“Orikamo” - an origami-fold face mask constructed from polypropylene surgical sterilization wrap and 3D-printed plastic clips.

A homemade mask to provide a barrier against transmission of airborne infectious disease agents including SARS-CoV-2, the virus that causes COVID-19 disease.

**DISCLAIMER**

NO HOMEMADE MASK can provide the guaranteed protection of certified personal protective equipment (PPE)

My approach was to make a mask that would:

1) mimic the fit of a commercial respirator

2) reduce moisture build up and maximize airflow, allowing for comfort and breathability despite highly restrictive filter.

This design takes advantage of the features of “duckbill” style commercial respirators that provide extra interior space and fit tightly underneath the chin.

I sought to make a homemade “last resort” respirator after I read about Dr. Bruce Spiess at University of Florida, whose medical team was developing masks made out of discarded (non-biohazardous) polypropylene sterilization wrap.

https://anest.ufl.edu/clinical-divisions/mask-alternative/

I developed a sewing pattern for a duckbill face mask using surgical wrap. The mask has good fit and breathability. However, the inevitable question arose - what if you don’t have access to a sewing machine?

At this point, I had seen several shared 3D-printed plastic frames that were intended to secure fabric. However the masks were awkward to assemble and the resulting masks gave little space for adequate air flow.

Since I had already worked with the duckbill shape, I tried folding the fabric to fit into a plastic frame. I saw that the shape I wanted resembled an origami “cup”, which is tapered on one end. This idea was the inspiration for the mask, even though the folds ended up diverging from the traditional pattern to reduce the amount of overlapping fabric.

Trying to stuff lots of fabric into a small frame was 100% unsatisfactory, so I decided to secure the folded fabric with clip adaptors that would also connect the ties to the mask. The resulting mask takes on its own structure due to the “stiff” nature of the polypropylene fabric... but it’s still flexible enough to conform to contours of the face for a tight fit.

The name “Orikamo” comes from an English speaker’s mash-up of the Japanese terms for FOLD (“ORI” or “ORU”) and DUCK (“KAMO”- referring to wild, not domesticated, duck).
MATERIALS:

Synthetic autoclave/sterilization/surgical wrap fabric with appropriate filter barrier properties

MASK - (1) rectangle of fabric

SMALL: 9 inches high x 10 inches wide
MEDIUM: 9 inches high x 10.5 inches wide
LARGE: 9 inches high x 11 inches wide

TIE - (1) 5/8-inch x 45-inch strip of fabric

(2) 3D-printed plastic clips for origami-fold mask

(2) narrow aluminium metal strips or other malleable wire for the nosepiece. Each piece should be ~ 2 inches long.

tape (see notes on page 6*),

NOTES:

- Diagram at right shows the fabric edges labelled TOP, BOTTOM, LEFT and RIGHT . . . and all the fold lines for the entire piece.

- Both layers of fabric should be folded in every step.

INSTRUCTIONS:

CUT 2 rectangles of fabric of the indicated size above.

This example shows a “MEDIUM” size mask constructed out of Halyard H600 fabric - one layer is blue and one layer is white.

CUT 1 strip of fabric 5/8 inch x 45 inches

1) Fold over TOP/LEFT corner diagonally toward the BOTTOM edge. Leave a 3/4-inch space between the LEFT edge and BOTTOM edge.
2) Pull the remainder of the TOP edge toward the BOTTOM edge, creating the other side of the diagonal pleat.

3) At the bottom left corner, leave 3/4 inches between TOP edge and LEFT edge.

4) Fold the BOTTOM edge upward 3/4 inch to cover the open ends of the pleat.

5) Fold the TOP edge 3/4 inch to cover the BOTTOM fold.
6) Hold the point that you just created, keeping the 3/4-inch folds in place with your finger. Flip the entire piece of fabric to the opposite side.

7) Apply clip so that the smooth part of the clip is facing toward you and the holes for the tie are on the opposite side of the fabric.

8) Repeat folding steps 1-6 for the RIGHT side of the panel, then apply the second clip to the point of folded fabric.

THREADING THE TIE

The portion of the mask with the pleated folds will lie against the bridge of the NOSE, and the opposite side will be the CHIN.

The finished tie will loop around the back of the neck; the open ends of the tie will extend up over the ears and tie on the back of the head.

9) Position the mask so that the bridge of the NOSE is facing up.

10) Locate a clip on one side of the mask and thread one end of the tie toward you through the upper hole of the clip.

11) Thread the tie away from you through the lower hole of the same clip.

12) Pull the tie through about 12 inches to have enough slack to thread through the other clip.

13) Thread the tie toward you through the lower hole.

14) Thread the tie away from through the upper hole.

15) Adjust the tie so that the each free end is about the same length relative to the mask.
To eliminate gaps on either side of the nose, use thin metal strips or wire. In my tests, I got a better fit using TWO separate pieces of metal instead of ONE continuous piece that goes over bridge of nose. NOTE: the images on this page show an example mask with blue fabric on the inside and white on the outside.

16) Invert mask so that the NOSE side is facing down. The folded pleats should be on the bottom.

17) Space TWO pieces of metal 1/8 inches apart, centered relative to the center of the mask.

18) Adhere the metal to the top of the pleats with tape.

19) Fold over the fabric 3/4 inch to cover taped metal and create folded seam for nose of mask.

NOTE: It’s not necessary to tape the folded edges of the mask, even though the fold can flex open a bit in the center. Once the mask is on, the folds will be secured against your skin ... you just have to make sure the folds are in place as you bring the mask against your face.

**Proper fit at the nose is the make-or-break point for sealing any mask.**

The gaps around the nose are typical failure points for a mask fit test. The metal strips have to be bent to apply sufficient pressure to the nose to close the gaps completely.

Once your mask is on, you can start by pushing the metal strip against the side of your nose to create a “V” shape. However, that bend alone may not be sufficient, depending on how hard you push.

It’s likely you’ll need to bend the metal to an angle of 110-120 degrees to effectively block airflow around the nose. To create this bend, slide one finger underneath the portion of the metal strip that’s sitting against your cheek. Push that end of the metal strip away from your face while keeping the other end against your nose. This will create a more extreme angle.

Once you have a 110 degree angle, do some final fine adjustments, pushing down along your cheek to match the contour. The metal strips should feel firmly pressed against your nose, but not too tight so that your nostrils are pinched to the point where airflow is impeded.
ADJUSTING MASK FOR GOOD FIT

TIES MUST BE FIRMLY TIGHTENED to SEAL MASK TO FACE!

- To put the mask on, lower the tie loop over the back of your head while the mask is lowered in front of your face. The tie loop will then rest on the back of your neck and the mask will rest underneath your chin.

- Make sure the fabric along the nose and chin of the mask is folded 3/4 inch as you bring mask up to your face. (optional, you can tape down the edge)

- Bring mask close to your face and gently pinch the metal strips at nose just enough to keep mask in place while you adjustment the ties. (you will adjust the metal nose strips later)

- Take the free ends of the tie in your hands and pull up over your ears. As you pull, the tie should slide through the holes in the clip, tightening around the back of neck.

For fine-tuning the tie tension, you can hold the plastic clip in place with your fingers as you adjust the tie upward from the neck so it pulls tight against the back of neck.

- Tie free ends on top of head.

- Go back to metal nose strips and adjust carefully. To get a good seal you will have to bend the strips significantly to get firm pressure on each side of your nose. (See more details on nose adjustments on page 5.)

MASK COMPONENTS and REUSE

Given an adequate supply of polypropylene surgical wrap, the origami-fold mask was intended to be worn ONCE, disposing the fabric portion of the mask (including the tie) after use.*

The plastic clips and strips of metal can be reused if decontaminated properly.

Most plastics used in home 3D printing will not stand up to autoclave sterilization, so that will not be an option unless the clips are specifically printed with a heat-safe plastic.

For some plastics, like the PLA used in this example, it’s likely that simple surface decontamination procedures, such as soaking in 10% bleach for 10 minutes, is appropriate and will not affect plastic integrity.

*In the single-use scenario, it's OK to use tape for part of the construction, since the fabric never has to be “undone”. However if the need was dire, the mask could be decontaminated by separating the fabric from the other components. The use of tape would then become a problem, since removing the tape pulls the fabric fibers underneath, which technically would destroy the barrier.