



Assembly Guide

V2.1 base

About this guide

This is an assembly guide for the ORCA hand v2.1 base.

The ORCA hand v2 [video tutorial](#) is often referenced as a useful follow along, however some elements of the video are outdated. This guide provides the latest instructions.

It is still a work in progress however, so if you notice some errors, please contact the following orca team members tom@orcahand.com
julien@orcahand.com

Chapters

General Indications	05
Prepare the parts	13
Assemble the Index	24
Repeat for Middle (x2) and Pinky	45
Assemble the Thumb	46
Assemble fingers to Carpals	63
Prepare the Wrist	74
Add the Wrist	76

Chapters, continued

Prepare the tower	98
Assemble tower to hand	116
Spooling	117
Add the board on the backplate	134
Assemble plates with magnets	128
Tensioning	137

Also: board flashing 88 Mounting to an arm 139

General Indications

- I) Tying an Ashley-Stopper Knot
- II) Trimming the tendon 5mm after the knot and stuffing the knot in its housing
- III) Always keep tendons straight and aligned
- IV) Fully pop each joint in
- V) Checking friction of each joint

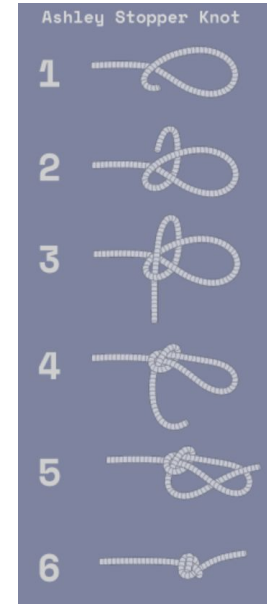
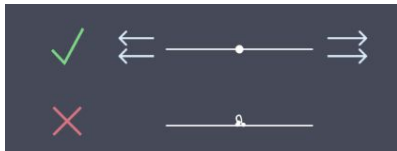
tendon = cord that pulls a joint / Zugseil, das ein Gelenk bewegt

I) Tying an Ashley-Stopper Knot

The A-S knot is a solid knot that will be used all the time during assembly.

For a video example see

<https://youtu.be/Tglz7HiyaoU?t=89>



A-S = Ashley-Stopper knot, a stopper at the cord end / Stopperknoten am Seilende

II) Trimming the tendon 5mm after the knot and stuffing the knot in its housing

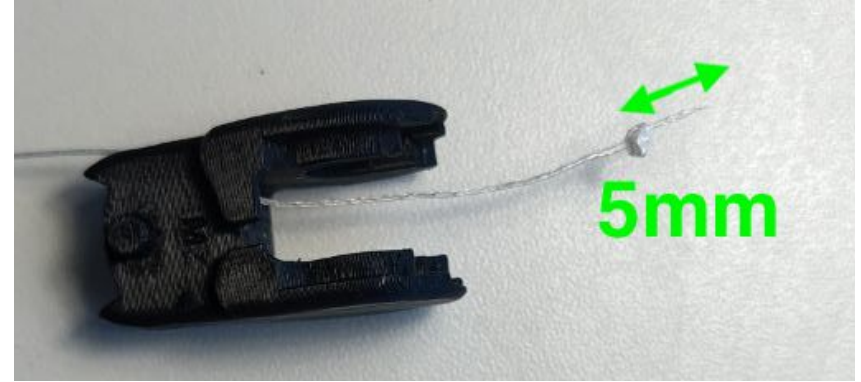
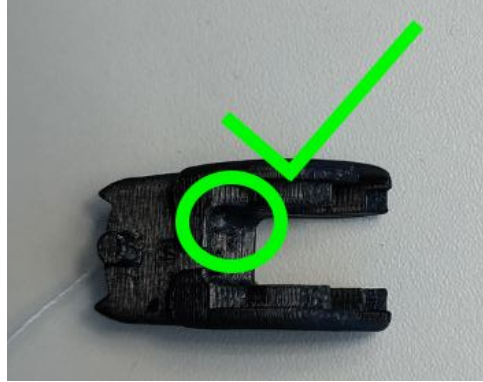
Loose thread sticking out could get caught in joints and create friction, which is why it is very important to trim the extra tendon left after a knot. However 5mm of margin must be left so that the knot doesn't come loose under heavy effort.

After trimming, pull hard on the tendon such that the knot falls into its housing. Then use a screw bit, allen key, etc to really stuff the entirety of the knot inside.

Make sure to not leave any sticking out.

knot housing = recess that holds the knot / Vertiefung für den Knoten

II) Trimming the tendon 5mm after the knot and stuffing the knot in its housing

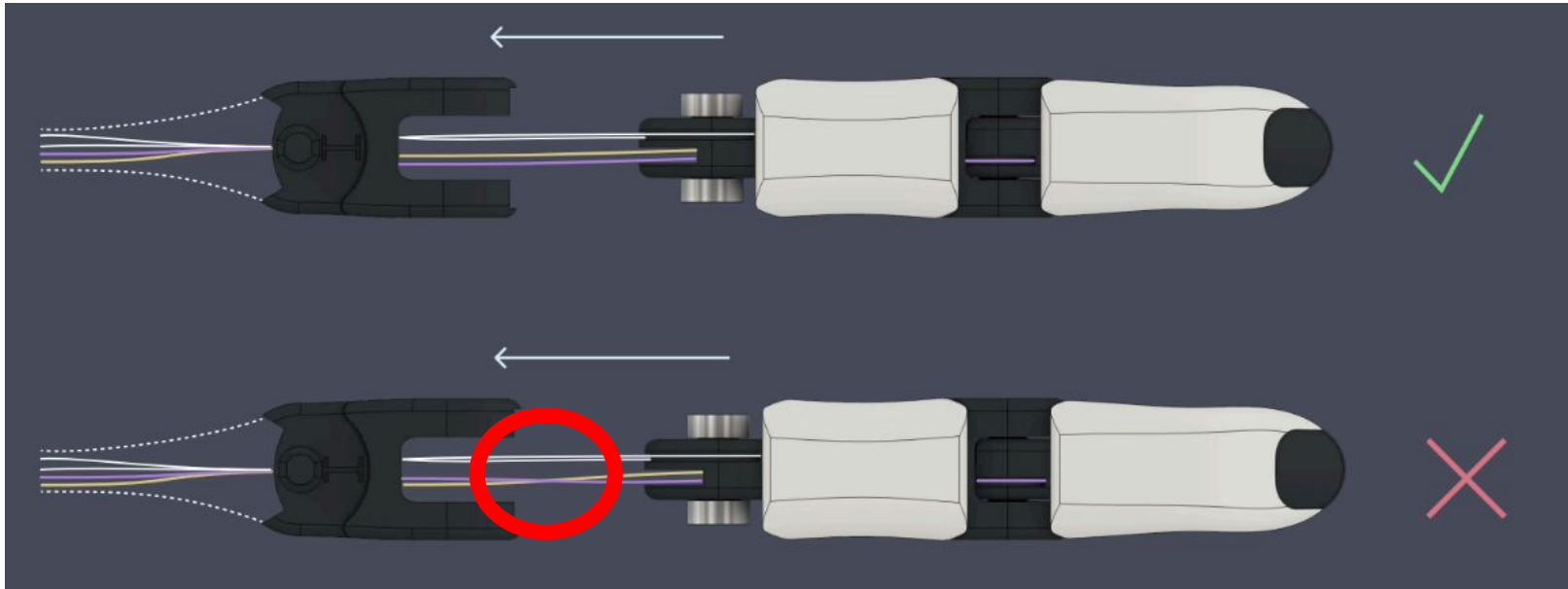


knot housing = recess that holds the knot / Vertiefung für den Knoten

III) Always keep tendons straight and aligned

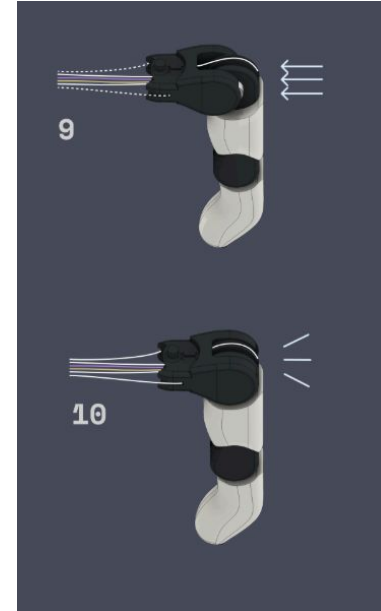
The orcahand is designed such that a tendon travels in a straight and direct line from one part to the other. Before assembling two parts, always tug on the tendons to straighten them and verify that no tendons cross over each other.

III) Always keep tendons straight and aligned



IV) Fully pop each joint in

Push the joint hard into position. You should feel/hear a pop when the bearing snaps into its position. The joint can turn freely around the bearing but can not move in any other direction.



bearing = part that lets the joint turn smoothly / Lager für leichtgängige Bewegung

V) Checking friction of each joint

After assembling each joint, move it / shake it around (see [here](#)). The joint must move without any friction in its whole range of motion. If you feel any friction, if the movement isn't smooth or the joint has a hard time going through its full range of motion, the joint needs to be popped out and fixed. Common causes of friction are tendons getting caught in the joint, or poor surface finish of the 3D printed part (solve by filing / sanding down the area which causes friction).

friction = resistance to movement / Reibung, die eine Bewegung bremst

Prepare the parts

Before we start, we will need to insert PTFE tubes in several parts to reduce the friction between tendons and plastic.

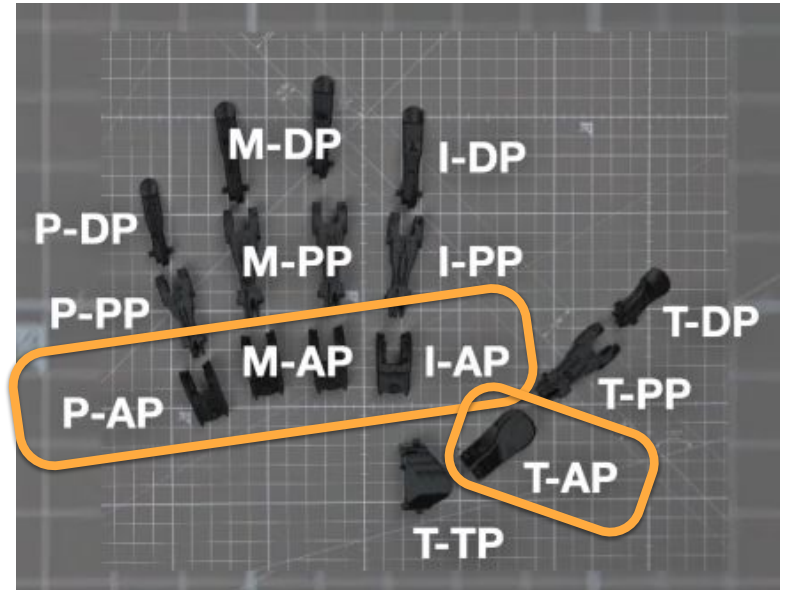
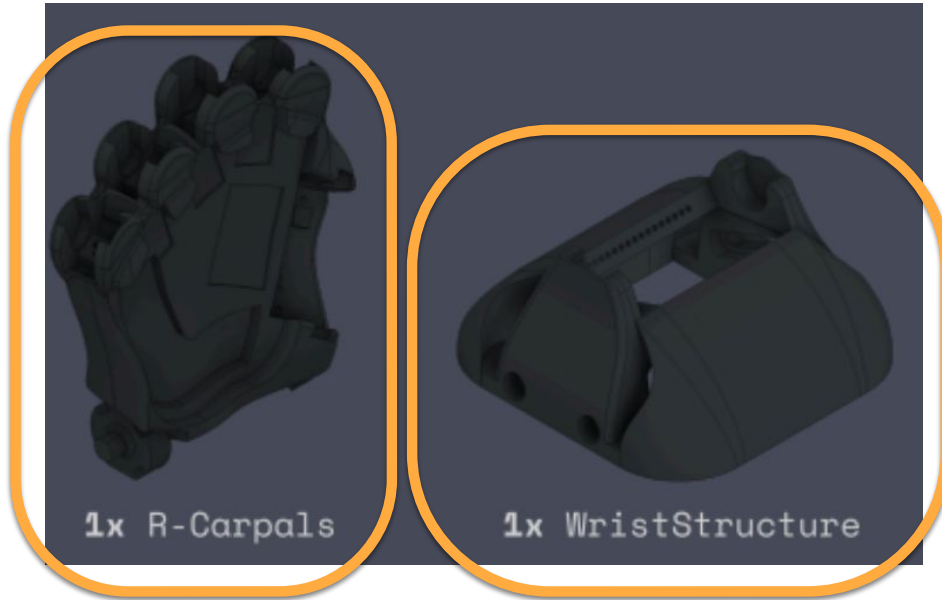
It is easier to prepare them all at the same time.

Grab some 1.5mm/0.9mm (outer/inner) PTFE tube, the AP of each finger (5 in total), the carpals and the wrist.

Since this step can be tricky, please refer to the extra tips at the end of this section.

PTFE tube = low-friction guide tube for a tendon / reibungsarmer Führungsschlauch fürs Zugseil

Prepare the parts



PTFE tube = low-friction guide tube for a tendon / reibungsarmer Führungsschlauch fürs Zugseil

PTFE tubes in APs

Each AP needs two PTFE tubes : one into each hole of the wide hole pair (highlighted in red).

Trim them so that they extend ~1mm out on both sides (8-10mm of PTFE tube is about the good length)

Do this for the AP of the Thumb, Index, Middle (x2) and Pinky.



AP = finger-base part for sideways movement / Fingerbasis für seitliche Bewegung

PTFE tubes in carpals & wrist

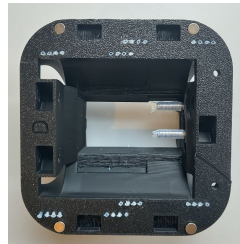
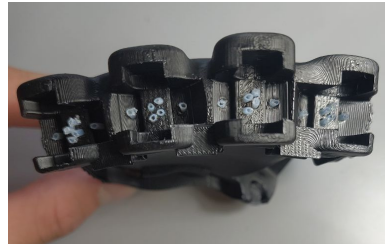
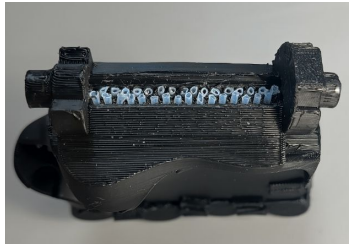
Insert a PTFE tube into each of the 32 channels of the carpals.

Trim so that they extend ~1mm out on both sides & have uniform length

Repeat with the wrist.

carpals = hand body where the fingers attach / Handkörper, an dem die Finger sitzen

PTFE tubes in carpals & wrist



(ignore the large PTFE tubes over the M4 screws, this will come later)

carpals = hand body where the fingers attach / Handkörper, an dem die Finger sitzen

PTFE tubes in carpals

When the carpals come out of the printer, the bottom exit of the channels is not very neat and needs to be manually finished.

Take a screw and screw it in and out of the 32 channels to create nice clean openings.

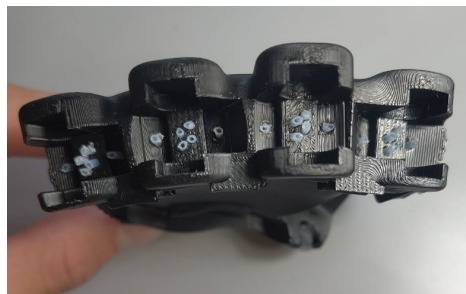
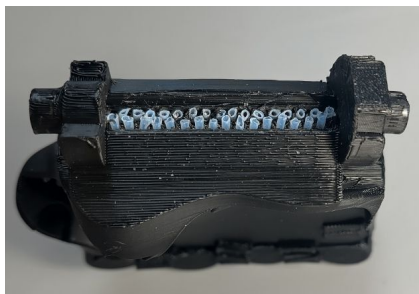
Click [here](#) for video illustration.

This will facilitate the next step :

Insert a PTFE tube into each of the 32 channels of the carpals.

Trim so that they extend ~1mm out on both sides & have uniform length

PTFE tubes in carpals



Inserting a PTFE tube which doesn't want to go in

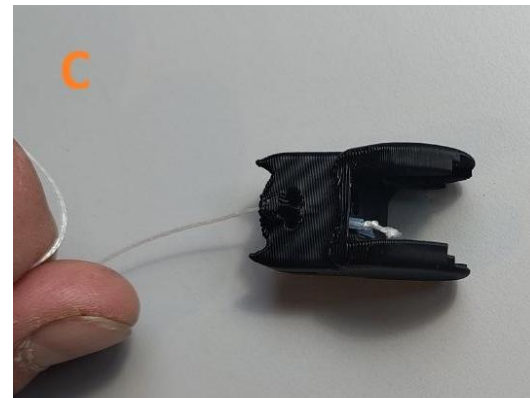
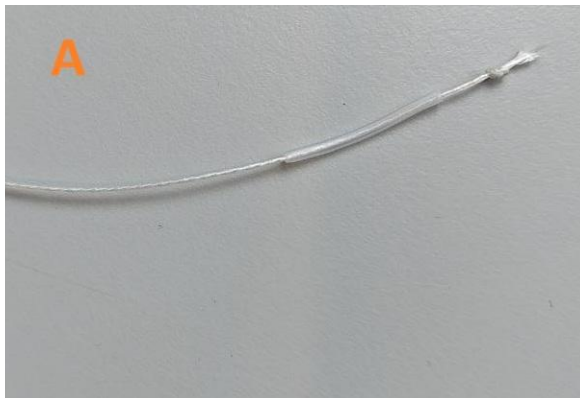
It can be challenging to insert tubes into some particularly tight holes or long, winding channels.

One trick that can help is to prepare a tendon with a knot on one end and thread it through the PTFE tube (step A).

Then thread the tendon through the channel (step B).

Use it to pull the PTFE tube inside the channel from the other end (step C) instead of trying to push it in.

Inserting a PTFE tube which doesn't want to go in



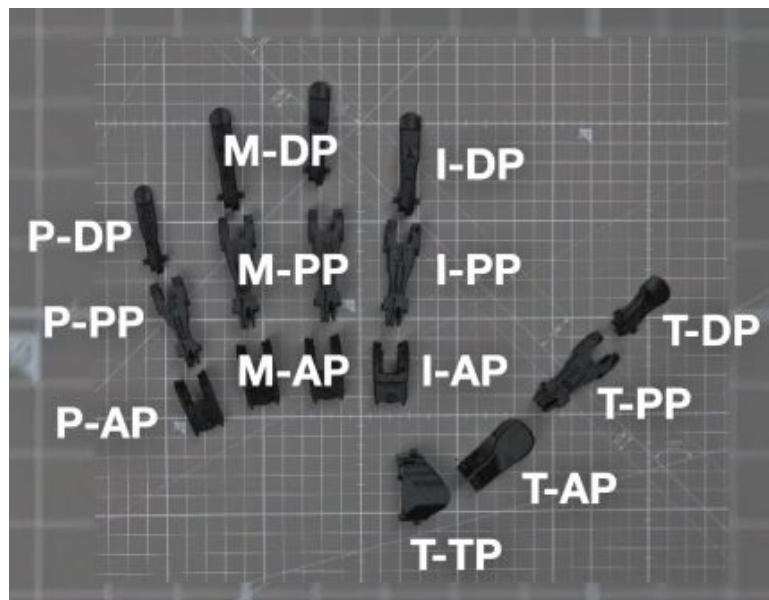
Using iron wire to open / free up stuffed, old PTFE tubes

If you re-use a PTFE, it might be deformed or blocked by something (bits of tendon from previous attempt, ...).

If you find it hard to push a tendon in, grab some iron wire (diameter ~ 0.45) and push it inside the tube to push out the debris.

(But be careful because the wire can also rip the PTFE tube)

Parts reference



Anatomy & part names

- DP** Outer finger segment, nearest the tip
Äusseres Fingersegment nahe der Spitze
- PP** Finger segment behind DP, towards the hand
Segment hinter DP, zur Hand hin
- AP** Finger-base part for sideways movement
Fingerbasis für seitliche Bewegung
- TP** Extra thumb-base part between AP and hand body
Zusätzliches Daumenbasisteil vor dem Handkörper

Anatomy & movement

Distal / proximal

Towards the fingertip / towards the hand

Zur Fingerspitze / zur Hand hin

Flexion / extension

Bend / straighten the finger

Finger beugen / strecken

Abduction / adduction

Spread fingers apart / bring them together

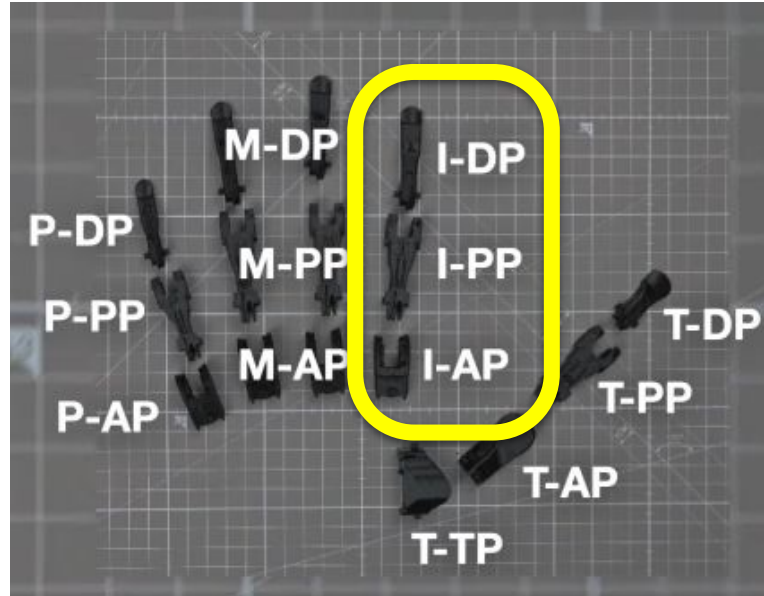
Finger spreizen / zusammenführen

Palm / dorsum

Inner face / back of the hand

Handfläche / Handrücken

Assembling the Index



distal = towards the fingertip / zur Fingerspitze · proximal = towards the hand / zur Hand hin

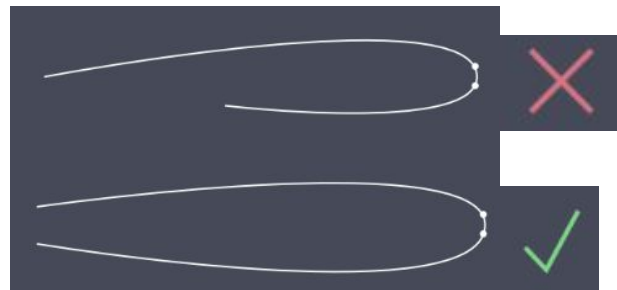
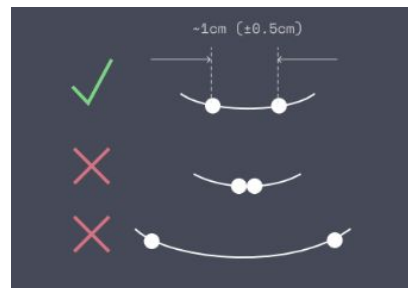
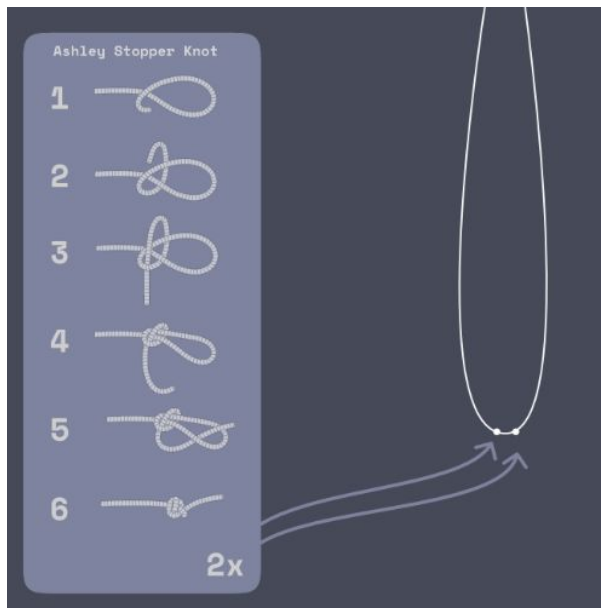
Prepare a double-knot tendon

Measure 1.5m of tendon.

Make 2 A-S knots in the middle of the tendon 10mm apart (+ - 5mm).

[video example](#)

Prepare a double-knot tendon



Prepare the DP

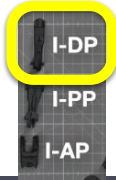
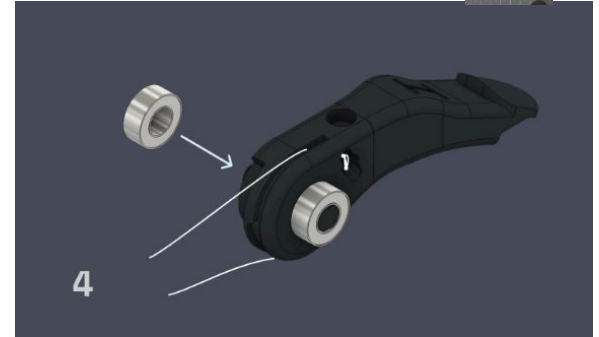
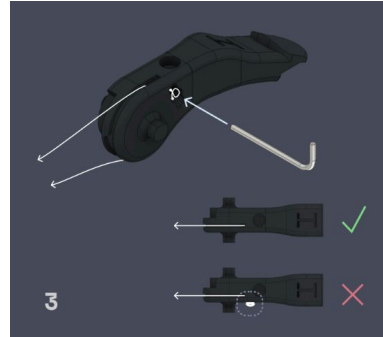
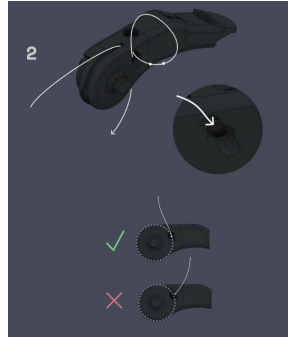
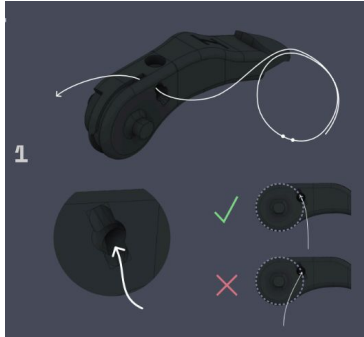
Thread a double-knot tendon the DP's knot-housing. Both ends of the tendon come in from the middle and come out outwards.

Then pull tightly and stuff remaining tendon in the housing.

Finally add in two 4mm thick bearings on the shaft.

DP = outer finger segment, nearest the tip / äusseres Fingersegment nahe der Spitze

Prepare the DP



DP = outer finger segment, nearest the tip / äusseres Fingersegment nahe der Spitze

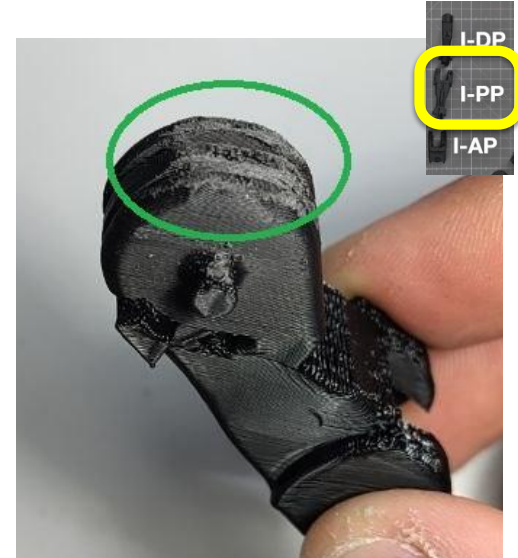
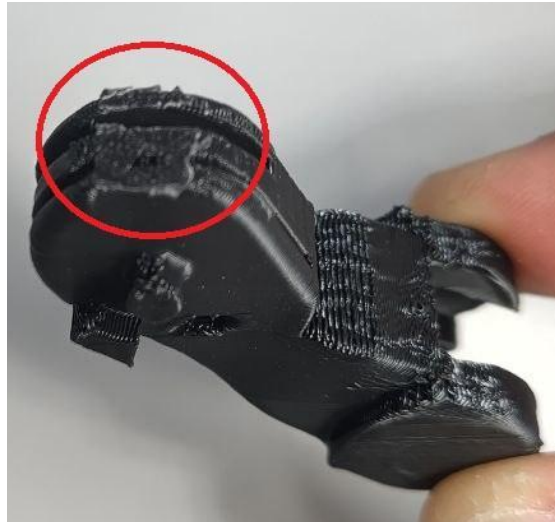
Prepare the PP

Remove all support material from the PP, then file or sand the underside until it is smooth. A smooth underside removes friction and allows the tendons to seat correctly in their grooves, which is important for the joint to function properly.

(This should be done for every part where you see a rough / messy finish on a functional surface, but it is especially common for the PP)

PP = finger segment directly behind the DP, towards the hand / Segment hinter dem DP, zur Hand hin

Prepare the PP



Left to right: as printed; rough underside (red); correctly sanded underside (green).

PP = finger segment directly behind the DP, towards the hand / Segment hinter dem DP, zur Hand hin

Add the PP

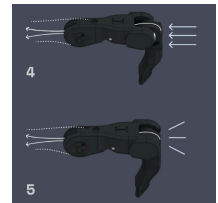
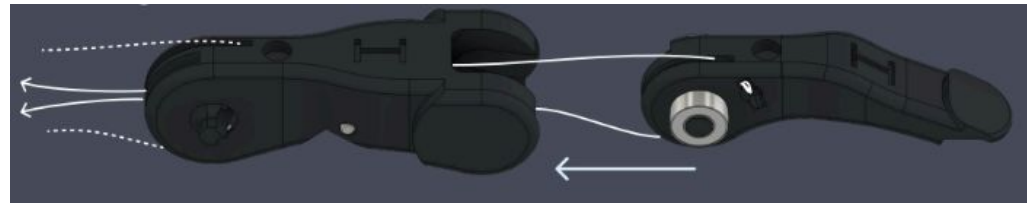
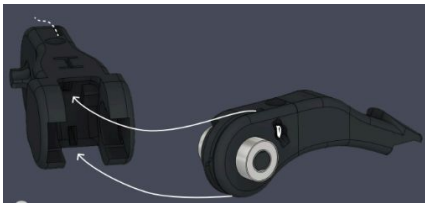
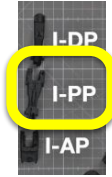
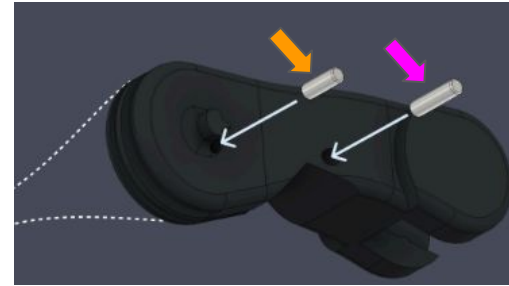
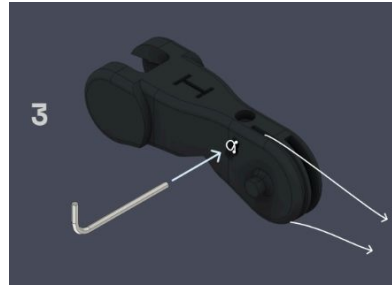
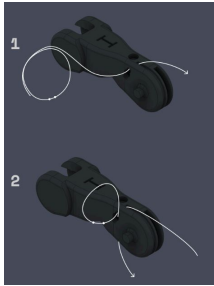
Thread a double-knot tendon the PP's knot-housing, pull and stuff it in (same procedure as for DP).

Insert a 2x8 pin in the middle-slot and 2x6 pin in the lower shaft slot.

Thread the DP-tendons in the PP, with the DP's top (side with letter I) tendon threading in the PP's top hole. Tug to verify there is no tendon crossing, then pop the joint in. [video example](#)

pin = small rod / Stift · shaft = axis a part turns around / Drehachse

Add the PP



pin = small rod / Stift · shaft = axis a part turns around / Drehachse

Add the PP

Add a second 2x6 pin in the upper shaft slot while making sure that the tendons are resting between the two pins.

Push the pins all the way in.

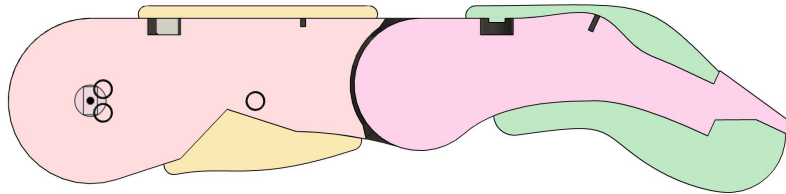
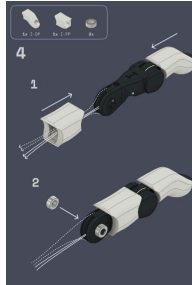
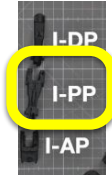
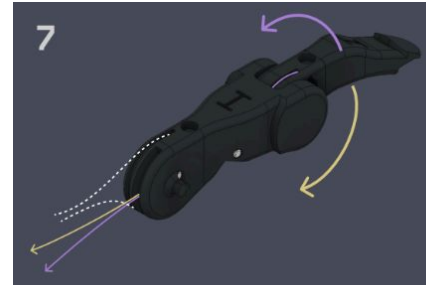
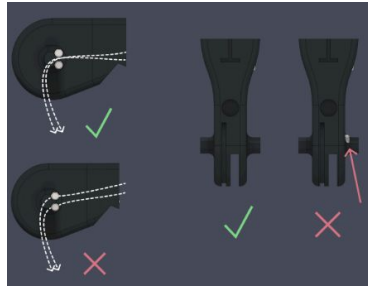
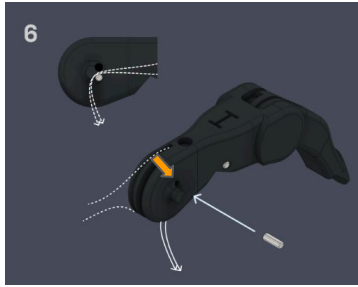
Verify that the left tendon pulls the DP down and the right tendon up.

Add the I-DP and I-PP skins.

Add two 4mm bearings.

skin = soft outer covering / weiche Aussenhaut

Add the PP



skin = soft outer covering / weiche Aussenhaut

Prepare the AP

1 / 2

Make sure that you have already inserted two PTFE tubes in the AP (see section Prepare the parts).

Cut two 75cm tendons.

Pass tendons through the side-holes of the AP (outside->inside).

AP = finger-base part for sideways movement / Fingerbasis für seitliche Bewegung

Prepare the AP

2 / 2

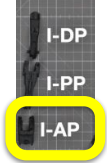
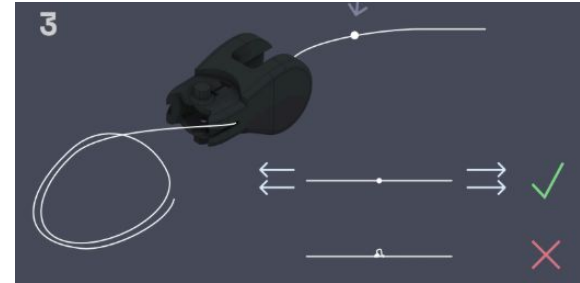
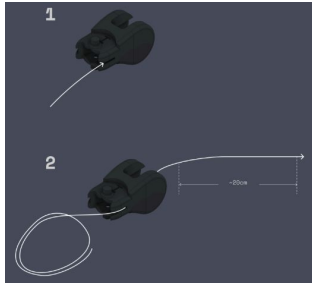
Pull 20cm through and make an A-S knot. Do an additional simple knot on top of the A-S.

Be sure to tie the simple knot around the A-S (not just next to it) to make the A-S larger.

Repeat on both sides.

AP = finger-base part for sideways movement / Fingerbasis für seitliche Bewegung

Prepare the AP



A-S



Single knot next to A-S (wrong)



Single knot around A-S (correct)

AP = finger-base part for sideways movement / Fingerbasis für seitliche Bewegung

Prepare the AP

(Next 3 steps are important for the knot to hold well !)

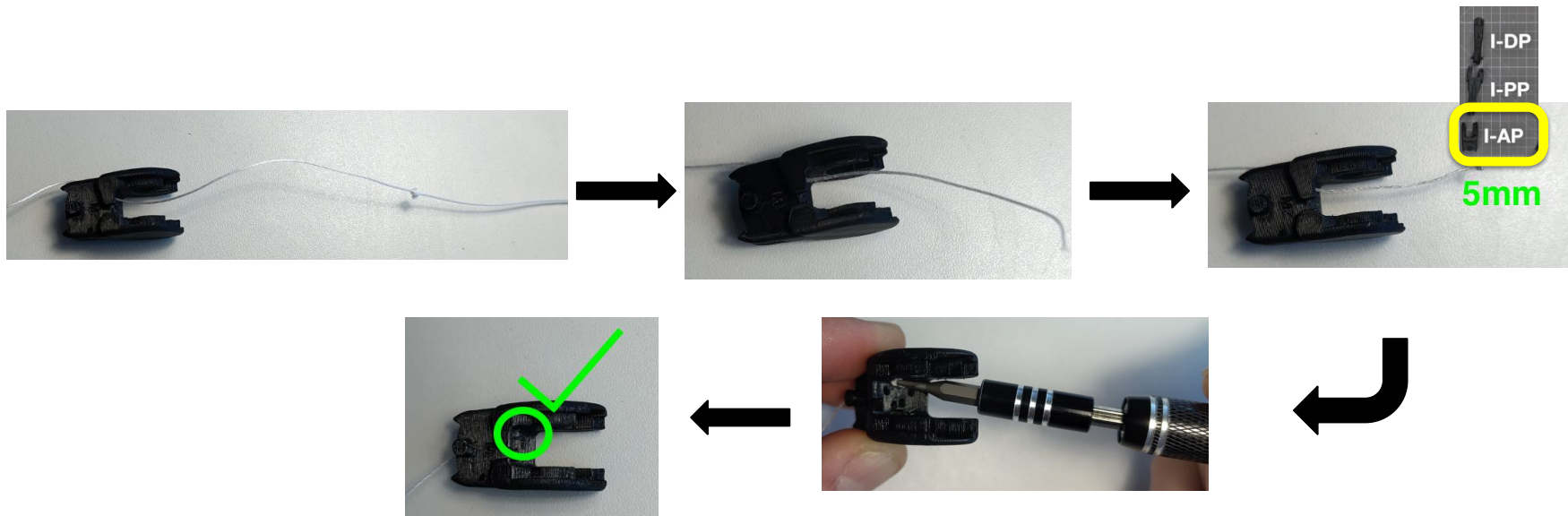
Pull the tendon very hard so that the knot is pressed into its housing and settles in its final shape.

Pull it out, trim the unnecessary tendon 5mm after the knot.

Pull it back it into its housing.

Finally stuff anything still loose into the knot-housing with a rod-like object.

Prepare the AP



Assemble the AP

1 / 2

Thread the tendons from DP & PP into the AP.

The order of tendon is straightforward if you keep the paths aligned but you can check on the image below to make sure.

Tug to verify that no tendons are crossing before assembling.

Pop the joint in.

extension = straighten the finger / strecken · flexion = bend the finger / beugen

Assemble the AP

2 / 2

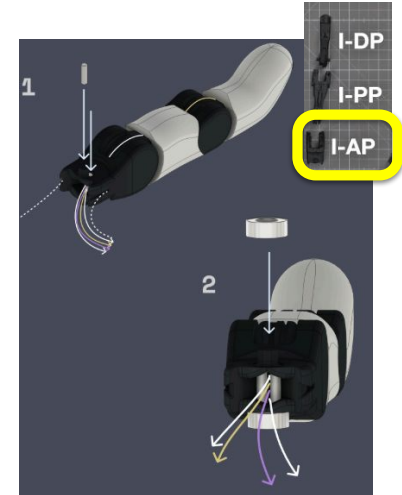
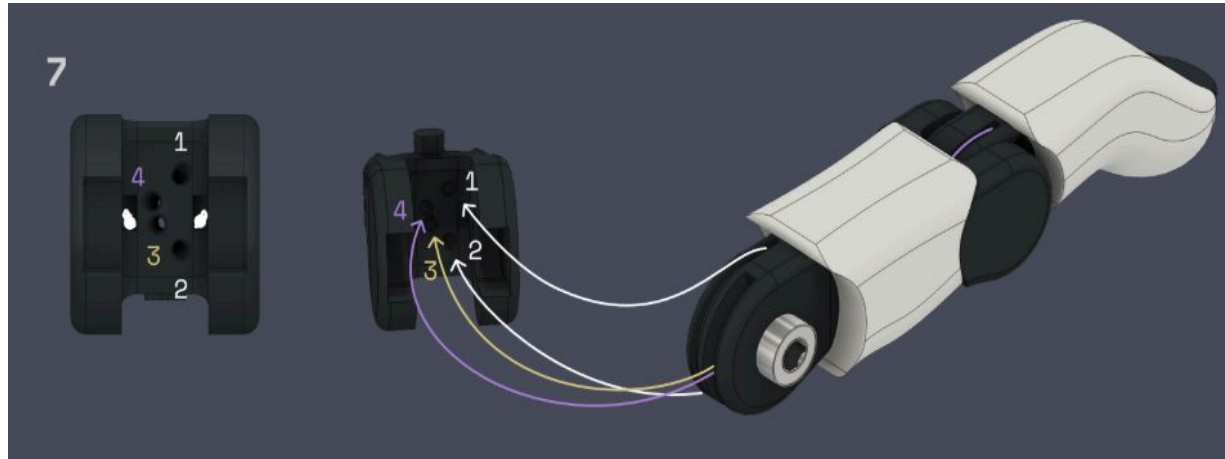
Add two 2x8 pin (ensuring that tendons are correctly seated between them) in the shaft slots.

Finally add two 4mm bearings.

Shake the finger to test if the joint moves freely. If not it could be due due to the bottom of the PP being too rough (cf Prepare the PP)

extension = straighten the finger / strecken · flexion = bend the finger / beugen

Assemble the AP



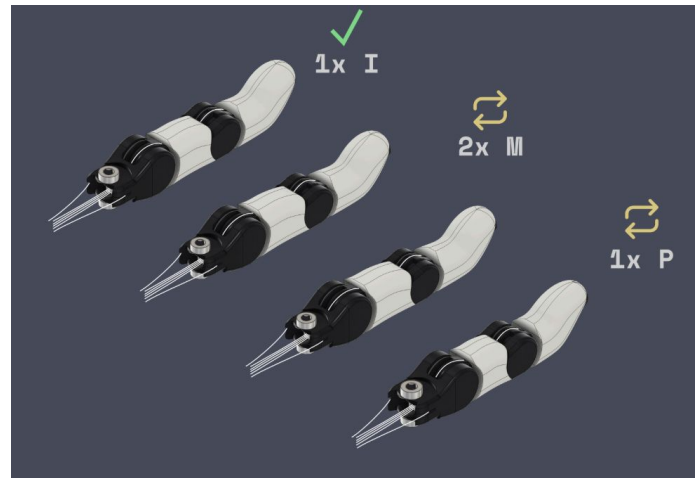
1 : PP extension 2 : PP flexion

3 : DP flexion 4 : DP extension

extension = straighten the finger / strecken · flexion = bend the finger / beugen

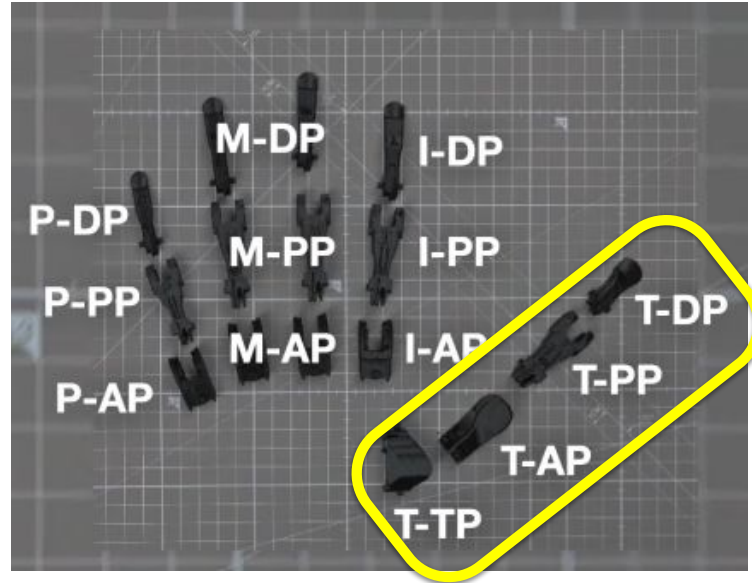
Assemble 3 more fingers

You have just finished your first finger.
Assembling the Middle and Pinky finger
works exactly the same as the Index.
Build 2 Middle and 1 Pinky.



index = Zeigefinger · middle = Mittelfinger · pinky = kleiner Finger

Assembling the thumb



DP and PP

Thumb assembly is similar to the other fingers, except it has one more piece (the TP).

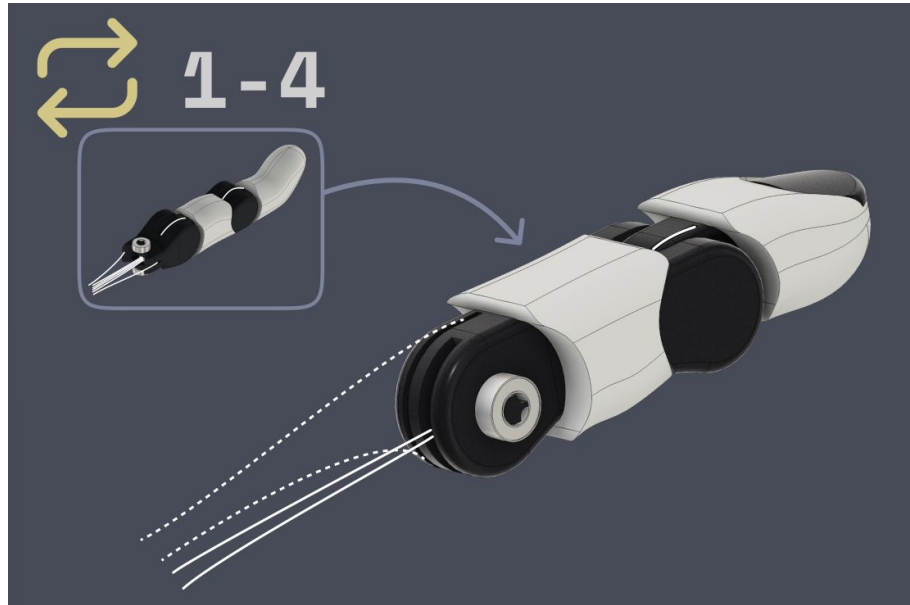
The DP and PP assembly steps are identical though, so follow the instructions given previously for these pieces.

Refer to the sections :

- Prepare the PP
- Add the DP

TP = extra thumb-base part between AP and hand body / zusätzliches Daumenbasisteil zwischen AP und Handkörper

DP and PP



TP = extra thumb-base part between AP and hand body / zusätzliches Daumenbasisteil zwischen AP und Handkörper

Prepare the AP

1 / 2

Although its shape is slightly different, the assembly procedure of the thumb AP is identical to what we've seen before.

Make sure that you have already inserted two PTFE tubes in the AP (see section Prepare the parts).

Cut two 75cm tendons.

Pass tendons through the top-holes of the AP (outside->inside).

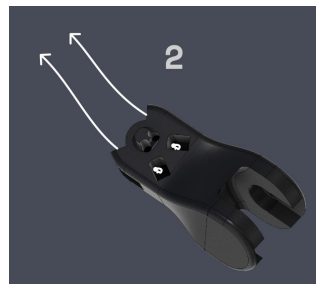
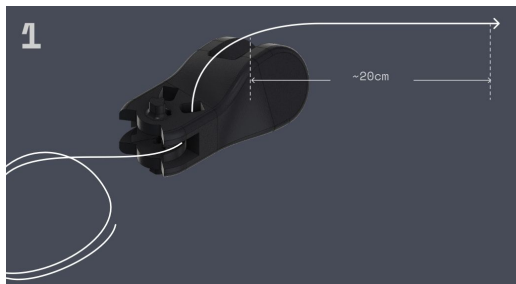
Pull 20cm through and make an A-S knot. Do an additional simple knot on top of the A-S.

Prepare the AP

2 / 2

Be sure to tie the simple knot around the A-S (not just next to it) to make the A-S larger.
Repeat on both holes.

Prepare the AP



A-S



Single knot next to A-S (wrong)



Single knot around A-S (correct)

Prepare the AP

(Next 3 steps are important for the knot to hold well !)

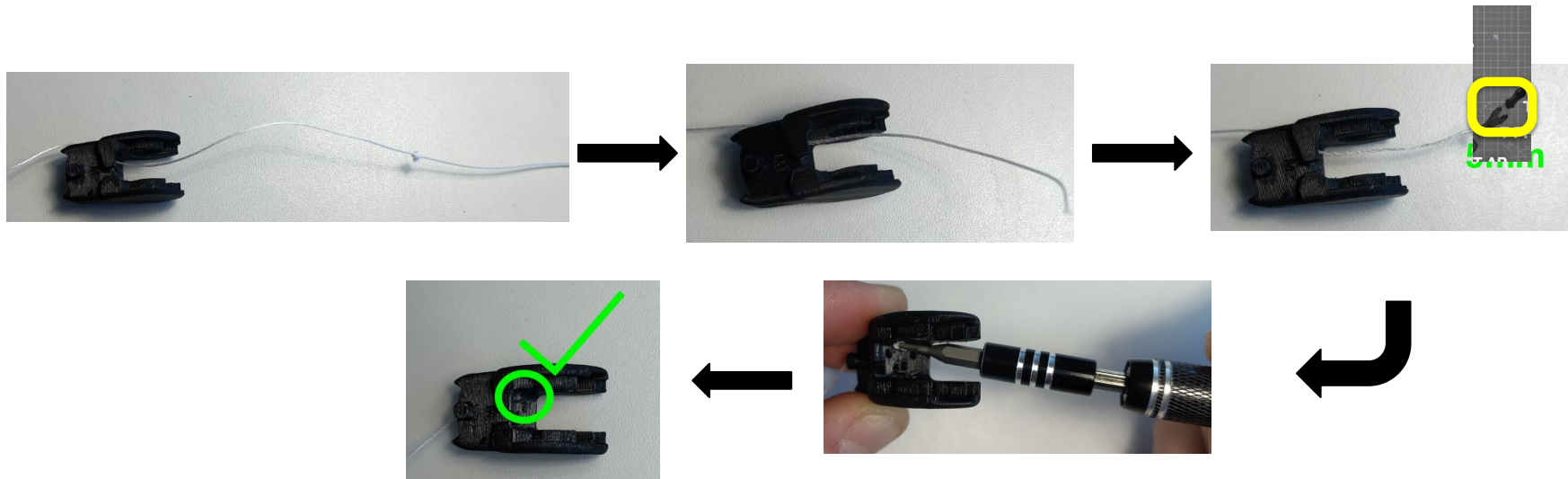
Pull the tendon very hard so that the knot is pressed into its housing and settles in its final shape.

Pull it out, trim the unnecessary tendon 5mm after the knot.

Pull it back it into its housing.

Finally stuff anything still loose into the knot-housing with a screw-bit / allen-key / etc

Prepare the AP



NB : this is an Index AP not a Thumb AP but the steps are exactly the same

Assemble the AP

Thread the tendons from DP & PP into the AP.

The order of tendon is straightforward if you simply keep the paths aligned but you can check on the image below to make sure.

Tug to verify that no tendons are crossing before assembling.

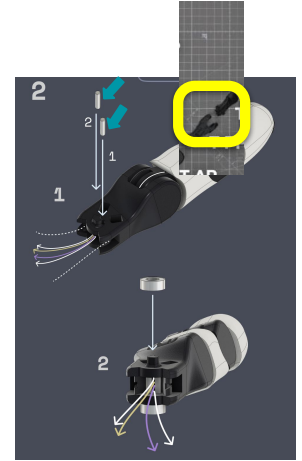
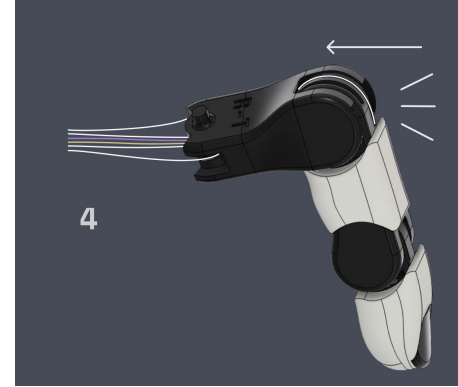
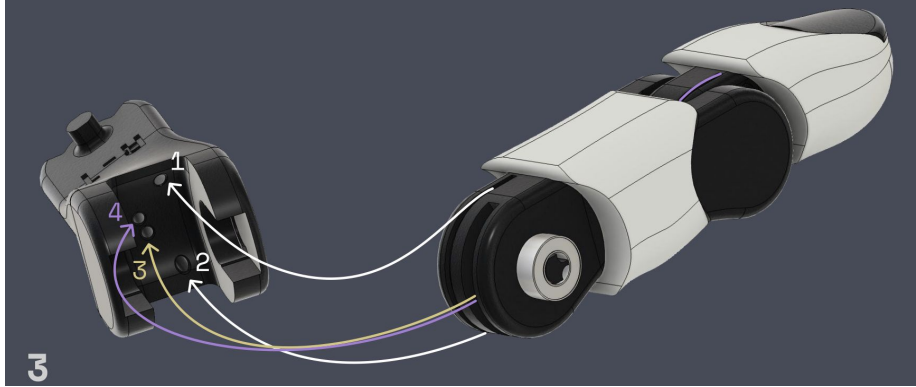
Pop the joint in.

Add two 2x10 pin (ensuring that tendons are correctly seated between them) in the shaft slots.

Finally add two 4mm bearings

DP = tip segment / Spitzensegment · PP = next segment towards the hand / nächstes Segment zur Hand

Assemble the AP



1 : PP extension 2 : PP flexion

3 : DP flexion 4 : DP extension

DP = tip segment / Spitzensegment · PP = next segment towards the hand / nächstes Segment zur Hand

Prepare the TP

1 / 2

This step is very similar to preparing the TP.

Cut two 75cm tendons.

Pass tendons through the side-holes of the TP (outside->inside).

Prepare the TP

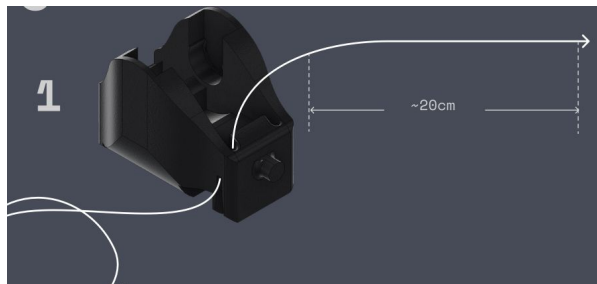
2 / 2

Pull 20cm through and make an A-S knot. Do an additional simple knot on top of the A-S.

Be sure to tie the simple knot around the A-S (not just next to it) to make the A-S larger.

Repeat on both holes.

Prepare the TP



A-S



Single knot next to A-S (wrong)



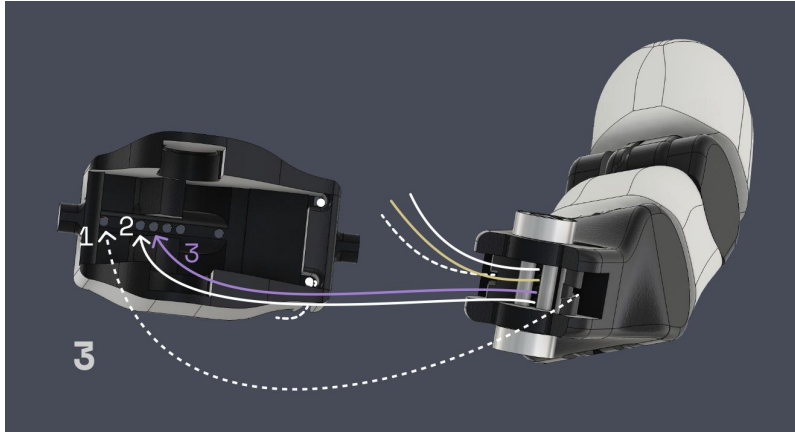
Single knot around A-S (correct)

Assembling the TP

Route all the thumb's tendons in the TP, following the order shown Below (note that the image shows an older version of the TP with individual holes instead of a slit, but the order is still correct).

abduction = spread away / abspreizen · adduction = bring back towards the hand / heranführen

Assembling the TP

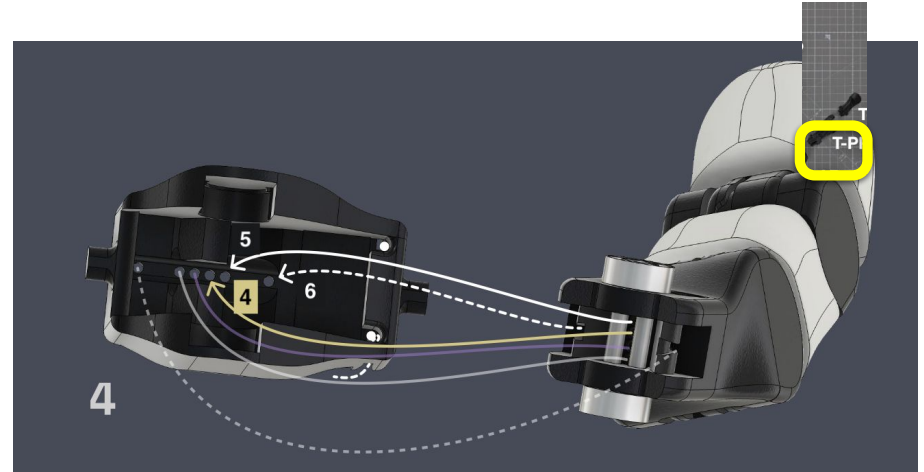


1. Right TP adduction

2. PP extension

3. DP extension

abduction = spread away / abspreizen · adduction = bring back towards the hand / heranführen



4. DP flexion

2. PP flexion

3. Left TP adduction

Finishing the thumb

Insert two 2x30 pins in the shaft slots (ensuring that tendons are correctly seated between them & that the order is kept).

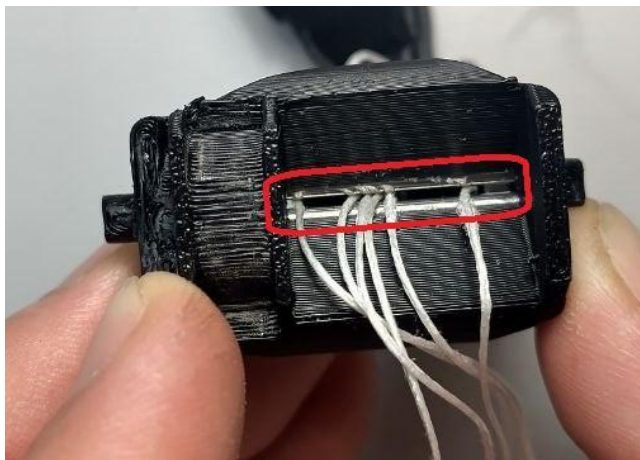
Tug to verify that no tendons are crossing before assembling.

Pop the joint in.

Add two 4mm bearings.

Congratulations you have assembled all 5 fingers !

Finishing the thumb



Adding the Carpals



carpals = hand body where the fingers attach / Handkörper, an dem die Finger sitzen

Threading in the four fingers

Make sure the 32 PTFE tubes are already in the Carpals.

Thread the tendons in the carpals (for the order, please refer to the image under or click [here](#)).

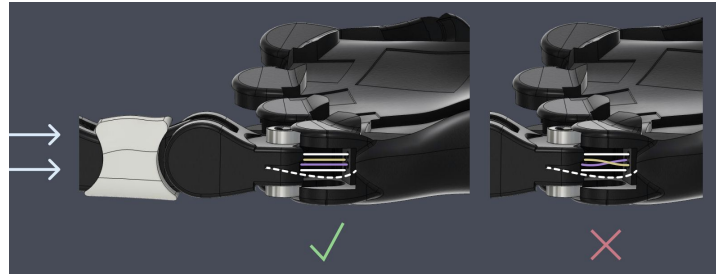
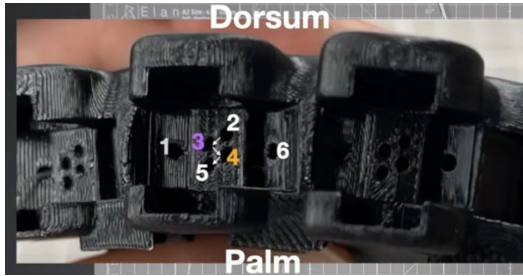
Tug to verify that no tendons are crossing before assembling.

Pop in the joint (really make sure that the finger's bearings have snapped into carpal's housing).

Repeat for the 2 Middle fingers and the Index finger.

abduction = spread fingers apart / Finger spreizen · adduction = bring fingers together / Finger zusammenführen

Threading in the four fingers



1. Right AP adduction 4. DP flexion

2. PP extension 5. PP flexion

3. DP extension 6. Left AP adduction

abduction = spread fingers apart / Finger spreizen · adduction = bring fingers together / Finger zusammenführen

Threading in the thumb

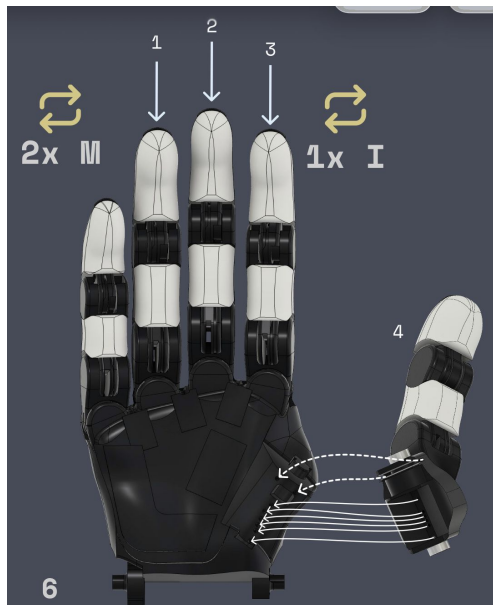
Make sure that the 6 tendons are in the order described in “Assembling the TP” before starting.

Then simply thread the tendons in the carpals (the order is logical when you look at the holes, but if you need a follow along click [here](#)).

Tug to verify that no tendons are crossing before assembling.

Pop in the joint (really make sure that it is in there).

Threading in the thumb



(Optional) Separating the tendons

1 / 2

(Optional) To make assembling the wrist easier, you can already separate the “dorsum” and “palm” tendons.

The tendons coming out the base of the Carpals are split in 2 lines, one nearer to the dorsum (back) of the hand, the other nearer to the palm. From side to side, the tendons are alternating between dorsum and palm.

palm = inner face of the hand / Handfläche · dorsum = back of the hand / Handrücken

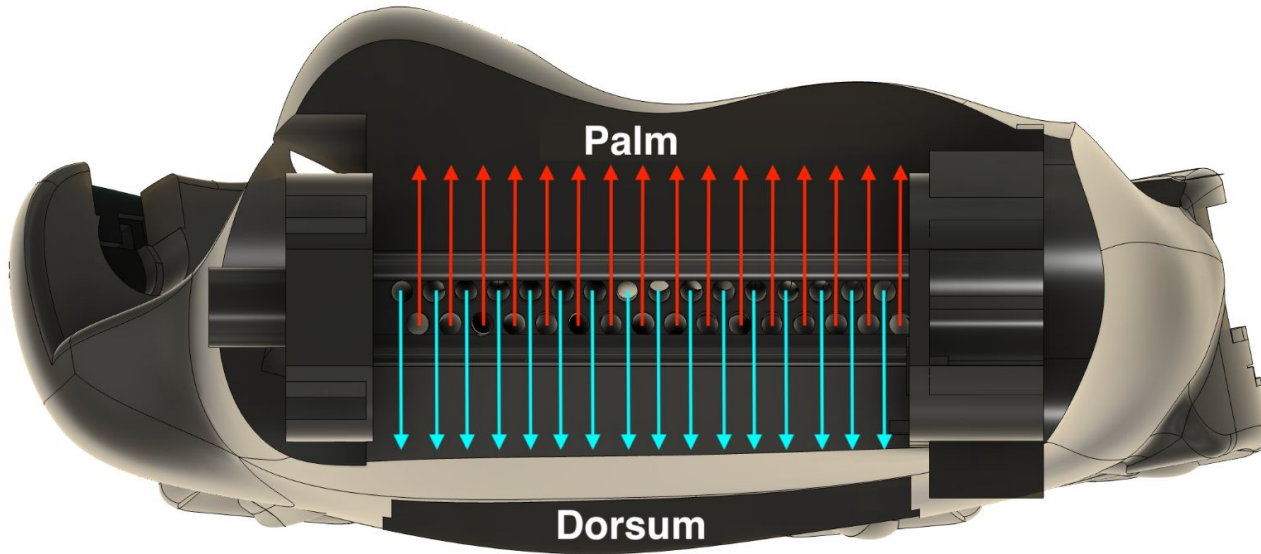
(Optional) Separating the tendons

2 / 2

Gather all the “dorsum” tendons (make sure that this represents one in two tendons) and bundle them together (for example with duct tape). It is easier to do this now because the pins in the next step reduce visibility.

palm = inner face of the hand / Handfläche · dorsum = back of the hand / Handrücken

(Optional) Separating the tendons



palm = inner face of the hand / Handfläche · dorsum = back of the hand / Handrücken

Skin, pins and gear.

Add the silicon skin of the palm, push hard to properly click it in each of its attachment points.

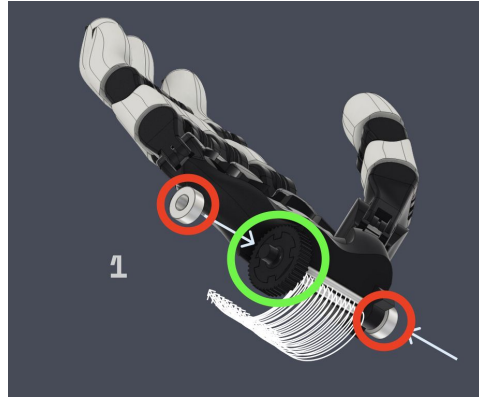
Add two 3x50mm pins through the shaft holes.

Mount the carpal pulley on the other side.

Finally add two 8x13x4 bearings on the shaft.

pulley = wheel that guides or drives a belt / Rolle für den Riemen

Skin, pins and gear.



pulley = wheel that guides or drives a belt / Rolle für den Riemen

Adding the Wrist

Preparing the Wrist

Make sure the 32 PTFE tubes are already in the Wrist.

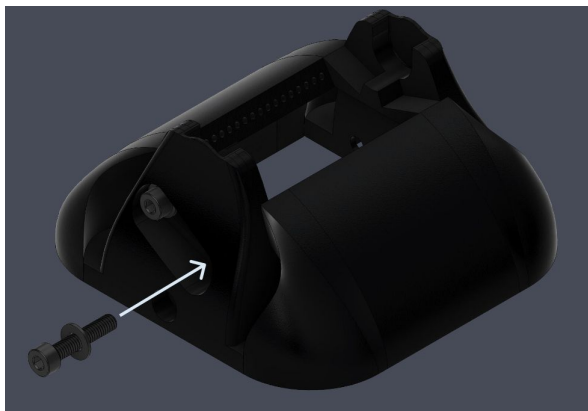
Insert two M4 screws with two M4 washers from the outside.

On the inside screw two M4 **square** nuts.

Put some XXX/XXX PTFE tubes to cover the screw threads.

Tip : If the PTFE tube is difficult to squeeze on, a good way to proceed is to hold the tube tightly pressed on the screw with one hand and use a screwdriver to screw it in the PTFE tube.

Preparing the Wrist



Threading in the tendons

1 / 2

It is worth going slowly through this step and double-checking often because it is easy to mistakes at this point and they are easier to fix now than later. Click [here](#) for follow-along.

Take the left-most “palm” tendon (cf Carpals : (Optional) Separating the tendons) and thread it into the left-most Wrist channel of the dorsum side.

palm = inner face of the hand / Handfläche · dorsum = back of the hand / Handrücken

Threading in the tendons

2 / 2

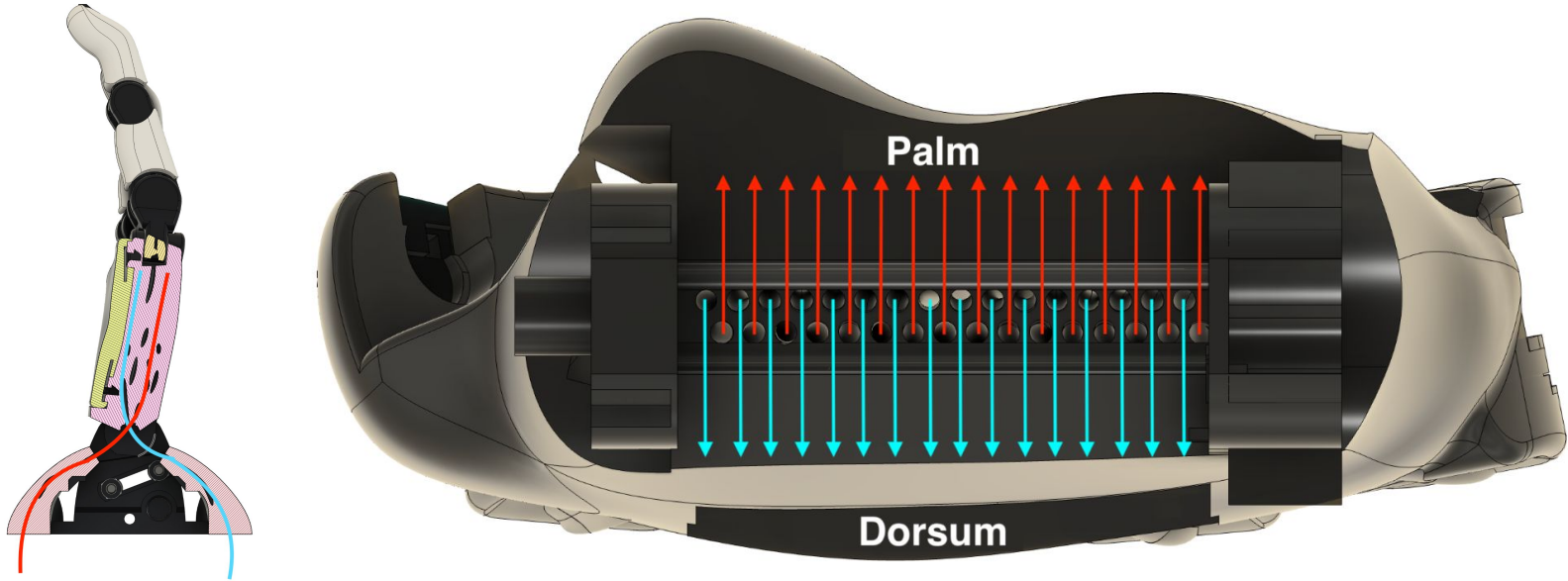
Repeat with the 2nd tendon from the left (make sure it is really the next one in line, sometimes they are entangled) into the 2nd channel from the left.

Repeat for all “palm” tendons.

Then repeat with all “dorsum” tendons into channels on the “palm” side.

palm = inner face of the hand / Handfläche · dorsum = back of the hand / Handrücken

Threading in the tendons



palm = inner face of the hand / Handfläche · dorsum = back of the hand / Handrücken

Verify the tendon order

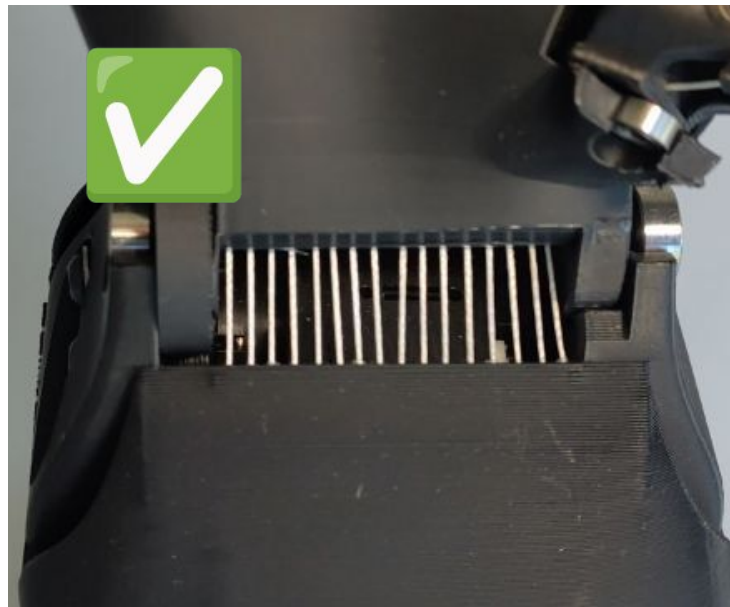
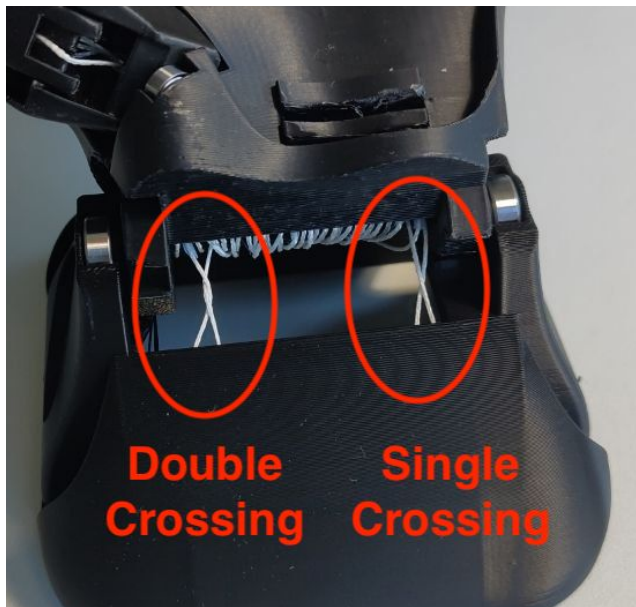
Refer to the next slide (Tendon Mapping) to check that each of the 32 tendon drives the correct joint.

Verify that no tendons are crossing.

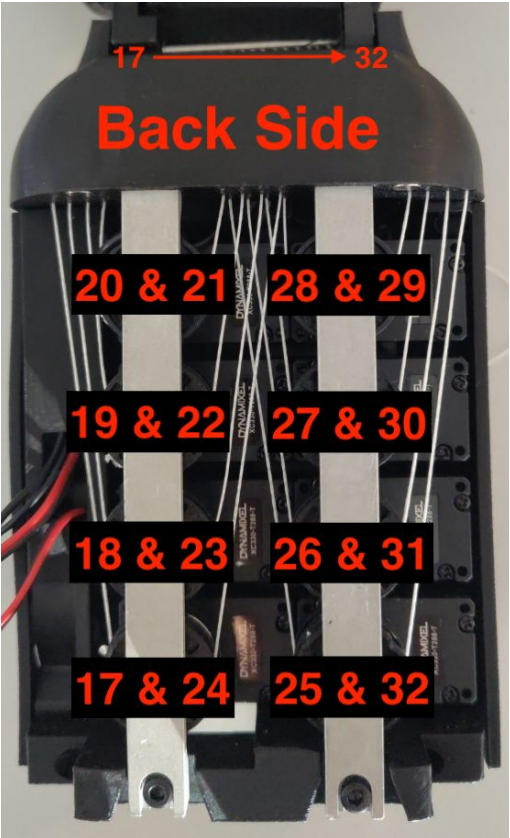
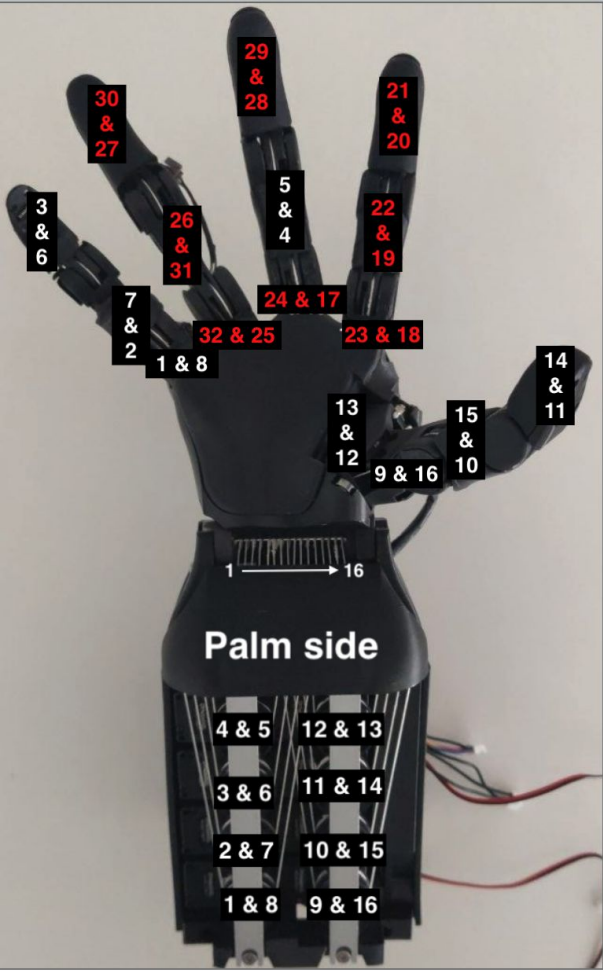
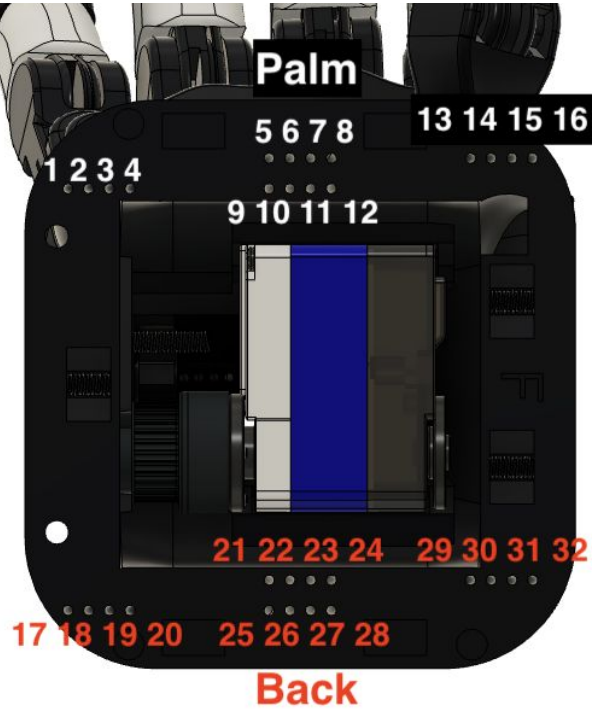
As a guiding principle, each tendon travels a straight line and does not cross any other.

This step is tedious but catching potential mistakes now will save a lot of time later.

Verify the tendon order



Tendon mapping



Tendon mapping: reading the diagram

The numbers are superposed over the joints they actuate (central image). The number above is the extensor and below is the flexor. For the AP the number to the left moves the joint to the left and vice-versa.

flex = bend / beugen · ext = straighten / strecken · L/R = left/right viewed from the palm / links/rechts von der Handfläche aus

Tendon mapping: 32 tendon paths

- | | | | |
|--------------|---------------|---------------|---------------|
| 1) P-AP-L | 9) T-AP-L | 17) M-AP-R | 25) R-AP-R |
| 2) P-PP-flex | 10) T-PP-flex | 18) I-AP-R | 26) R-PP-ext |
| 3) P-DP-ext | 11) T-DP-flex | 19) I-PP-flex | 27) R-DP-flex |
| 4) M-PP-flex | 12) T-TP-flex | 20) I-DP-flex | 28) M-DP-flex |
| 5) M-PP-ext | 13) T-TP-ext | 21) I-DP-ext | 29) M-DP-ext |
| 6) P-DP-flex | 14) T-DP-ext | 22) I-PP-ext | 30) R-DP-ext |
| 7) P-PP-ext | 15) T-PP-ext | 23) I-AP-L | 31) R-PP-flex |
| 8) P-AP-R | 16) T-AP-R | 24) M-AP-L | 32) R-AP-L |

flex = bend / beugen · ext = straighten / strecken · L/R = left/right viewed from the palm / links/rechts von der Handfläche aus

Tendon mapping: reading the names

First letter stands for Thumb, Index, Middle, Ring or Pinky, while the two following letters indicate the joint.

In last position, ext means extension (finger opens/moves away from the palm) and flex means flexion (finger closes / moves in towards the palm).

For the APs, in last position L means moving to the left (when looking at the palm side) and R means moving to the right.

So R-DP-flex means : Ring finger - DP - flexion

flex = bend / beugen · ext = straighten / strecken · L/R = left/right viewed from the palm / links/rechts von der Handfläche aus

Assemble the wrist

1 / 2

Click [here](#) for follow along.

Fit the belt on the carpal pulley and let it rest down into the wrist, making sure the belt passes in between the two (PTFE-coated) M4 screws. They will act as belt tensioners.

Assemble the Carpal's to the Wrist structure (pop it in well).

Take the large wrist motor, fix the pulley-carrier on it with four M2x8 screws.

Assemble the wrist

2 / 2

Take the Wrist Pulley, insert a **4x10 pin** in the middle, then mount a 4mm bearing on it.

Fit the wrist pulley on the belt and push the 4mm bearing into its housing in the wrist.

Assemble the wrist motor onto the wrist pulley.

Move the two M4 screws inward to tension the whole belt-and-pulley system.

Assemble the wrist

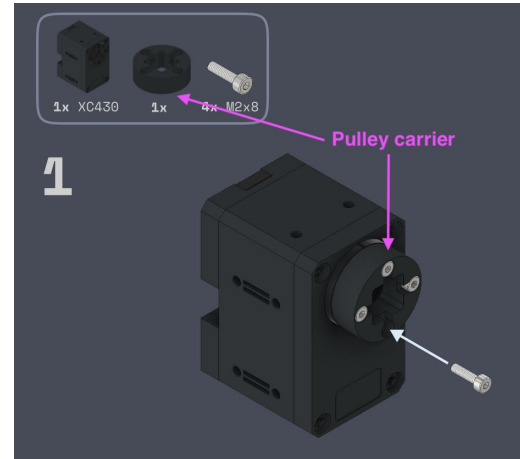
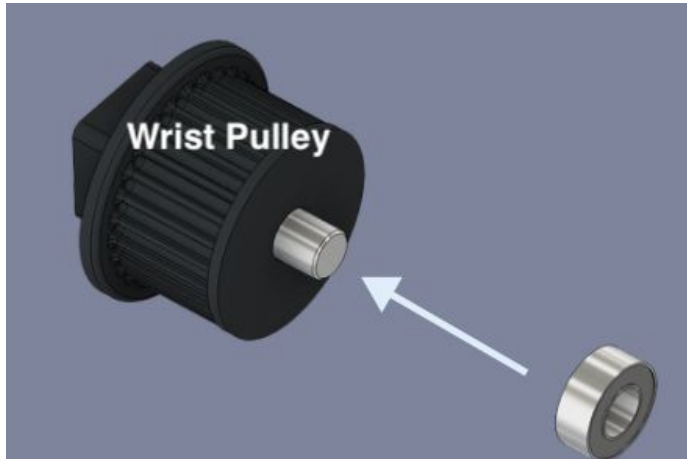
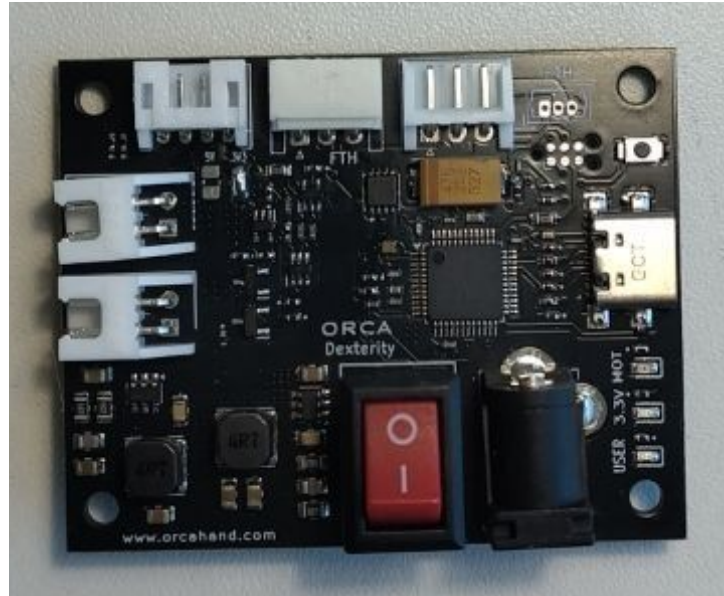


ILLUSTRATION NEEDED

Tom pls call me when you get here

Flashing the OH board / Via Console



1. Bootloader (once per board)

1 / 2

A new board is empty and invisible on USB. It first needs a bootloader, written once through the J-Link probe.

You need: J-Link EDU Mini + Tag-Connect cable (TC2030-CTX-NL), 12V supply, a Mac with the J-Link software.

Power the board on. Three green LEDs (USER, 3.3V, MOT). The probe never powers the board.

Press the Tag-Connect onto the pads next to the USB-C port. Hold it with your fingers the whole time.

bootloader = small program that loads the firmware / Startprogramm zum Laden der Firmware

1. Bootloader (once per board)

2 / 2

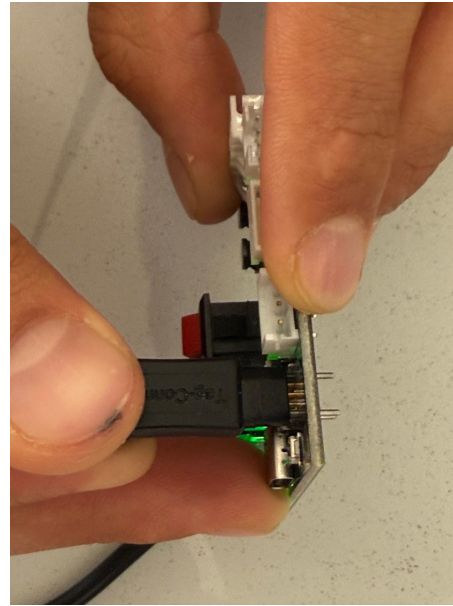
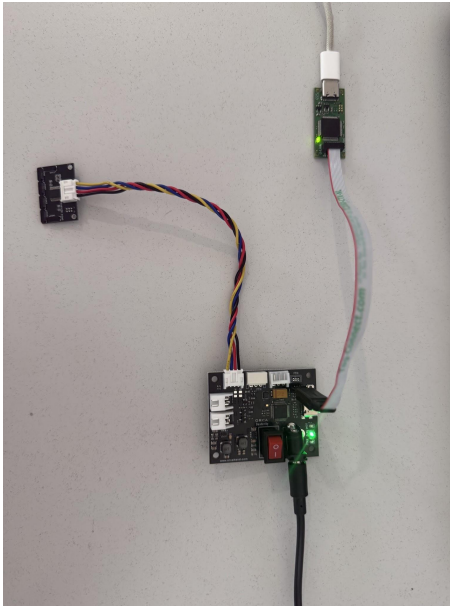
Run: `cd orca_firmware/oh_board/samd21_bootloader &&
./flash_when_stable.sh`

While it says "Waiting for stable VTref", press harder. When it says "Flashing", do not move. About 10 s.

Check: unplug the probe, plug USB-C into the Mac. The board shows up as "SAM-BA". Bootloader done.

bootloader = small program that loads the firmware / Startprogramm zum Laden der Firmware

1. Bootloader (once per board)



bootloader = small program that loads the firmware / Startprogramm zum Laden der Firmware

2. Firmware (over USB-C)

1 / 2

The bootloader only makes the board visible. The firmware is what talks to the motors and sensors.

Keep the board plugged into the Mac over USB-C. Use a data cable, not a charge-only cable. No probe needed.

Run, with the side of the hand this board goes into (right or left):

```
cd orca_firmware/oh_board/usb_to_dynamixel_dual_cdc && ./upload.sh  
right
```

firmware = program running on the board / Betriebsprogramm auf der Platine

2. Firmware (over USB-C)

2 / 2

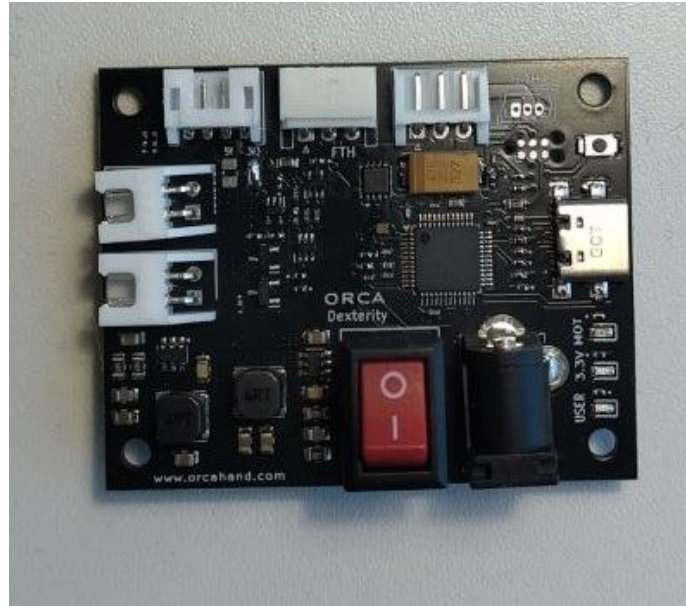
Apple Silicon Mac: the first run may ask for Rosetta. Install it once, then run again.

Check: the board now shows up as "ORCA" instead of "SAM-BA". Done.
Later updates always go over USB-C.

Not working? No device = wrong cable or step 1 skipped. 0.000V in step 1
= board off or Tag-Connect not seated.

firmware = program running on the board / Betriebsprogramm auf der Platine

2. Firmware (over USB-C)



firmware = program running on the board / Betriebsprogramm auf der Platine

Firmware via J-Link (every install and update)

1 / 2

The connector board (in the wrist) has no USB. Every flash goes through the J-Link probe and the Tag-Connect.

Power it from a powered OH board through the 4-wire cable. The green LEDs on the OH board must be on.

Press the Tag-Connect onto the 6 pads of the connector board and hold it the whole time.

Left and right hands use different firmware. Pick the side of the hand this board goes into.

flash = write a program to the board / Programm auf die Platine laden

Firmware via J-Link (every install and update)

2 / 2

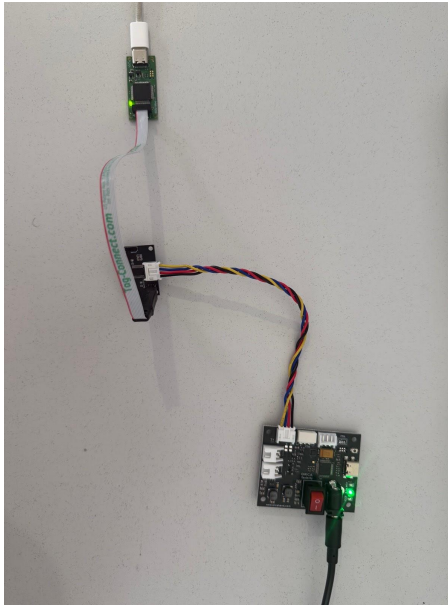
Run: `cd orca_firmware/connector_board && ./flash.sh --r` (left hand: `./flash.sh --l`)

The script checks probe, power and chip first and prints a plain fix if one of them fails.

Done when it prints "Flash complete - firmware loaded and target started". Anything else: read the printed fix.

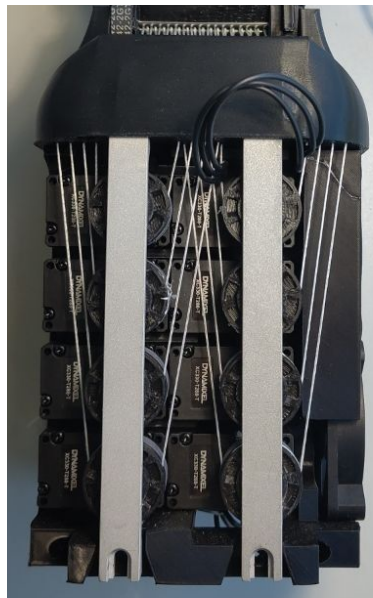
flash = write a program to the board / Programm auf die Platine laden

Firmware via J-Link (every install and update)



flash = write a program to the board / Programm auf die Platine laden

Tower structure



Wires & fans

1 / 2

Click [here](#) for follow along.

Fit four M3 nuts in the designated hexagonal slots (highlighted blue), leave others empty.

Pass a long (180mm) 3-pin connector through the cable slot (highlighted red).

Using four M3x14 screws, fix the two fans on the structure and pass their cables through the same slot as the 3-pin connector.

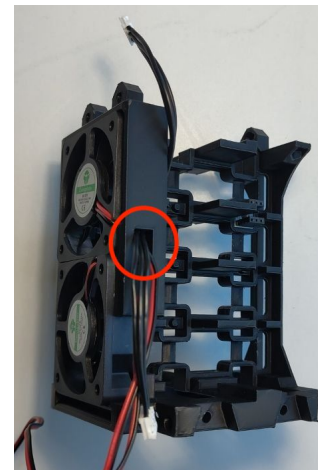
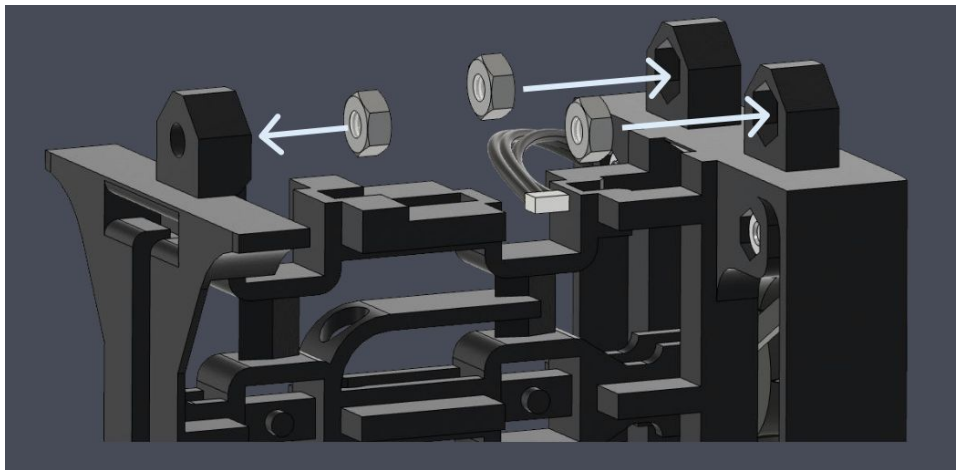
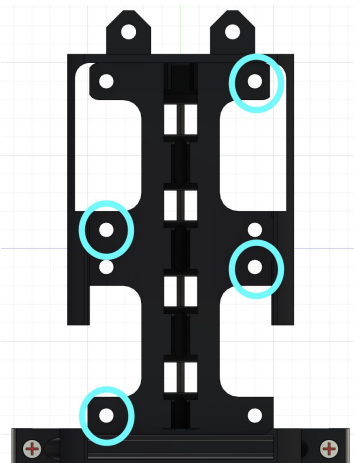
Wires & fans

2 / 2

Make sure the fan cables are routed properly so they don't get damaged.

Add three M4 nuts in their slots at the top of the tower.

Wires & fans



FeeTech motors assembly

The procedure is slightly different with FeeTech motors compared to the current instructions (Dynamixel).

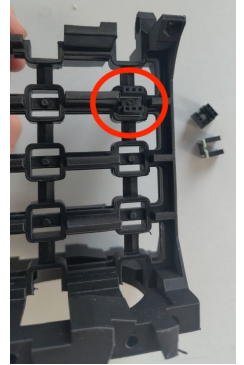
We will make dedicated slides for the FeeTech soon, But in the meantime please refer to this [guide](#)

Motor connector PCBs

Click [here](#) for follow along.

Take a motor connector PCB and fit it into one of the square housing with round center peg.

Repeat twelve times.



PCB = printed circuit board, carrying electrical connections / Platine mit Leiterbahnen

Prepare the motors

Click [here](#) for follow along

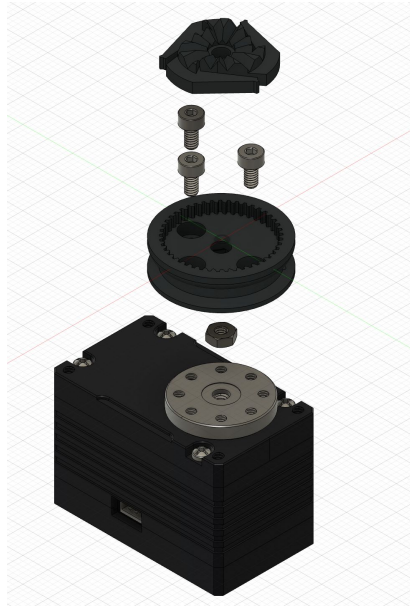
Take an M2 nut and insert it into the base of a bottom spool (recognizable by the three screw holes).

Fix the bottom spool to a small motor with three M2x4 screws.

Snap a ratchet part on top of the bottom spool (make sure that it really clicks in).

spool = wheel that winds the cord / Seilspule · ratchet = toothed locking mechanism / Rastmechanismus mit Zähnen

Prepare the motors



spool = wheel that winds the cord / Seilspule · ratchet = toothed locking mechanism / Rastmechanismus mit Zähnen

Connect the motors

1 / 2

Click [here](#) for follow along

Power your OH Board with a **12V power supply**

Plug the 3-pin connector (cf step Wires & Fans) on the correct input based on what type of motor you have (FeeTech or Dynamixel).

On your PC, navigate to the `orca_core` directory and run the command

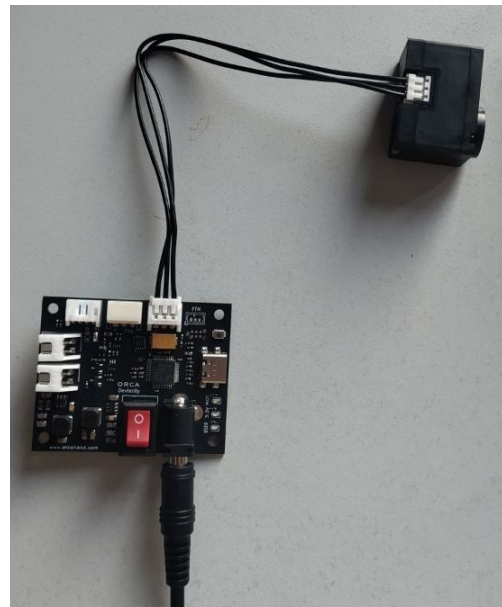
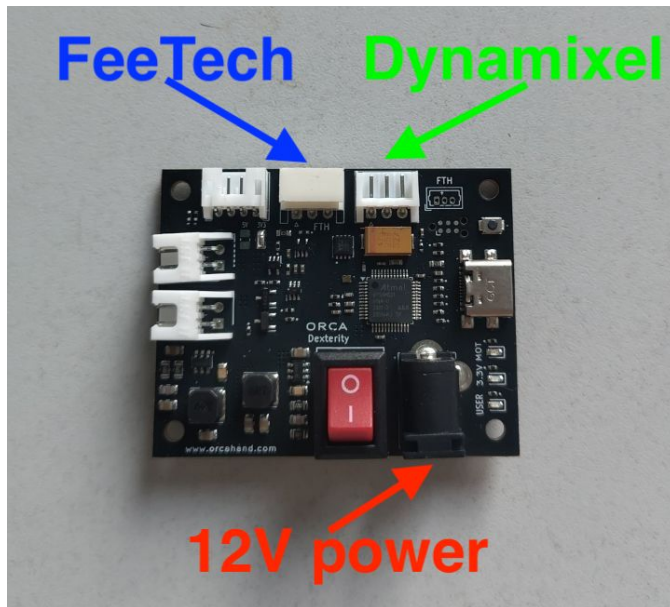
Connect the motors

2 / 2

python scripts/configure_motor_chain.py -motor-type XXXX (replace XXXX by dynamixel or feetech based on your motor type)

Once you see the “Scanning for motor ...” message, plug the 3-pin wire in the top right motor of the palm side.

Connect the motors



Motor order

The order in which you connect the motors is important.

The script assigns each motor an ID from 17 to 1, in descending order.

Refer to the figures on the right for the correct motor IDs Motors must be connected in descending ID order !

Start with motor 17 (top right palm side) and end with motor 1 (wrist).

Motor order



Connect the motors

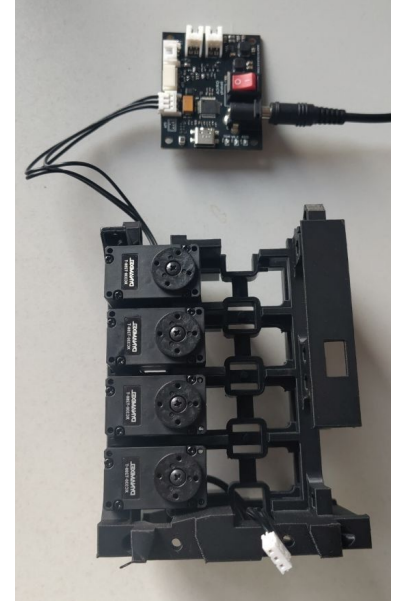
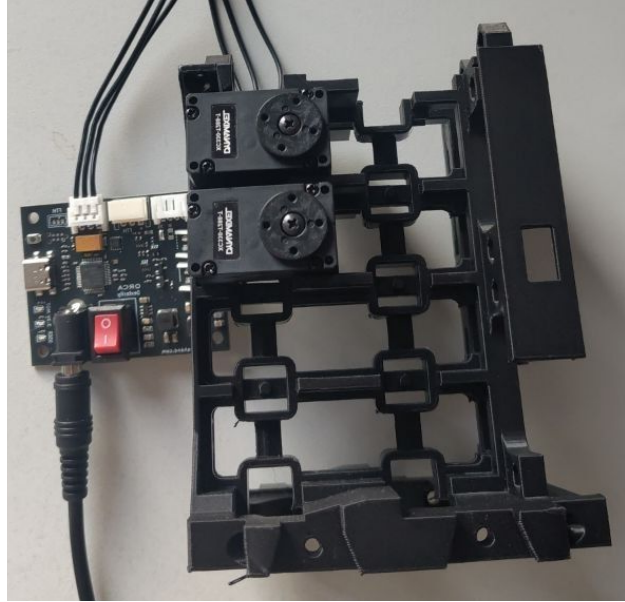
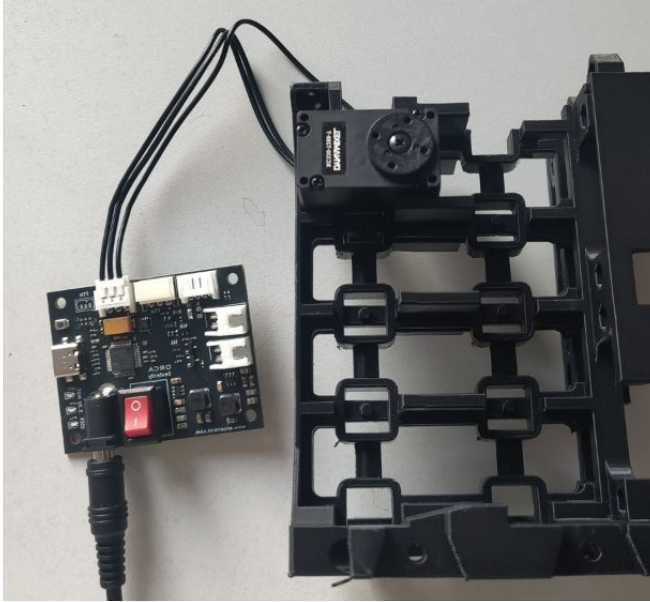
Once the message “ Found default XXXX motor” appears, install the motor on the Tower by plugging it on top daisy chain connector, and install the second one next to it.

At each step, only install the next motor after the current one has been found.

Repeat twice. Four motors make one column of motors.

daisy chain = connect devices one after another / Geräte nacheinander verbinden

Connect the motors



daisy chain = connect devices one after another / Geräte nacheinander verbinden

Connect the motors

1 / 2

Four motors make one column of motors.

Use a short (30-50mm) 3-pin connector to link the bottom of the first column to the bottom of the next column.

Be careful not to clamp the cable.

Repeat until all 16 motors are connected and recognized by the software.

Use a 3-pin connector to link the 16th spool motor to the wrist motor.

Connect the motors

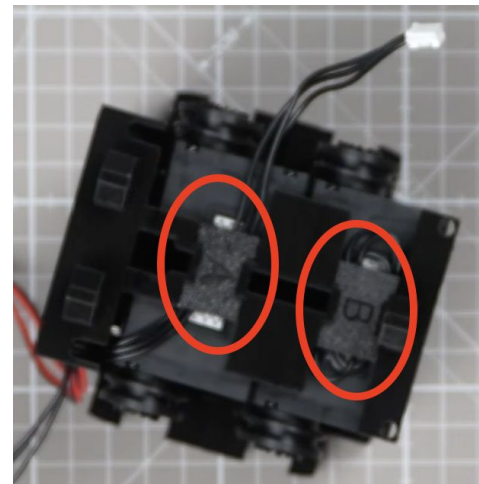
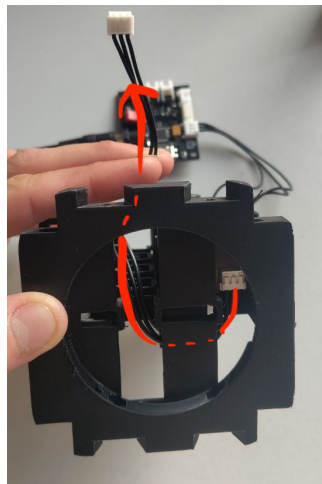
2 / 2

If the 17th motor is recognized and everything worked, the script should stop with a message saying “All motors configured”

Finally add the cable covers (highlighted red 2 top, 2 bottom).

You can disconnect the OH board and close your PC.

Connect the motors



Assemble the Wrist to the Tower

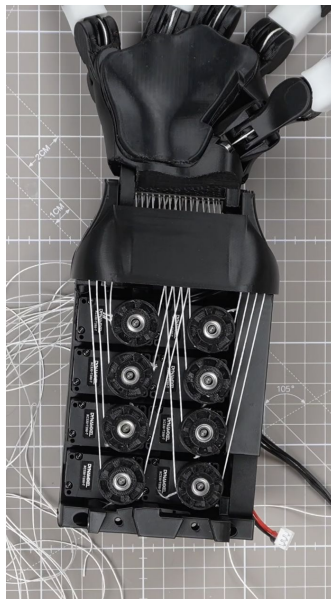
Click [here](#) follow along

Fit the Wrist on top of the Tower. Make sure the cable of the wrist motor is not clamped and that the edges of the structures align perfectly.

Insert three M4x10 screws in the sides to secure Wrist and Tower together.



Spooling



Tendons in the bottom spools

1 / 2

Click [here](#) for follow along

The tendon on the left (inner rows), closest to the column, goes in the spool of the highest motor.

Thread the tendon in the spool from the bottom towards the top, measure about 8 cm (a palm's width) of tendon from the exit and tie an A-S knot.

Turn the spool counterclockwise to wind up the tendon (should be 3-5 revolutions).

counterclockwise = opposite to clock hands / gegen den Uhrzeigersinn

Tendons in the bottom spools

2 / 2

Make sure that the tendon is winding ON the spool and not getting stuck under it.

Repeat with the next tendon to the left in the next spool from the top, and so on.

Thread tendons in all the spools of the front and back (16 total).

Please refer to the slide Adding the Wrist : Tendon Mapping if there you have any doubt.

counterclockwise = opposite to clock hands / gegen den Uhrzeigersinn

Tendons in the bottom spools



counterclockwise = opposite to clock hands / gegen den Uhrzeigersinn

Tendons in the top spools

1 / 2

Click [here](#) for follow along

Take a top spool. Add a 4mm bearing in the housing.

Thread the closest tendon on the right (outer rows) into the top spool, set it on the highest motor of the column, measure 8 cm and tie an A-S knot.

Lift up the spool, wind up the tendon to the max (should be 3-5 revolutions), set it back on the motor-spool-ratchet assembly.

antagonist tendons = two cords pulling a joint in opposite directions / Zugseilpaar für entgegengesetzte Bewegungen

Tendons in the top spools

2 / 2

Make sure to position it so that the ratchet teeth engage with the top spool's underside and use an M2x8 screw to fix it in place.

Quick check : the bottom-top spool assembly drivers a pair of antagonist tendons.

When you rotate it back and forth you should see one single joint moving back and forth. If two different joints are moving, there is a mistake somewhere.

Repeat with the 15 tendons left on the front and back side.

antagonist tendons = two cords pulling a joint in opposite directions / Zugseilpaar für entgegengesetzte Bewegungen

Tendons in the top spools



antagonist tendons = two cords pulling a joint in opposite directions / Zugseilpaar für entgegengesetzte Bewegungen

Spool holders

1 / 2

Click [here](#) for follow along (NB : nut placement has changed since the video)

Insert four M3 nuts in the hexagonal slots of the inside bottom of the tower.

Slide the metal spool holders into their slots under the wrist and press down.

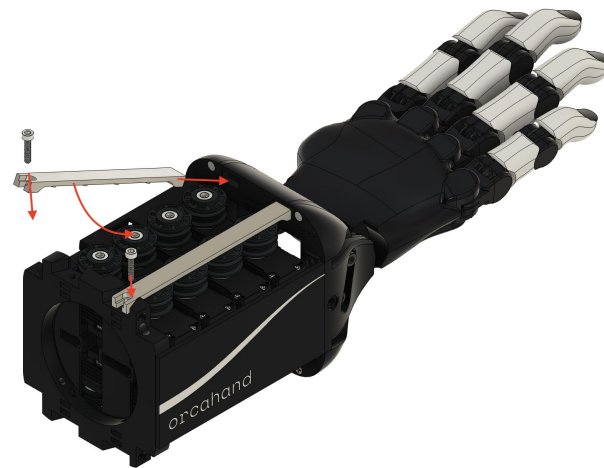
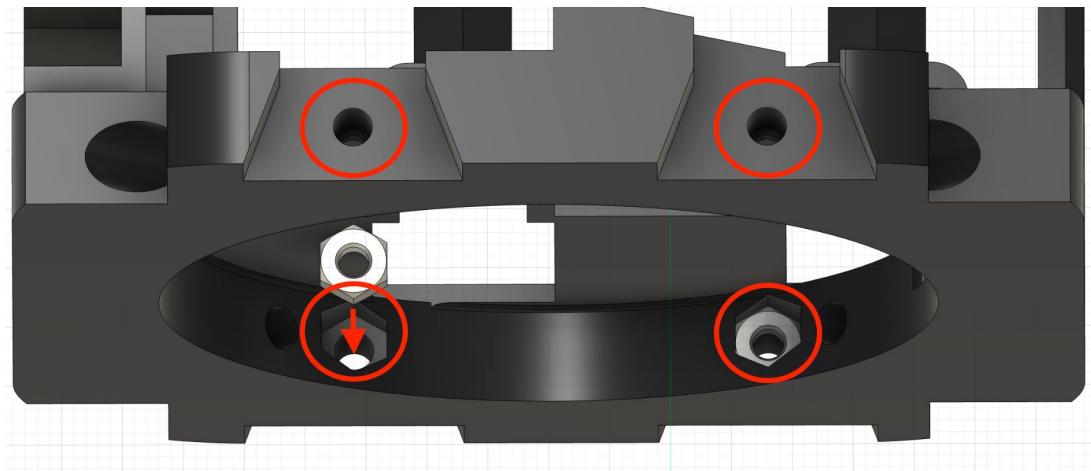
Spool holders

2 / 2

You may need to push the spools around a bit so that the metal pegs align with the bearings.

Once all pegs are aligned in their bearing, use an M3X14 screw to fix the spool holder in place.

Spool holders



Hull



hull = outer housing panels / äussere Gehäuseabdeckung

Magnets on the Tower & Wrist

Hint : Keeping the same polarity for each magnets will make the next step easier.

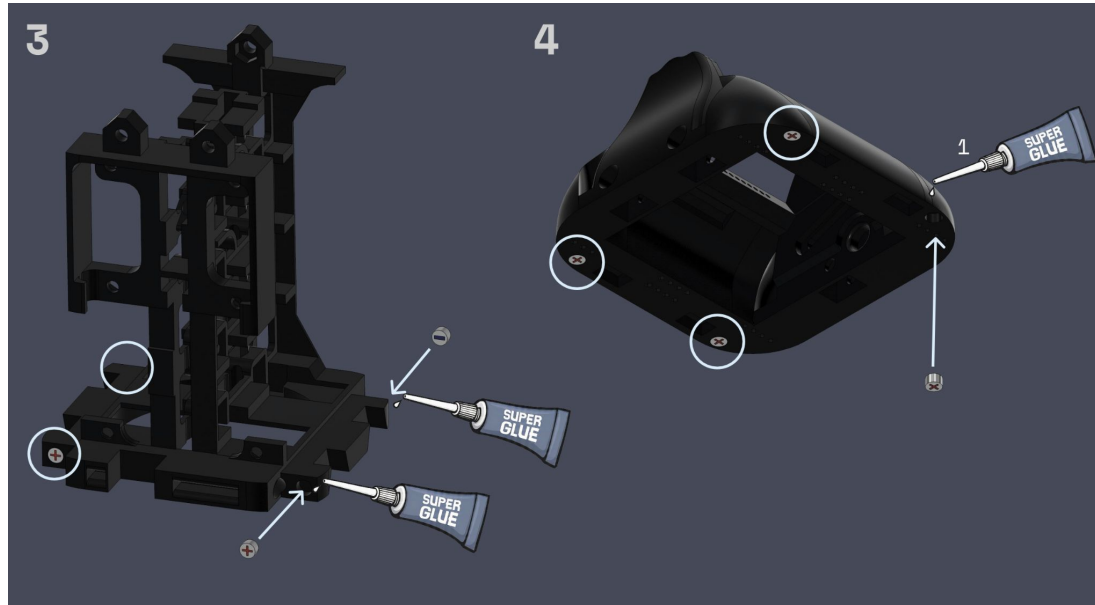
Pour a small drop of superglue into a round slot at the base of the tower, then insert a magnet and push hard for 10 seconds.

Be sure to wipe any glue that comes out of the slot to prevent glue from getting on on your fingers or other parts of orcahand.

Do this for the four magnets in the Tower and four in the Wrist.

polarity = which magnetic pole faces out / welcher Magnetpol nach aussen zeigt

Magnets on the Tower & Wrist



polarity = which magnetic pole faces out / welcher Magnetpol nach aussen zeigt

Magnets on the Front & Back Hull

1/2

Important ! Carefully double check the polarity of the magnet before inserting in the hull slot.

If the magnet is glued in the wrong way, it's impossible to get out and you will need a new hull !

Be careful to wipe the part and your fingers between each magnet because glue traces are very visible on the smooth black PLA.

Magnets on the Front & Back Hull

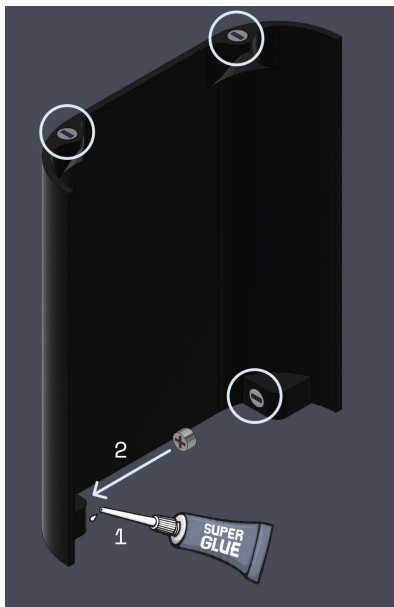
2 / 2

Repeat the glue->insert->wipe step for each of the four magnets on the front and back hull plates.

Assemble the front hull plate on the palm side of the orcahand.

It should snap in place thanks to the magnets.

Magnets on the Front & Back Hull



Side plates

Snap on the fan side plates



Back hull plate (OH board)

1 / 2

Connect the fan cables to the side connectors of the board.

Connect the motor 3-pin cable to the appropriate connector (depends on motor type).

If the fan wires are too long, roll them up as shown to the right

Slide two M3 nuts in the slots of the back plate.

Place the board face down in the back hull, secure it with an M3x14 screw in the bottom left hole.

dorsum = back of the hand / Handrücken

Back hull plate (OH board)

2 / 2

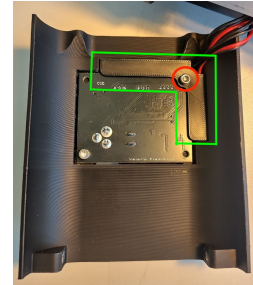
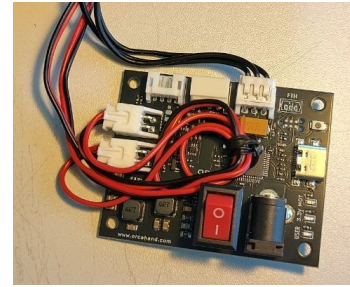
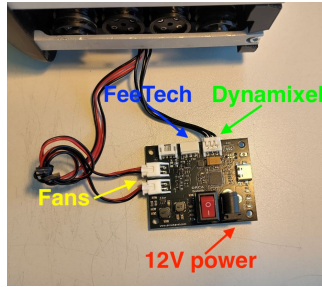
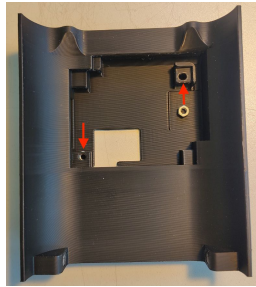
Shove the cables in the grooves next to the board, place the cable cover on top and secure the whole with an M3x14 screw.

Assemble the back hull plate on the dorsum side of the orcahand.

It should snap in place and fit snugly, with all outside edges properly aligned.

dorsum = back of the hand / Handrücken

Back hull plate (OH board)



dorsum = back of the hand / Handrücken

Finished !

Congrats, you just finished assembling your first orcahand !

We hope the explanations were clear and easy to follow.

Please go through this [checklist](#) of crucial points and common mistakes.

You can now proceed with the [tensioning](#) procedure to make the hand ready for use.

tensioning = adjusting how tight the tendons are / Zugseilspannung einstellen

Finished !



tensioning = adjusting how tight the tendons are / Zugseilspannung einstellen

Mounting to an arm

1 / 2

If you want to mount the orcahand onto a robotic arm, an ISO 9409-1-50-4-M6 connector comes with the hand.

It is compatible with any arm whose flange follows the ISO 9409-1-50-4-M6 norm, including but not limited to :

Universal Robots: UR3, UR5, UR7e, UR10e, UR16e

Franka Research 3 / Panda

Kinova Gen3

Techman TM series

flange = mounting face at the end of the arm / Befestigungsfläche am Armende

Mounting to an arm

2 / 2

Doosan M / H series

Please follow the instructions detailed [here](#) on how to use the connector.

flange = mounting face at the end of the arm / Befestigungsfläche am Armende

Things left to do in this guide

- Explain how to flash the OH boards
- Adapt the instructions if it's not the OH board
- Explain how to clone the orca_core directory for the step Connect the Motors