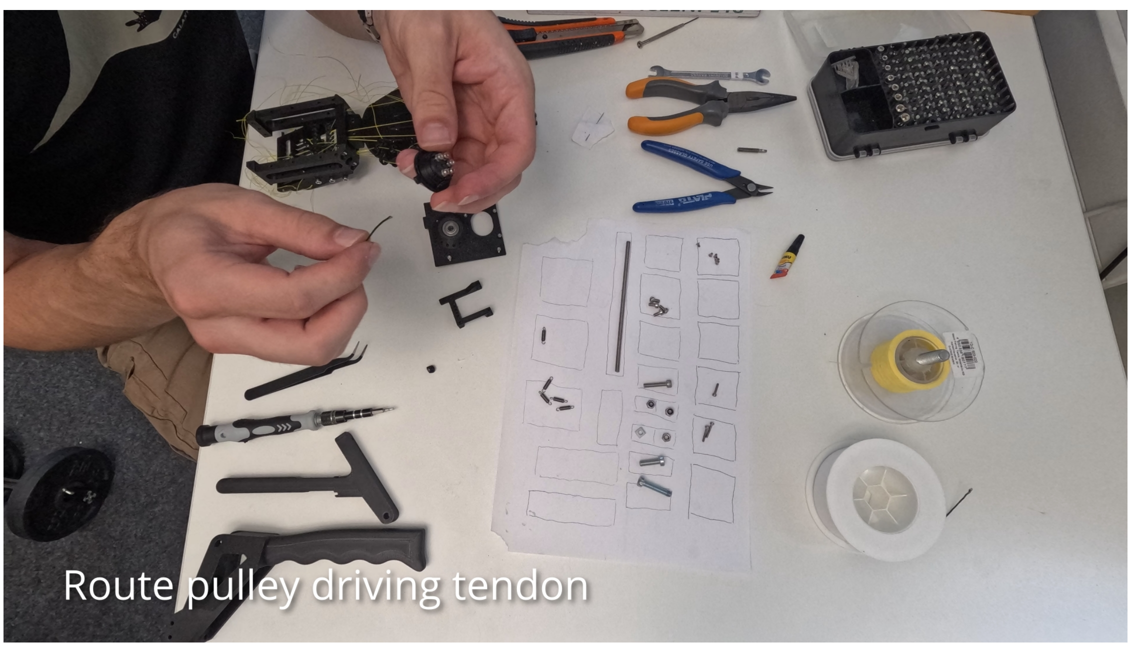

Figure 2.5d: Driving/actuation tendon routed through pulley.

Step 2.5d: the driving/actuation tendon is routed through a hole in the driving/actuation pulley stage next to the stop (Fig. 2.5c inset).

Figure 2.5e: Pull tendon at both ends and leave a few cm out the top face.

Step 2.5e: to aid process, tendon can be pulled out the underside of the pulley once through the lateral hole, then fed back via the through hole out the top of the pulley. Leave a few centimeters emerging from the top hole and remove any slack in the tendon path.

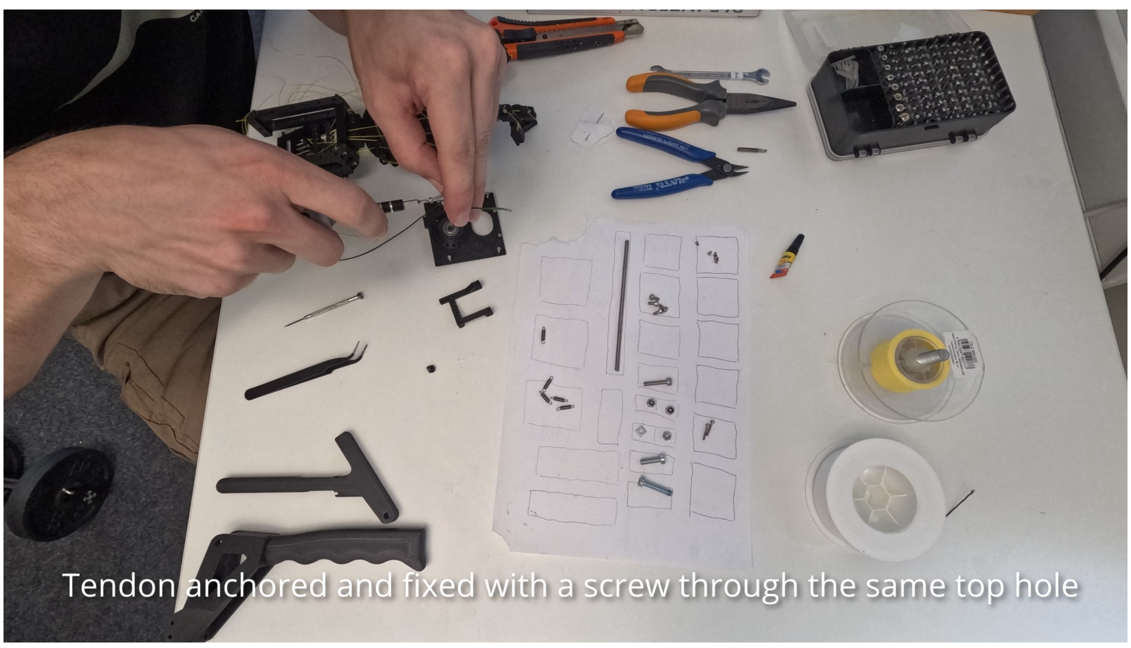

Figure 2.5f: Fix in place with an M2x8 screw in the same hole.

Step 2.5f: anchor tendon in place by screwing in an M2x8 screw in the same hole. The tendon is held by friction and clamping over the length of the screw.

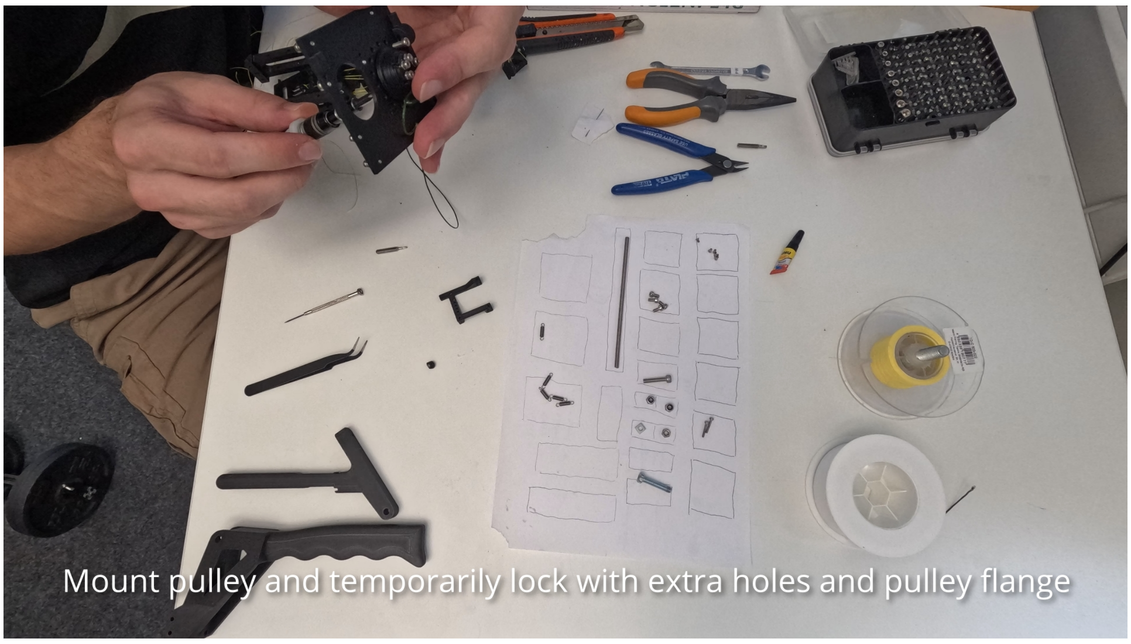

Figure 2.5g: An M2.5 screw can temporarily stop the pulley rotating by obstructing the pulley stop.

Step 2.5g: Mount the pulley with the M5x16 bolt through the 2 bearings. The pulley should be on the flat side of the assembled base.

Figure 2.5h: Driving tendon can be secured by wrapping around and extra M2x5 screw.

Step 2.5h: actuation/driving tendon should route around the base pulley clockwise and out through the tangential hole in the assembled base.

Figure 2.5i: *sea* adds elasticity to active tendon paths for more adaptive behaviours and spreading loads across multiple fingers.

Step 2.5i: mount *sea* part on pulley base with 3 M2x4 caphead screws. 2 M2x10 screws can be screwed into the top holes by the tendon slots. Only screw these in 1 mm so all 10 slots remain open.

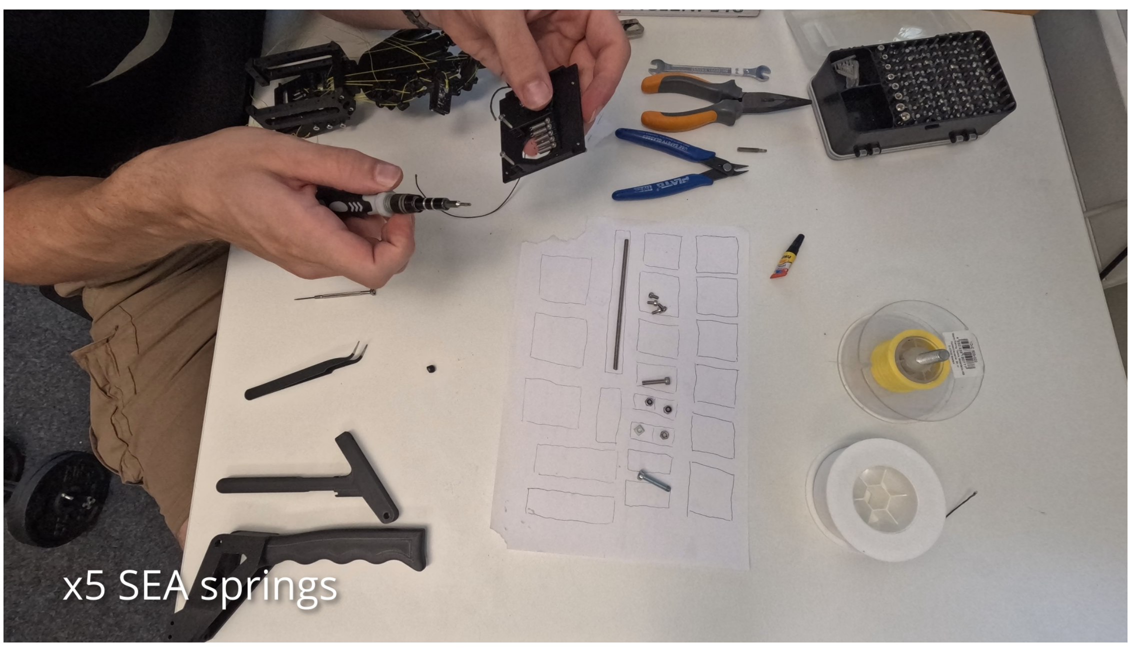

Figure 2.5j: Stronger springs will more evenly distribute forces between fingers, though require more force for adaptive behaviours. Typically use approx. 1 N/mm.

Step 2.5j: 5 M2x4 countersunk screws attach SEA springs facing inwards towards the tendon slots.

Figure 2.5k: Active tendons will go through the top slot, then sea spring, then middle slot, then to the pulley. Assembly can begin with pulley base resting on the box.

Step 2.5k: route each of the active tendons through the wrist slots, then the pulley base top slot, then spring, then middle slot. Ensure tendon order matches pulley order (Fig. 2.5c inset); this is ordered by pulley diameter, corresponding to relative finger joint sizes, hence: thumb, middle, index, ring, then little.

Note: if springs are hook type rather than close loop, tendon routing can skip springs at the stage for ease of handling.

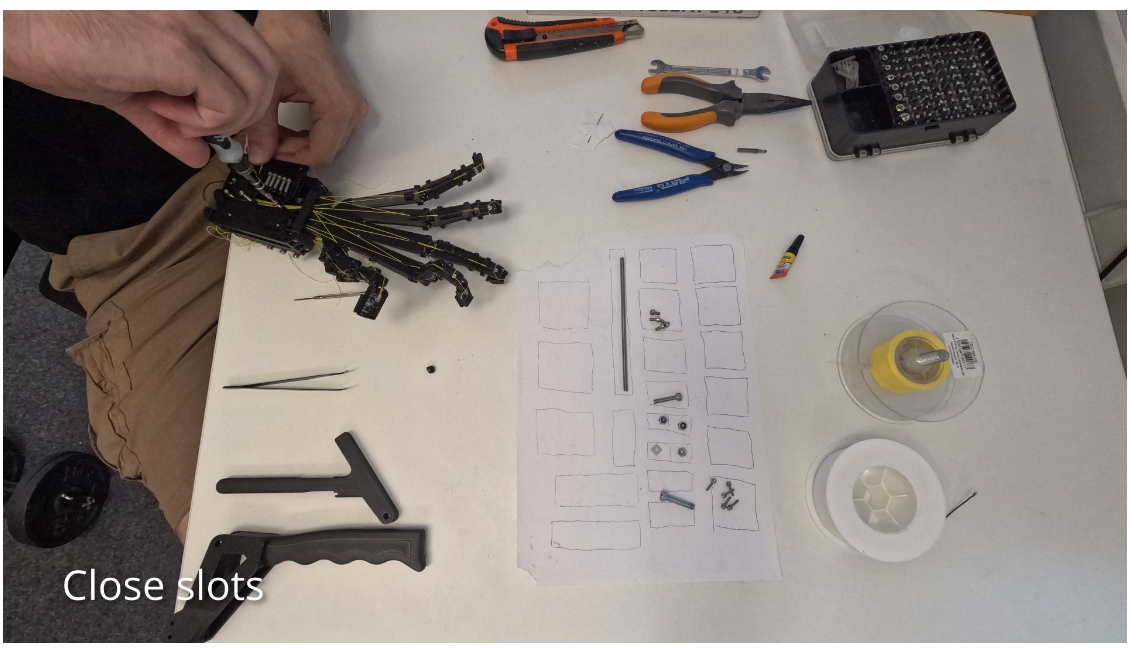

Figure 2.5l: Finish screwing in M2x10 screws.

Step 2.5l: tendons are prevented from leaving their slots and reinforced with the 2 M2x10 screws which can now be fully screwed in.

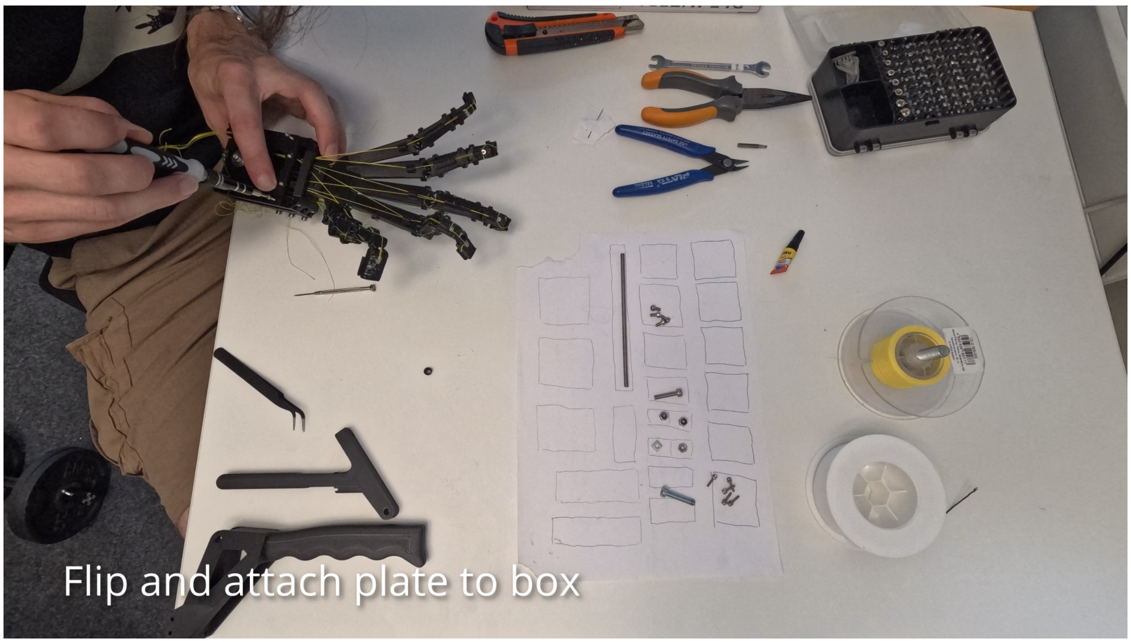

Figure 2.5m: Assemble pulley base into box.

Step 2.5m: pulley base should now be flipped to face down on the box; active tendons should not be twisted together. The base is then fastened flush with the lower end of the box with 4 M2x8 screws.

Figure 2.5n: Tweezers to hook tendon over spring.

Step 2.5n: if using hook type springs, now tendons can be routed through spring by tweezers through access hole.

Figure 2.5o: Hook type tendons can be pinched slightly with pliers to prevent tendon unhooking.

Step 2.5o: if using hook type springs, hooks can be closed to prevent tendon hooking by gently squeezing each loop with pliers. Each tendon should be able to freely pull then begin to stretch its SEA spring when the fingers resist.

2.6 Actuation pulley

The following steps are for the default 5-to-1 adjustable tension pulley. Tendons are clamped between the anchor screw head and a nut. Turning the screw wraps the tendon and adjusts tension. Unwrapping is prevented by locking the flat side of the nut against a surface. The direction of wrapping is important so torque applied from tendon tension acts to tighten the nut rather than loosen and unanchor the system.

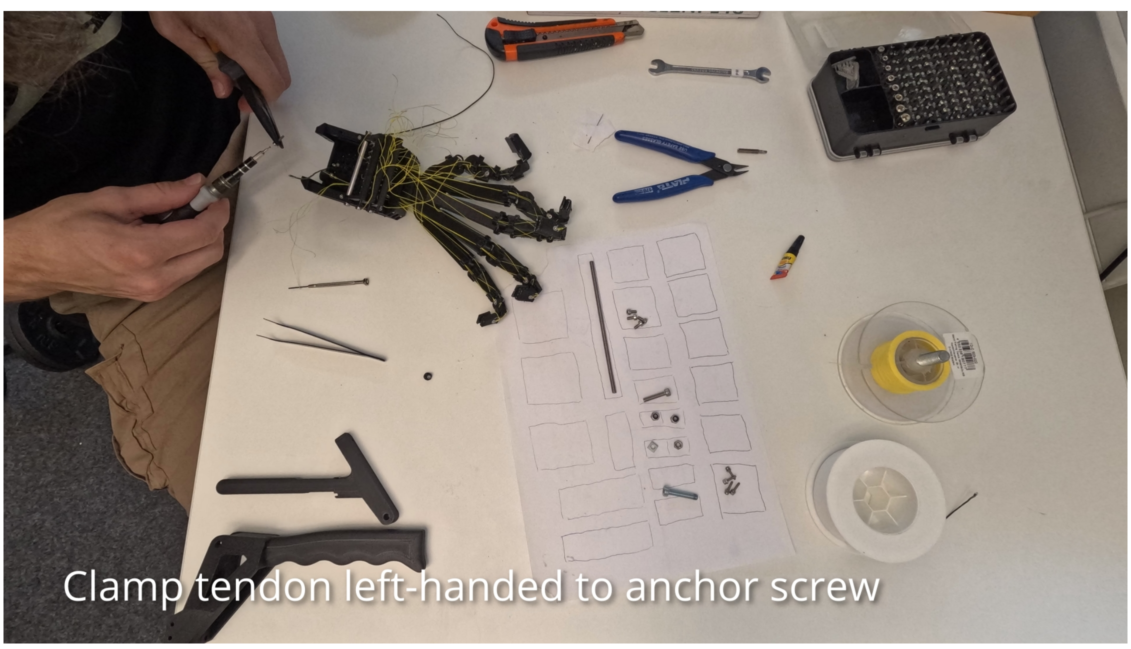

Figure 2.6a: Clamp tendon only a few cm from the pulley.

Step 2.6a: loosen the nut on the anchor screw then wrap the tendon once around anti-clockwise. The tendon should emerge from the left side of the screw when looking from the top and the hand is in front.

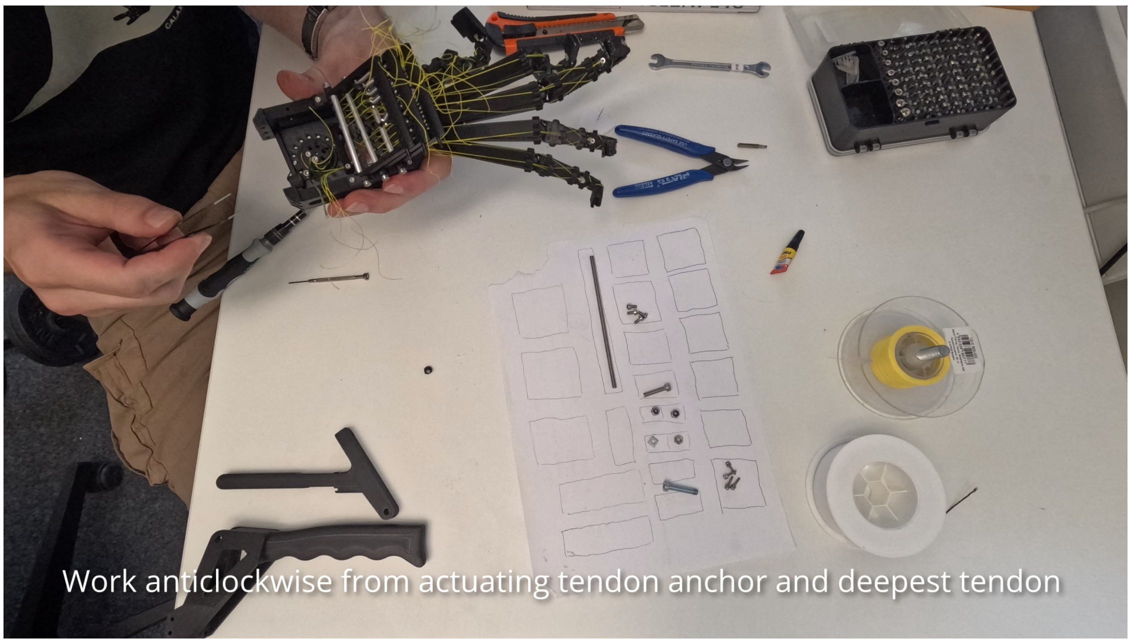

Figure 2.6b: Easiest to route the thumb tendon first, then work upwards.

Step 2.6b: push the anchor back into the corresponding pulley hole (one for each pulley stage seen by corresponding slots).

Figure 2.6c: Turn anti-clockwise to wrap tendon and increase tension.

Step 2.6c: assembled tselect should be in the pulley center hole, then turn flat side to face anchor screw. Gently hold tendon in place going anti-clockwise from the anchor around the pulley and turn the anchor to wrap the tendon and remove any slack.

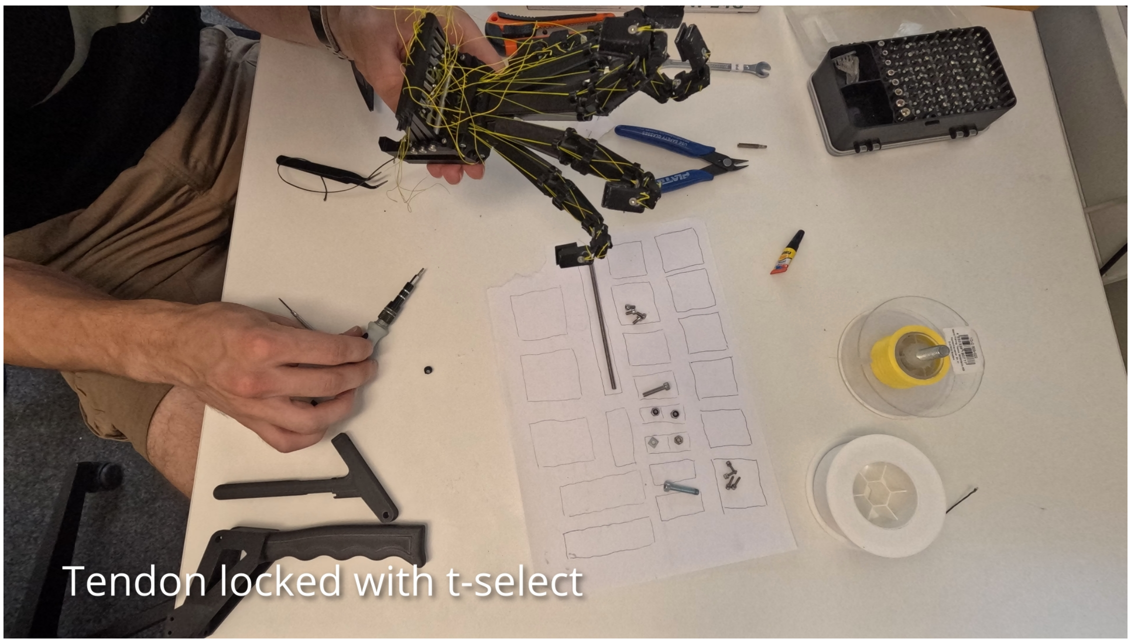

Figure 2.6d: Use screw socket in tselect to turn flat face to desired position (towards active anchor for tension adjustment, towards driving tendon anchor to lock all tendons.

Step 2.6b: turn the tselect towards the driving tendon anchor to lock active tendon anchor in place. Final tension adjustment can be made later. Repeat steps 2.6a–2.6d for each active tendon.

2.7 Passive tendon fine adjustment

Figure 2.7a: Passive tendon tensions set starting posture.

Step 2.7: with slack taken up by active tendons, passive tendon pretension can be finally adjusted so all 15 hand joints are seated nicely. Here, starting/resting posture can also be configured but default is with a small flex in each joint. Retension by holding end of tendon to be adjusted, loosening anchor screw and repeating steps 2.4f–2.4h.

3 Manual Handle

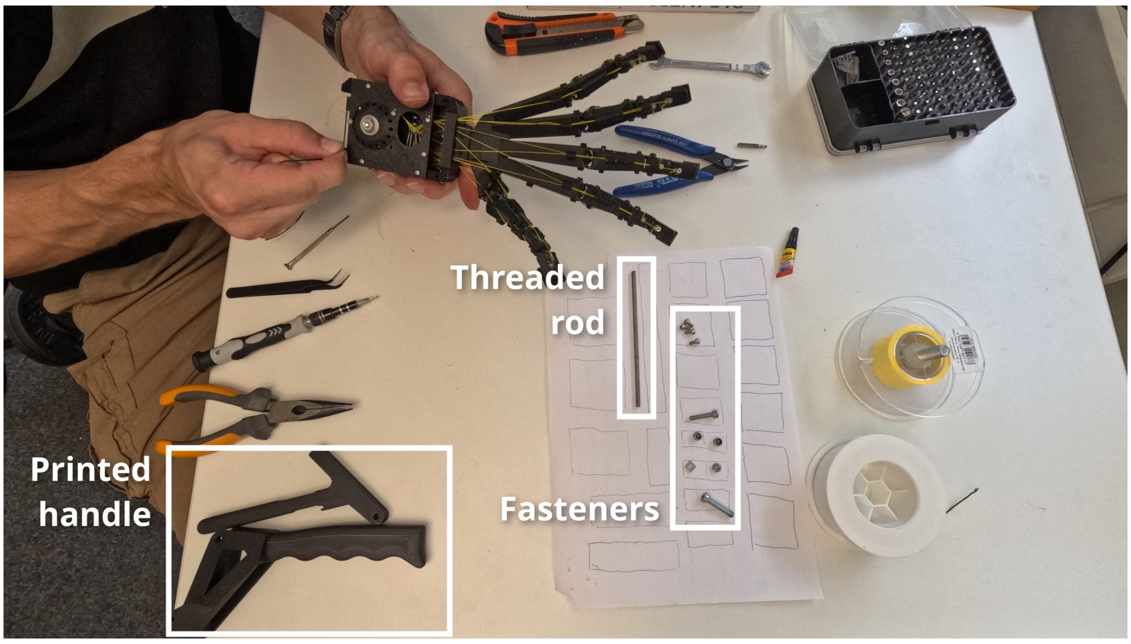

Figure 3a: Manual handle parts for testing and demonstrations.

Manual handle assembly needs the following parts from section 3 of Table 1:

- PLA printed parts (here),
- 140 mm M4 threaded rod,
- 1 M4x25 caphead screw,
- 4 M4 square nuts (only one needs to be a square nut),
- 1 M5x25 caphead screw.

Handle assembly is aided by the following tools:

- side cutters,
- screwdriver for M4–M5 screws,
- 2 spanners for M4 nuts.

Note: 2dof manual handle is out of date and doesn't yet include tension adjustment and reinforcement.

3.1 Route tendon and connect handle

This section takes the printed part *handle* and 4 M3x6 screws.

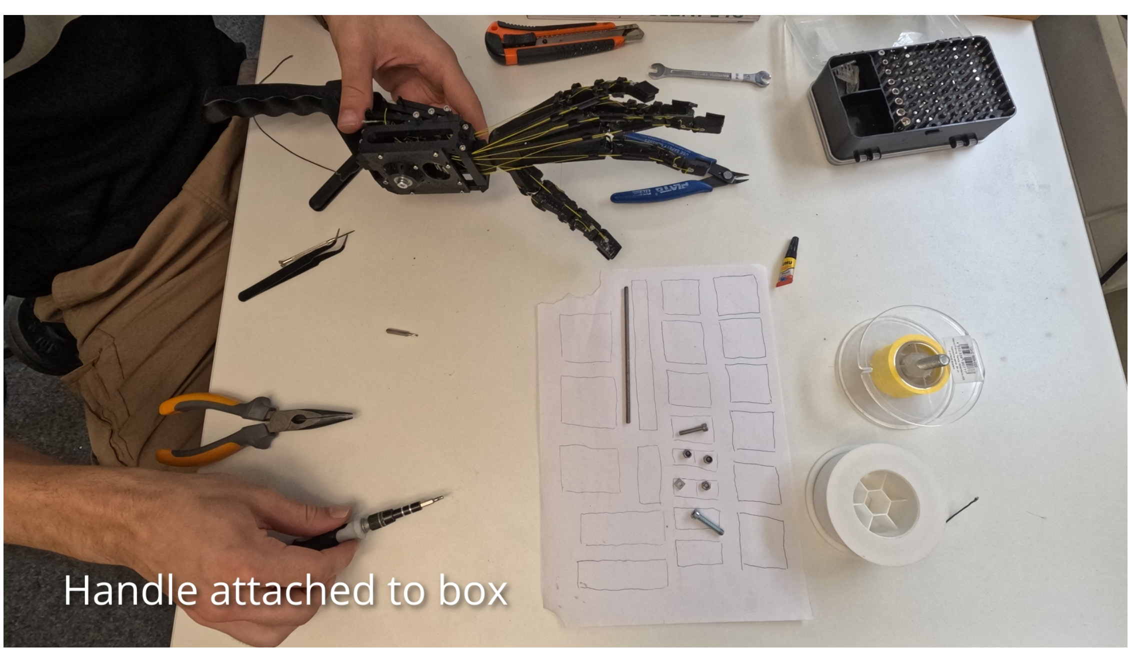

Figure 3.1a: Only 4 screws needed to fix handle to box. Ensure driving tendon is routed first.

Step 3.1a: ensure driving tendon is free and emerging from the actuation box base hole. The handle has a corresponding tendon hole which the tendon must be passed through before affixing the handle using the M3x6 screws. Ensure the tendon is not pinched anywhere in the path.

3.2 Actuation lever

This section takes the printed part *lever*, threaded rod, 4 nuts and 2 screws.

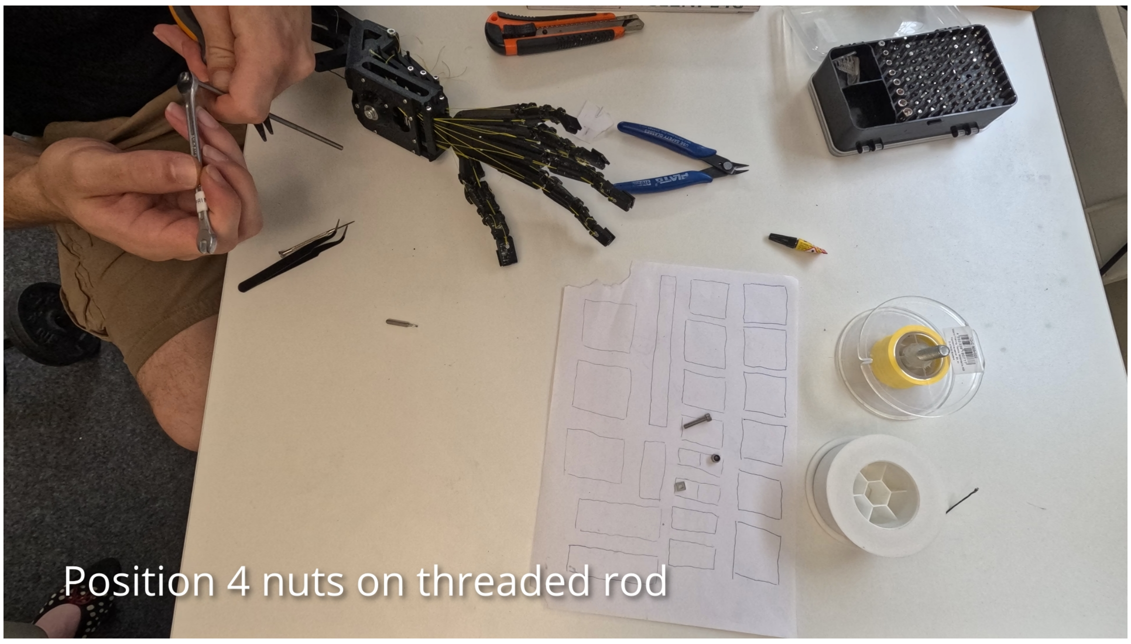

Figure 3.2a: Preparing threaded rod.

Step 3.2a: first the lever fits inside the handle and pivots on the M5x25 screw. The lever should pivot freely and the hole can be drilled out if not. The driving tendon will be fixed to the threaded rod, prepare rod by tightening 2 of the nuts against each other at on end, these should be very tight are are uses as a grip for turning the rod to adjust tension later. The other 2 nuts should be placed together loosely approximately 90 mm from the first pair of nuts. This can be test fit in the lever and should press fit. The fixed nut pair should stick out the end of the lever and the loose nut pair should have approx. 3 mm gap with the flat inside the lever.

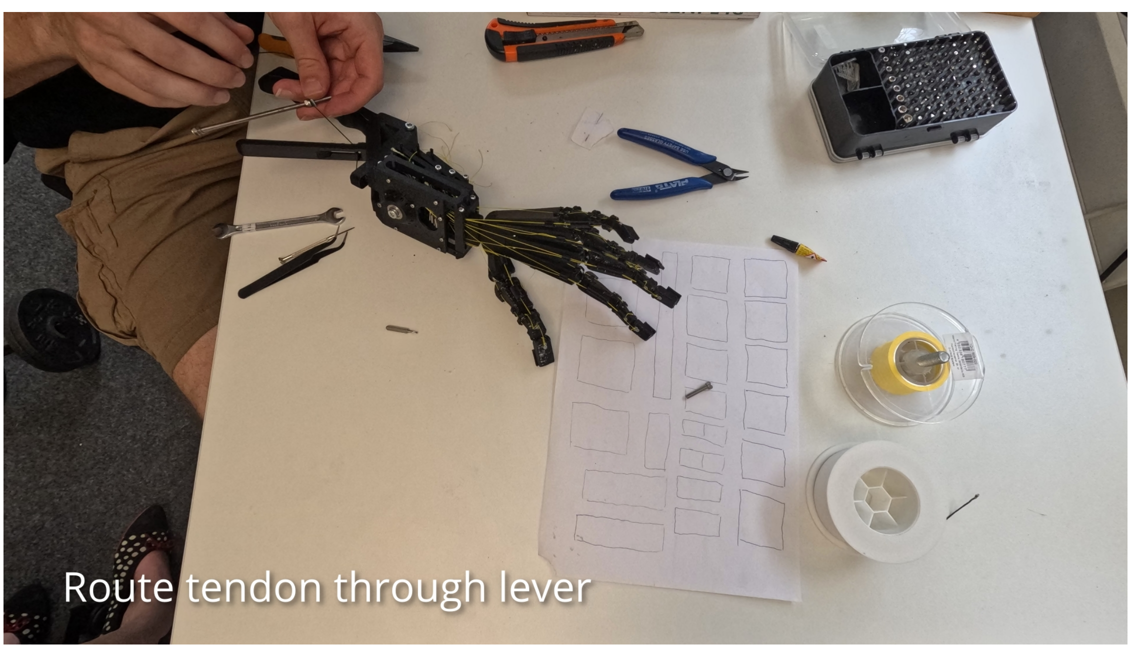

Figure 3.2b: Tendon through small routing hole in lever then anchored to threaded rod.

Step 3.2b: with the hand facing towards you. the tendon should be routed through the small hole on the left near the top of the lever.

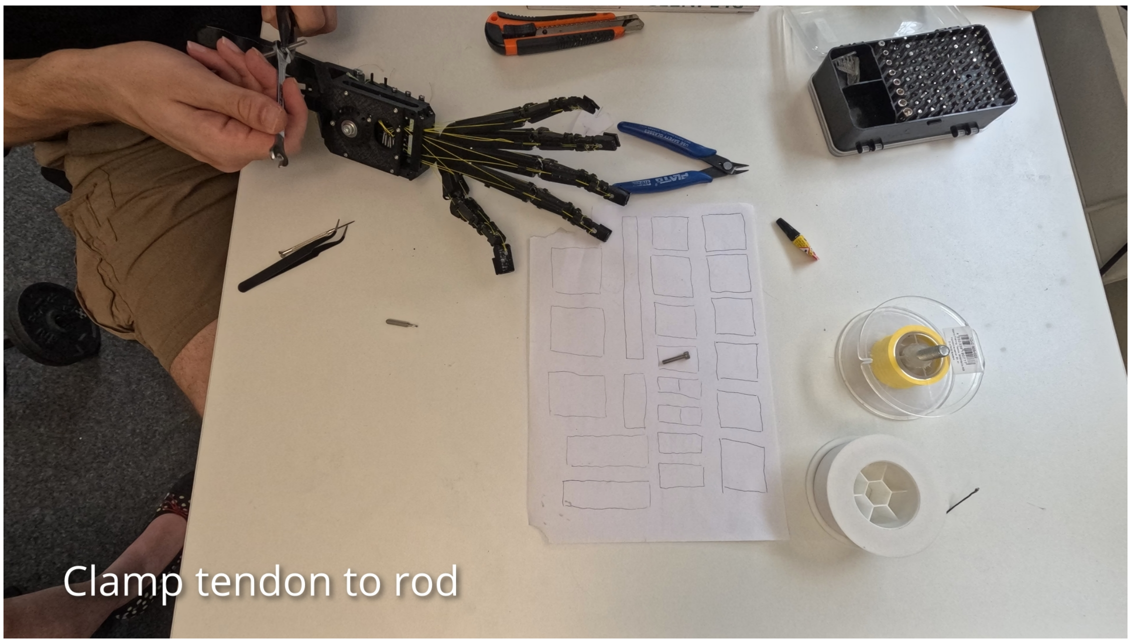

Figure 3.2c: Clamp tendon between the 2 loose nuts.

Step 3.2c: loop the tendon once around the rod between the loose nut pair. The tendon side should match the small routing hole in step 3.2b. Leave a few centimeters between the lever and rod, then firmly tighten the nuts to fix the tendon.

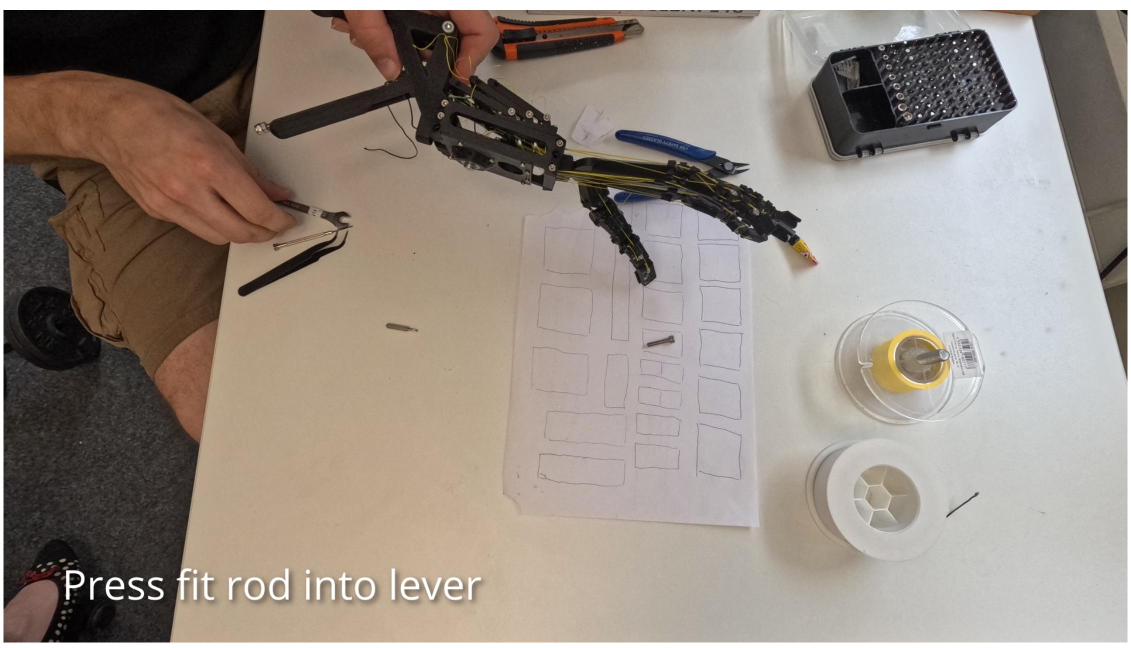

Figure 3.2d: Rod should seat inside the lever for adjustment and lever reinforcement.

Step 3.2d: the threaded rod should press fit into the handle, ensuring tendon is not trapped or looped.

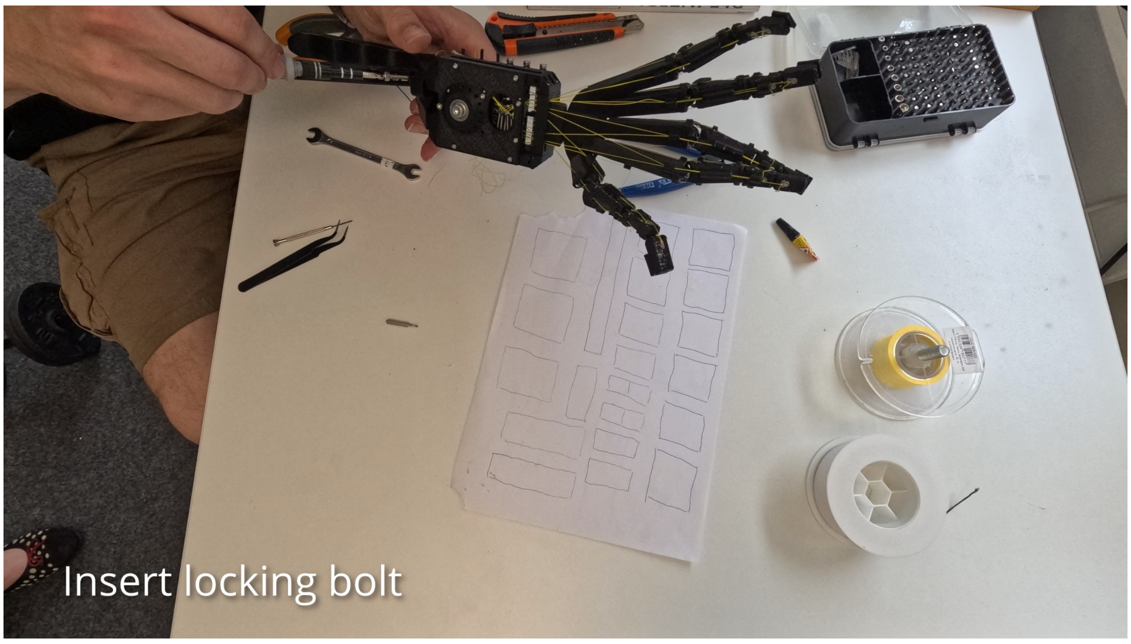

Figure 3.2e: Tension is adjusted similar to the active pulley. Locking screw inserts and retracts to constrain unwrapping.

Step 3.2e: opposite the threaded rod, the Mçx25 screw can be partially screwed in. When fully screwed in this should align with the top nut of the tendon clamping pair and prevent unraveling.

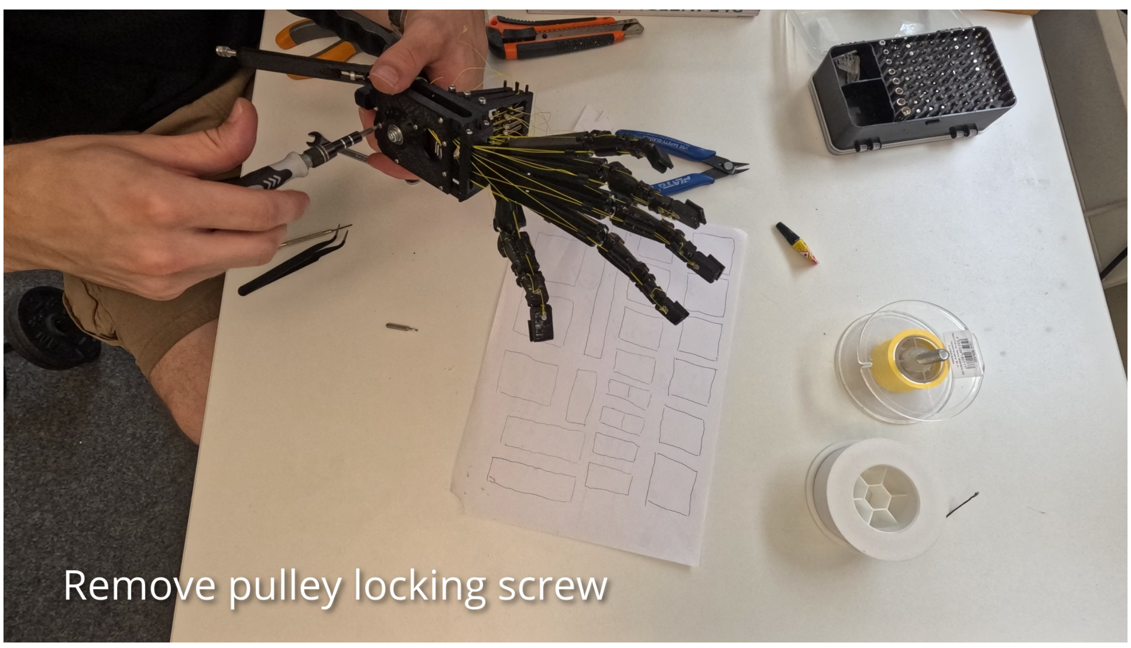

Figure 3.2f: Any temporary locking screws should be removed.

Step 3.2f: if M2.5 pulley locking screw was used in step 2.5g, then remove it now.

3.3 Active tendon fine adjustment

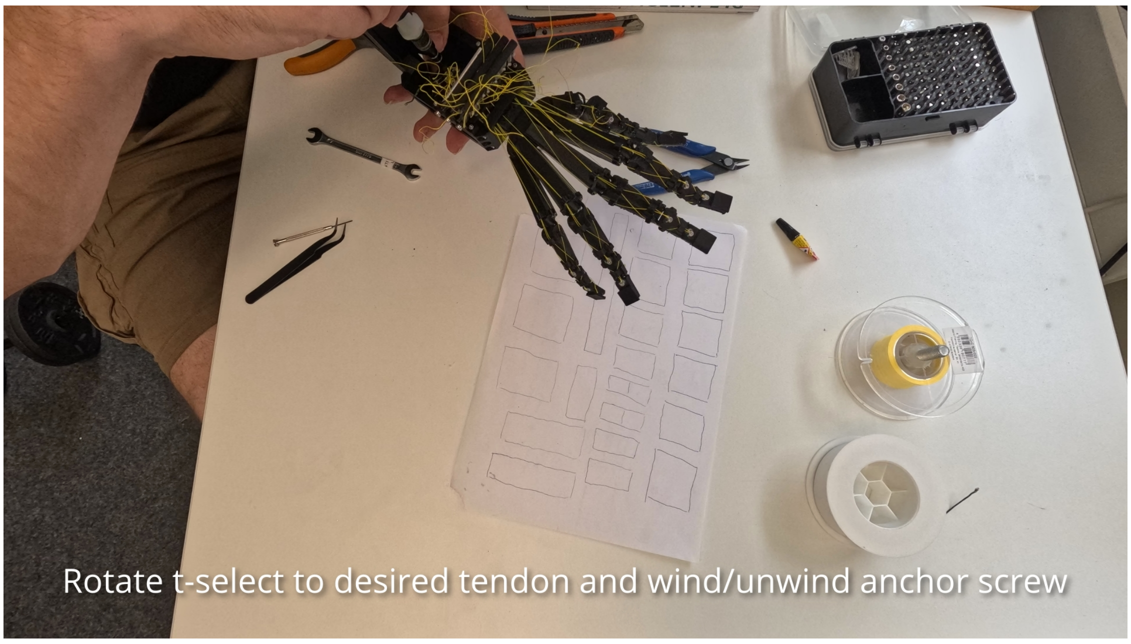

Figure 3.3: Final adjustments to driving tendon and active tendons.

Step 3.3: loosen M4 locking screw so the head is away from the clamping nuts. Turn the threaded rod anti-clockwise looking from the base to tighten the tendon. Refasten locking screw so the head constrains the top locking nut. Torque applied from tendon tension and resisted by the locking screw should act to fasten the clamping nuts. At this point, actuation can be tested and active tendons can be adjusted finally by following steps 2.6c–2.6d.

4 Testing

Congratulations! You should now have a functional hand for initial testing. The manual handle is great for getting to know what the hand and configuration can and can't do before going and trying your own.

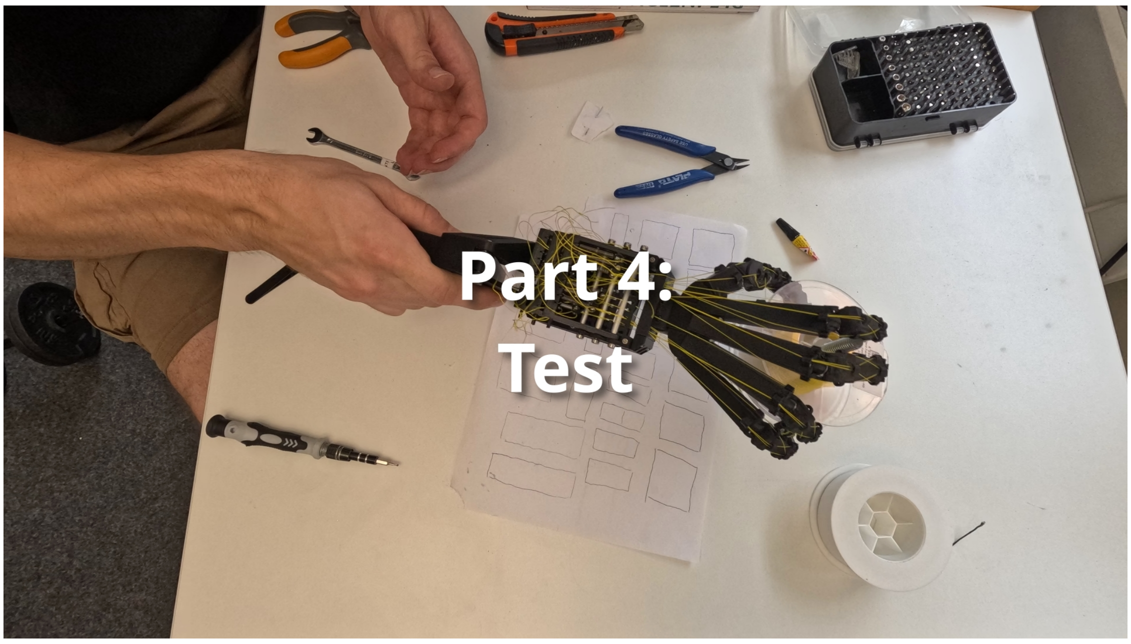

Figure 4: The fun part.

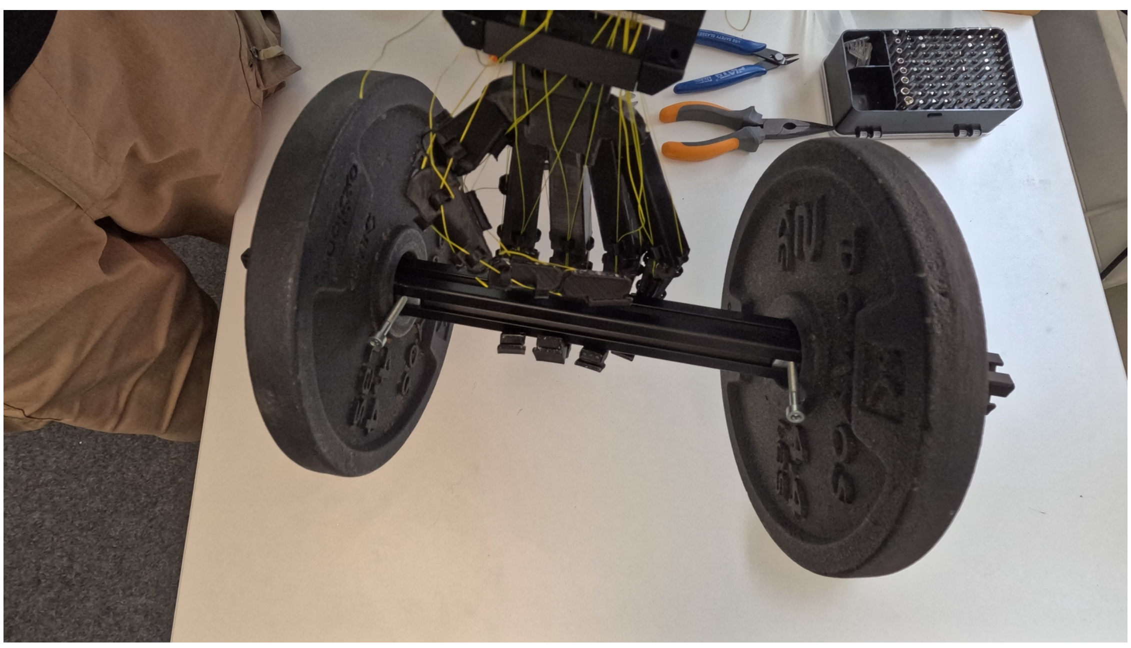

Figure 4a: Lifting 4 kg with no adjustment.

Stay tuned for more updates/examples/features like quality of life improvements/skins/sensors/configuring different actuation synergies.

Troubleshooting

Content to follow... In the meantime, feel free to contact me at kieran.gilday@epfl.ch or raising issues in Github with any questions or problems.