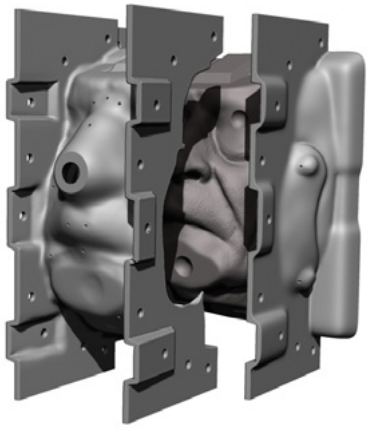


Digital is in every aspect of work now. Even in entirely manual industries, schedules, budgeting, outcomes, and plans are made, studied, and distributed digitally.

Understanding these processes, how they could affect the work-flow of a practical workshop (*and how you can use and benefit from these tools*) is becoming increasingly important.

Previously, to most people, 'digital' meant the Visual FX department creating CGI in post-production.

This was mainly because of the surge of CG seen in the early 90s, which many said was the end of all practical effects.

This has thus far proved to have been not the case. Instead, we have seen a massive increase in workload for both practical and visual effects.

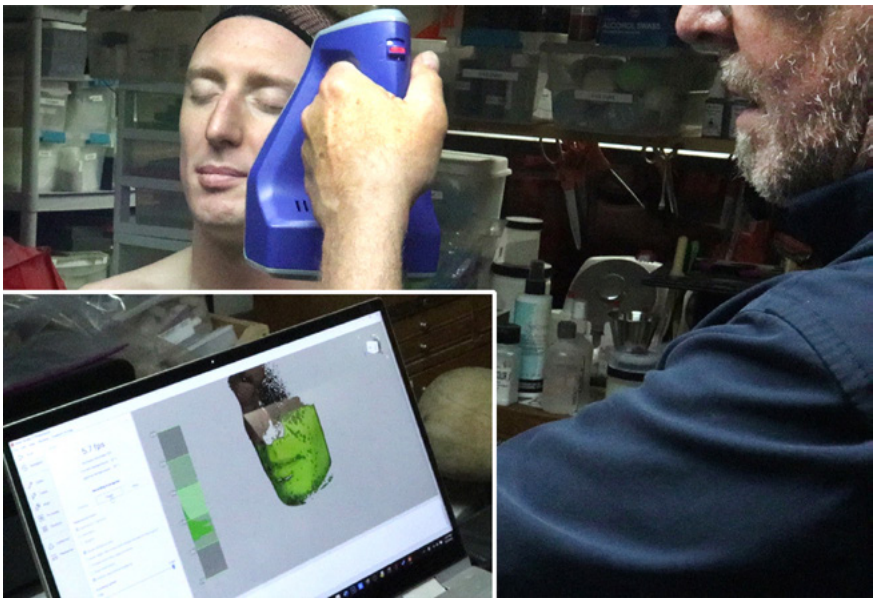
Technology has advanced in many areas since then, and now digital tools and language, previously exclusively used within the visual FX world, have become part of the workshop.

The main areas which have impacted the practical workshop are:

1. 3D scanning instead of lifecasting using hand-held 3D scanners.

2. 3D printing to produce objects either as prototypes, items to be remoulded or as finished, usable items.

3. Digital sculpting and CAD work to create items to be 3D printed or available for other departments to reference, such as VFX.



Todd Debreceni uses an Artec Spider to scan a human head instead of the traditional technique of lifecasting. Although the scanner is excellent, the cost is high (currently around £20,000). There are other scanners which cost much less and require less computing power.

3D SCANNING

Lifecasting has long been a critical skill in creating prosthetics, elements such as bodysuits, custom gloves, helmets, or armour.

The benefits were that highly detailed duplicates of living people could be created in the workshop using materials and techniques familiar to the department.

There have also been disadvantages to this process, including discomfort for the subject being cast, the performer or the casting team travelling and setting up a workspace to do the cast, heavy materials to be taken to the casting location, and a mess to be disposed of afterwards.

Often the performer isn't located near the crew tasked with the work, so it is necessary to have a local team do the lifecast and then ship it overseas, incurring great risk and expense.

The biggest concern from a prosthetic point of view was the weight of casting material could distort the face, pulling skin downwards and making significant changes to the basic form of the subject's features. Both silicone, alginate, and the plaster bandage used over the top could cause this.

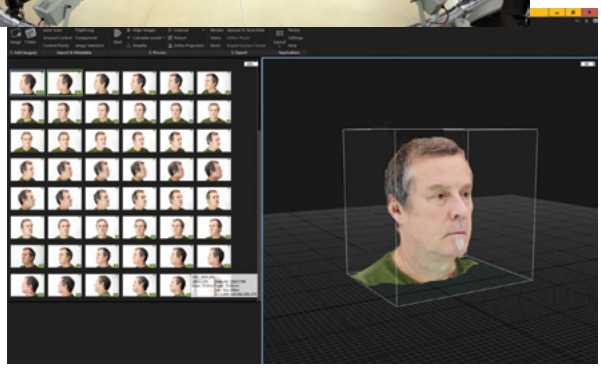
3D scanning using a hand-held scanner, by contrast, allows the process to be completed much faster, causes far less discomfort, does not distort the features at all, and the resulting data can be sent anywhere in the world instantly. The resulting raw scan data still typically needs some clean-up work, as was always the case with a plaster, but this can be done digitally, and the work can be spread among crew working remotely.

This speeds up the process hugely, and the cleaned-up scans can then be printed locally, moulded, and cast in durable materials which are already well-known and reliable.

High-end scanners are expensive and require powerful computers to handle the data comfortably.

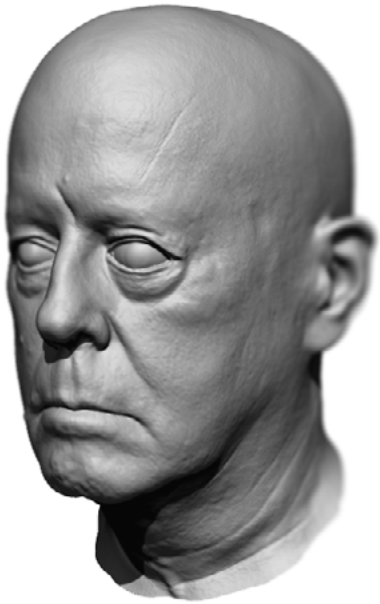
The programmes that work with the data also require large amounts of processing power and memory, so scanning to a high standard can involve some large hardware outlay.

Scanning using multiple cameras in a purpose built booth can create 3D versions of objects by assembling the separate images into a three dimensional form.



Usually, these are not automatically scaled correctly, unlike hand held scanners which are essentially measuring devices.

Todd Debreceni's head scan from a Revopoint Pop 2



3D SCANNING

There are, however, lower budget options, such as the Revo Point POP2, which is currently around £500 and works with a free app on a smart phone. The resulting data can be pretty good and is an excellent introduction to the process without eye-watering price tags.

By comparison, an excellent scanner some workshops use is the Artec Space Spider, which retails for around £20,000 at the time of writing. Having acquired such a scanner, you would still have some experience to get the best out of it and know how to use the software.

The more expensive scanners capture more detail, creating bigger file sizes and requiring more processing power. Sometimes this degree of detail isn't necessary, but in either case, a working knowledge of the process is essentially the same.

It may be that you work on a production which has already taken care of the scanning aspects and forwarded to you some scans which need turning into cores and workable models. Knowing how to do that means you can be of use in the workshop and expands your potential employers.

Starting small with a relatively inexpensive scanner is a great way to become familiar with the process, alongside working with existing 3D models, which you can find for free or purchase (there are plenty of retailers selling 3D scans such as https://www.3dscanstore.com/ , https://www.turbosquid.com/ and https://3dheadscans.com/ for example).

Once the scan has been processed and made into a virtual tool, it can be output into the real world as an object using a 3D printer.

Often there are artefacts collected in the scanning process which need cleaning up on the 3D model. This can be done in a 3D modelling program such as ZBrush or Meshmixer.

3D SCANNER COSTS

Artec Spider
(Currently around £20,000)

Einscan Pro HD
(Currently around £7,500)

Einscan H
(currently around £6000)

Revopoint Pop 2
(Currently around £500)

3D SCANNING

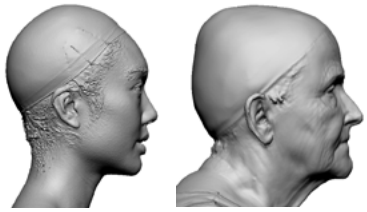
Scanners are optical devices, that use light to see a surface and take frame using two or more lenses to find and measure points in space.

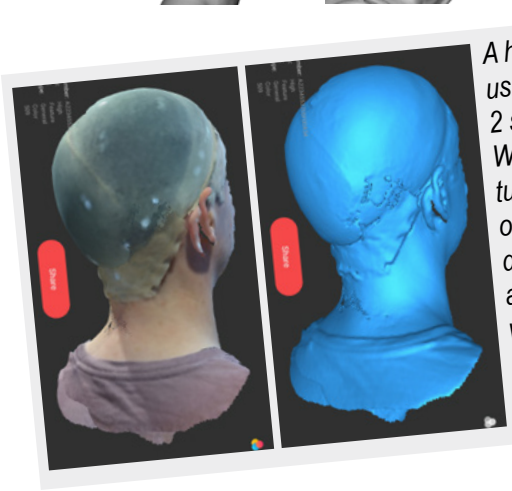
This means if the lens can't see it then it can't record it as a surface. This may be things which are very dark and don't reflect light, things which are transparent, shiny or even large areas without detail.

Hair can be tricky for a scanner to see as the multitude of surfaces thousands of strands of hair confuse the sensor. There are things you can do to help the scanner, such as putting a stocking wig caps or bald-caps, flattening eyebrows and hairlines and applying powder to beards to help them appear as a solid rather than a mass of strands.

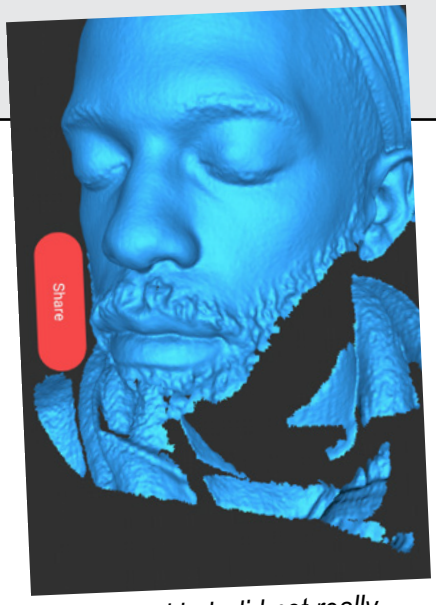
If you are used to working with life casts, then these precautions are nothing new, and in fact are less trouble than what you may be used to.

Stocking net caps clearly seen to manage hair in these 3D scans.



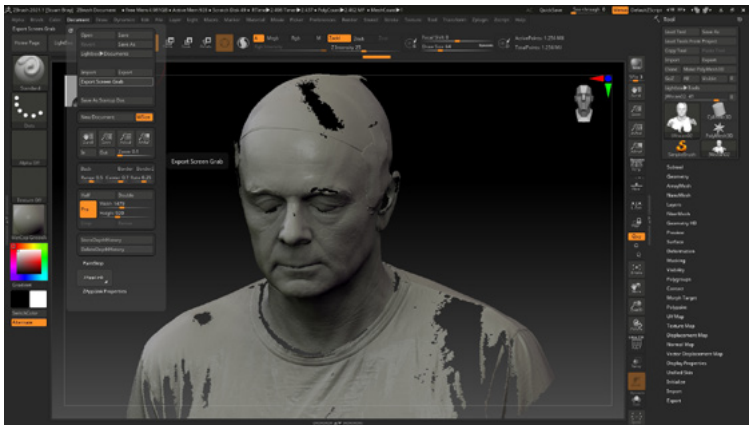


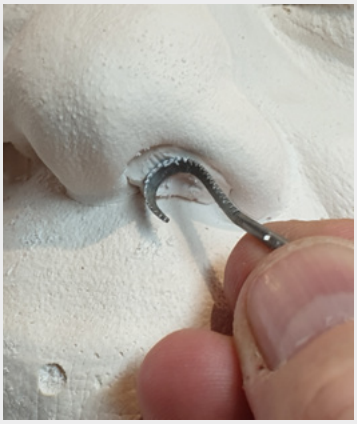
A head scan (right) using a Revopoint Pop 2 scanner in colour. When the colour is turned off, you can observe the three dimensional surface and see areas which will need cleaning up, smoothing or resurfacing.



Here, beard hair did not really scan well, although the mass of the eyebrows registered perfectly. This was no great problem to repair, and the beard area in this case was not needed.

This 3D scan is detailed, but some areas did not scan properly, so they will be fixed afterwards here in ZBrush.





Cleaning up plaster casts is a job that needs doing to make everything perfect. Here an air bubble in the nose is shaved down.

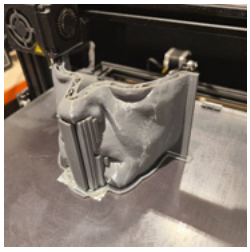
3D PRINTING

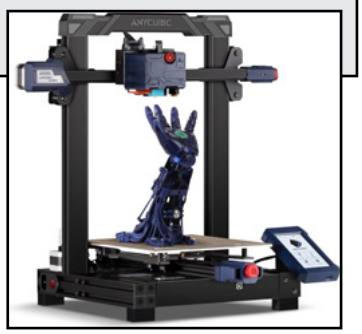
3D printing is making objects by building successive layers of material (usually a thermoplastic or light-sensitive resin) in a machine built for the task.

It can take a long time to produce a 3D print (sometimes days), depending on the size and detail required, but it is highly accurate, repeatable, and best of all, you can do other things while the printer works for you.

The first step is to have a digital object you intend to print. This is then turned into a series of thin layers in a piece of software designed for this task, known as a 'slicer'.

The printer can create an object in a material suited to the act of printing, similar to how a pot may be created by laying coils of clay on top of each other or how a wall is created with courses of bricks.

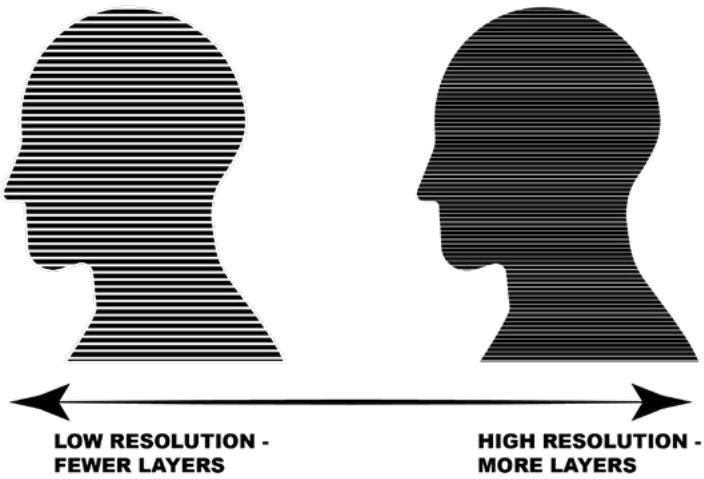


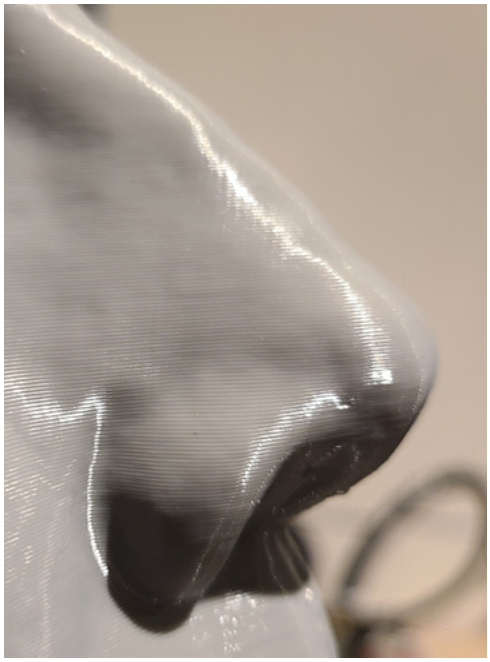


The two main kinds of printers most commonly used are plastic filament printers known as 'FDM or Fused Deposition Modelling, which essentially is like a highly accurate hot glue gun crossed with an Etch-A-Sketch, and resin printers, correctly termed 'mSLA' which stands for Masked Stereo-lithography Apparatus.

In both cases, an object is sliced into thin slices (can be as thin as 100th of a mm), and the printer then deposits each layer, building up on the previous layer until the finished item has been printed.

The thinner the layers, the more of them it requires to complete the print, but the detail is far greater. A lower-resolution print is faster but is less detailed, the print lines being apparent. **It is always a trade off between time, quality and cost!**





The illustration above shows the effect of increased resolution resulting from thinner layers, allowing more layers in the same size piece. ***Right:*** *a nose with 0.3mm thick layers.*

3D PRINTING

For many things, these layer lines may not matter. Often, it can be sanded smooth or coated with a resin to create a smoother finish and then this item is remoulded to quickly create a duplicate suitable for working on.

If you needed a mask to cover a head, for example, then the print lines on a core would be of little consequence as you would be sculpting over the top in clay and making a mould using traditional techniques over the top.

If you intend to print a finished mould suitable to have the appliance cast directly out of, you would need a much finer surface finish, so that a higher-resolution print would be necessary.

Where 3D printing comes into its own is how it frees up time. Although a large, detailed print may take a long time, it can be split into several pieces and completed on multiple printers.

Even if the printers are in different locations, the dimensions of each piece will be accurately reproduced, and pieces made to fit together can be reassembled. This is commonly done if the item will be remoulded anyway. In a workshop now, it is quite common to see a 3D printed face or head scans instead of starting with a lifecast and plaster copy. The printed (and highly accurate) heads are typically still moulded in silicone to create multiple copies in whatever material is required.

Still, the data could have been sent from another country only a few days before with no shipping delays or costs to get to this point. If multiple items are needed for the same performer, multiple crews could each produce their items based on the core simultaneously – something impossible with a single cast that needed to be moulded first.

If prosthetic makeup, a body harness, a paint design, and a fake head were all needed for the same actor, each crew member could create their own piece needed for their part of the job, assuming sufficient printers are available.

The costs of printers are much lower than scanners. A decent FDM printer can be around £250 - £500, and a decent mSLA printer can range from £500 to $2000, depending on the size and quality. Both will require consumables and maintenance, but this is relatively straightforward once you know how they work.

The digital model of a neck core designed for an appliance to be sculpted onto it.

Once remoulded and cast out in hard resin, the neck is identical to the digital model and ready for conventional sculpting.

A NOTE ON SILICONE INHIBITION

Typically, platinum silicones are used for appliance and appliance moulds. This material can be quite fussy, and some materials can prevent platinum silicones from setting properly. Latex, for example contains sulphur which can stop platinum silicones from curing, as can Aloe Vera and some printing resins. Adding deadener to soften the silicone can increase the delicate nature of the silicone and make inhibition more likely and severe.

To reduce this issue, extended UV curing times, washing in Bicarbonate of Soda Solution and applying a couple of layers of Manns Inhibit X on the surface can be used.

WHEN 3D PRINTING GOES WRONG

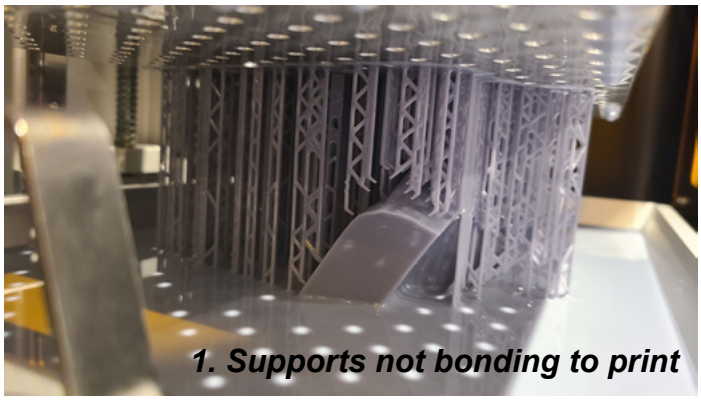
3D printing isn't all lightness and flowers. A 3D printer works to tight tolerances and can take days at a time, with mechanical and chemical failures to contend with.

Sometimes it's a power cut, sometimes it's too cold, maybe you set it at the wrong angle or you didn't have enough support.

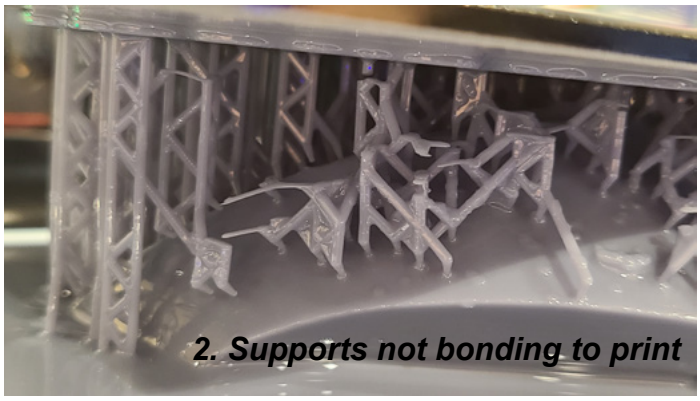
It isn't easy and requires constant testing, monitoring, and adjusting. It takes hours sometimes to clean up and try again.

This is the work which is unseen and unknown when you see a finished print. Like all good work, the hard graft of earning your stripes isn't seen front and centre. It is work .

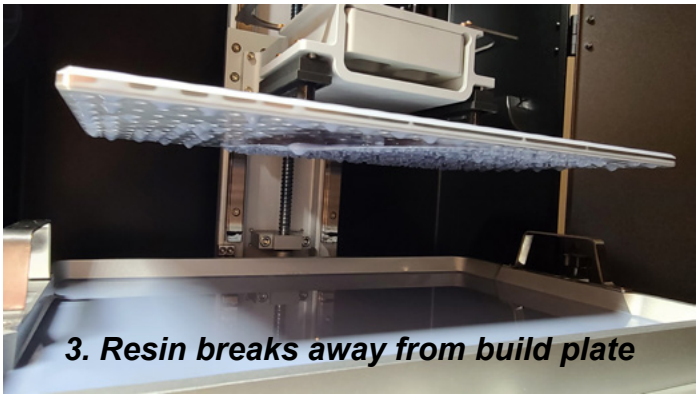
There isn't a computer doing it all for you. It is a tool and, like any tool, needs to be learned over long experience.



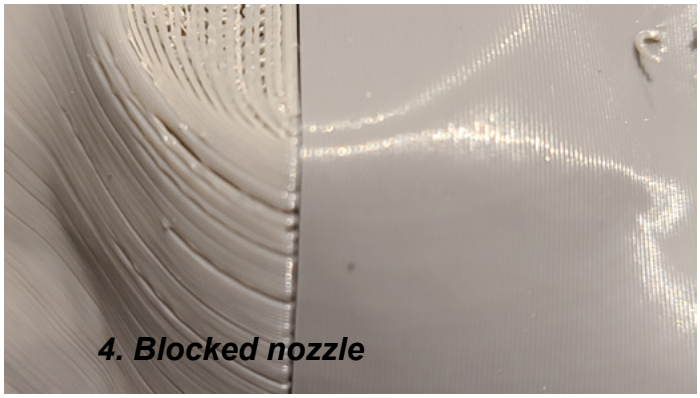
1. Supports not bonding to print



2. Supports not bonding to print

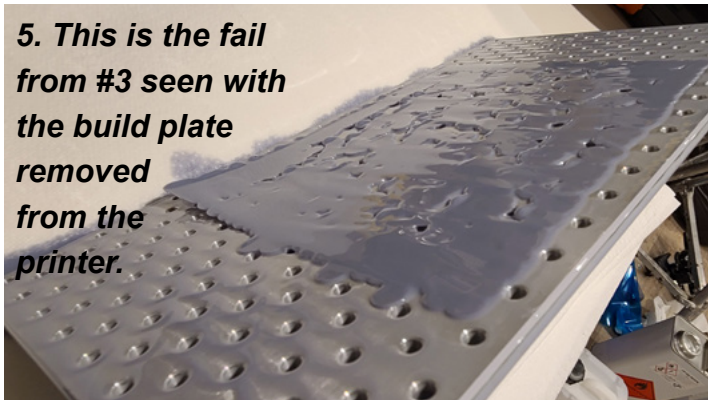


3. Resin breaks away from build plate



4. Blocked nozzle

There are many variables with 3D printers. Mechanical parts are being asked to operate repeatedly for hours and hours on end. Things wear, wobble and weaken over time and quality may deteriorate during a print as a result. Sometimes the failure is minor, and can be repaired. Sometimes it is catastrophic and means a do-over once you have figured out why it happened. ***That there is the trick - being a detective and trying to solve the riddle and make the necessary changes to get a good result!***



5. This is the fail from #3 seen with the build plate removed from the printer.

DIGITAL SCULPTING

Scanning acquires the shape of existing things and turns them into digital copies. Printing, by contrast, can produce real-life versions of digital items.

What sits between these two worlds is the ability to manipulate the form and shape in a digital space to create exactly what you want.

Many of the processes with materials can be achieved digitally, such as cleaning up 'life cast' scans and turning scan data into customised cores, perfectly oriented and complete with keys and undercuts removed.

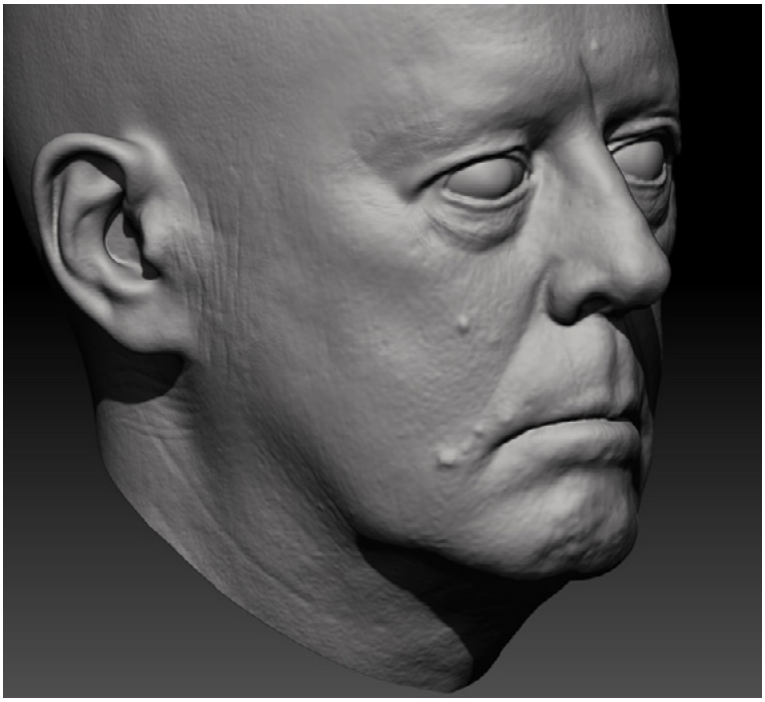
Once approved and signed off, these can be 3D printed, saving considerable time and materials and allowing a level of accuracy and examination not possible in the real world.

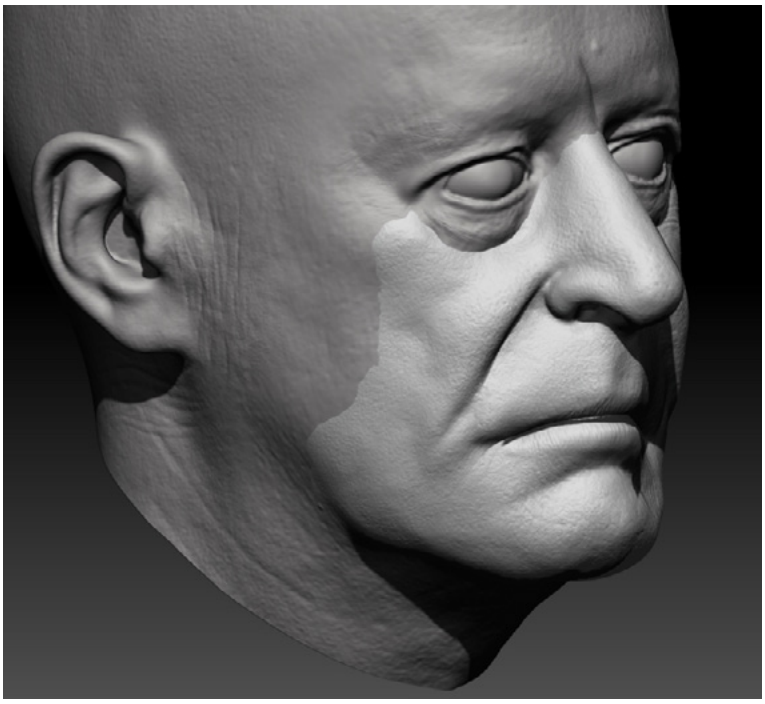
The ability to make something see-through, perfectly symmetrical, smooth and scaled to whatever size required gives a superpower to those in the workshop.

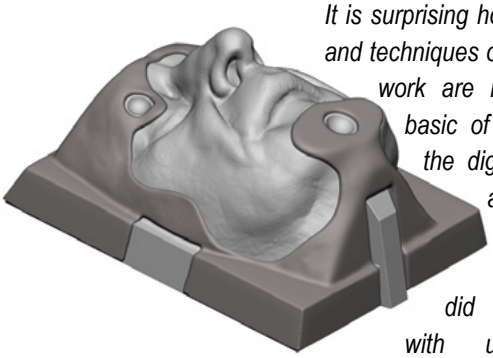
Combined with practical skills such as mould making and sculpting, working in digital 3D means you can decide which tools to use for the job, and very often, they are used in combination.

The most used sculpting programme is ZBrush, available through purchase or subscription. It is industry standard, well supported and maintained with a vast community of users, tutorials and help.

There are cheaper, stripped-down versions with reduced functionality for those starting out. ZBrush costs about £1000 a year.







It is surprising how transferable the skills and techniques of conventional appliance work are in digital versions. The basic of moulds still apply, and the digital tools give sculptors and mould makers a great set of tools to do what they always did but much faster and with unparalleled accuracy.

DIGITAL SCULPTING

Autodesk makes one called Mudbox, which is similar but not as widely adopted. It is far less expensive, but the smaller user community means less help is available.

The wider usage of ZBrush by industry means most people will opt for ZBrush to align with their target employers. Mudbox is about £300 for 3 years currently.

An alternative for the iPad is Nomad Sculpt, which is very similar in many ways to ZBrush, which is far cheaper and available for a low one-off charge. Nomad Sculpt costs a one-off charge of £15.

Many also use Blender, which is a free, open-source software which can be used to sculpt, render, and animate 3D models. Being free, it is widely adopted and has a vast community sharing tutorials, tips and advice.

Alongside sculpting, which typically is for creating organic shapes, it is often necessary to create more hard-edged or precise things. In this case, using a CAD (computer-aided design) program is helpful - there are plenty of free, browser-based programs, such as Tinkercad and Onshape. There is also FreeCAD and Fusion 360, which have free options with limited functionality.

Engineers typically used CAD in the past for the technical production of things most of us would never have access to. Now that 3D printing has blown that wide open, many more people are using CAD, and the previous business models of CAD app creators mean there are wildly differing prices, all based on the software's capability.

DIGITAL SCULPTING

If you are designing landing gear for an aircraft, understandably, the software would be massively sophisticated and be able to measure stresses and simulate the moving functions of motors etc. All that would come with a hefty price tag, and rightly so. If you are making a gizmo to hold your smart-phone on your desk, expecting people to fork out £250 a month is a bit steep.

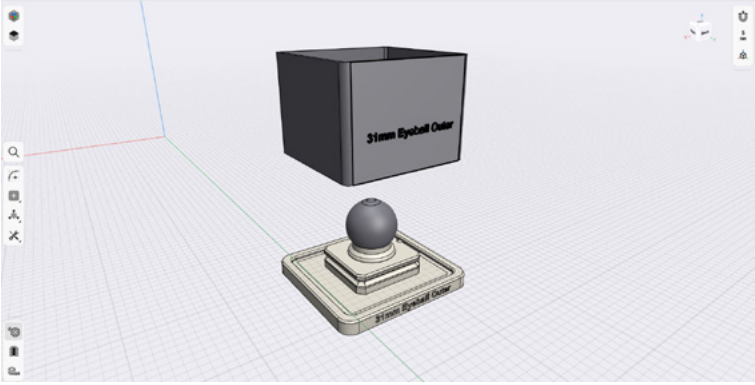
The recent explosion of 3D printing interest and the lower costs of printers now means there is a new interest in free and reasonably priced software, which will see the advent of good quality apps which don't cost the earth.

I like Shapr3D, which I use on iPad and desktop PC, which costs around £300 a year. It works well, and I regularly use it, so it is a justified cost. If you are dipping a toe, check out free browser-based apps such as TinkerCAD.

I have found that having even a basic knowledge of these tools means a whole other dimension of work is available to you. I have only really started using this in work over the last few years, and I have had many instances when the only way to achieve the objective was by digital means.

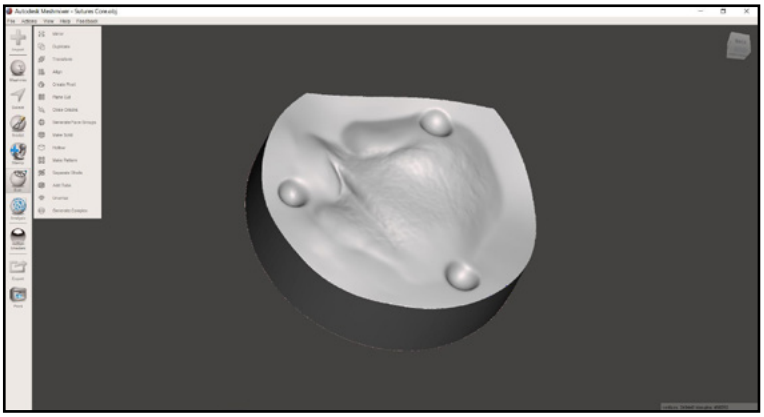
One last great free program is Meshmixer, also by Autocad. It has a lot of great tools which you would think other paid software would have, but strangely does not.

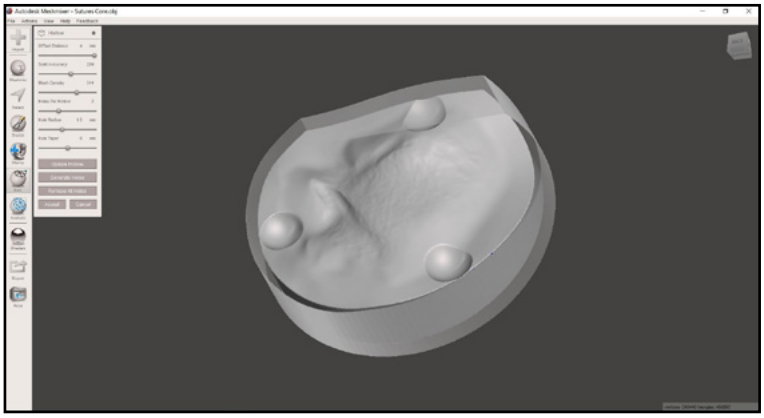
Meshmixer is great for simple but important jobs like making an object hollow, spotting problems with the mesh and fixing them, slicing clean lines and giving accurate scale information if you want to change the size and proportions.



CAD programs are surprisingly useful for hard edge stuff in the workshop. Objects can be output into ZBrush and modified further with all that ZBrush has to offer. This eyeball mould blank was made in Shapr3D before being 3D printed.

Meshmixer is a free 3D program from Autodesk and is very handy for quick edits. Often I will output something from ZBrush to make it hollow in Meshmixer and send it back to ZBrush to finish it, as the hollowing tool (seen below) is much easier to use than ZBrush.





A NOTE ON SOFTWARE

It may seem intimidating that there are so many 3D programs, but in many ways it is like a supermarket.

If you go into any decent sized supermarket, they could stock up to 40,000 different items under one roof.

I would guess your shopping cart has maybe 40 or 50 items, and the chances are you usually buy those same items again and again because that is what you need or like.

There are alternative versions of whatever it is you have, but likely you will simply go with your usual, familiar brand unless some reason to change occurs.

Maybe there is something new and exciting you want to try. Maybe your usual product is out of stock, or they have changed the ingredients or hiked the price suddenly, so you are motivated to try something new.

Whatever the reason, you typically ignore everything in that store that you are not looking for.

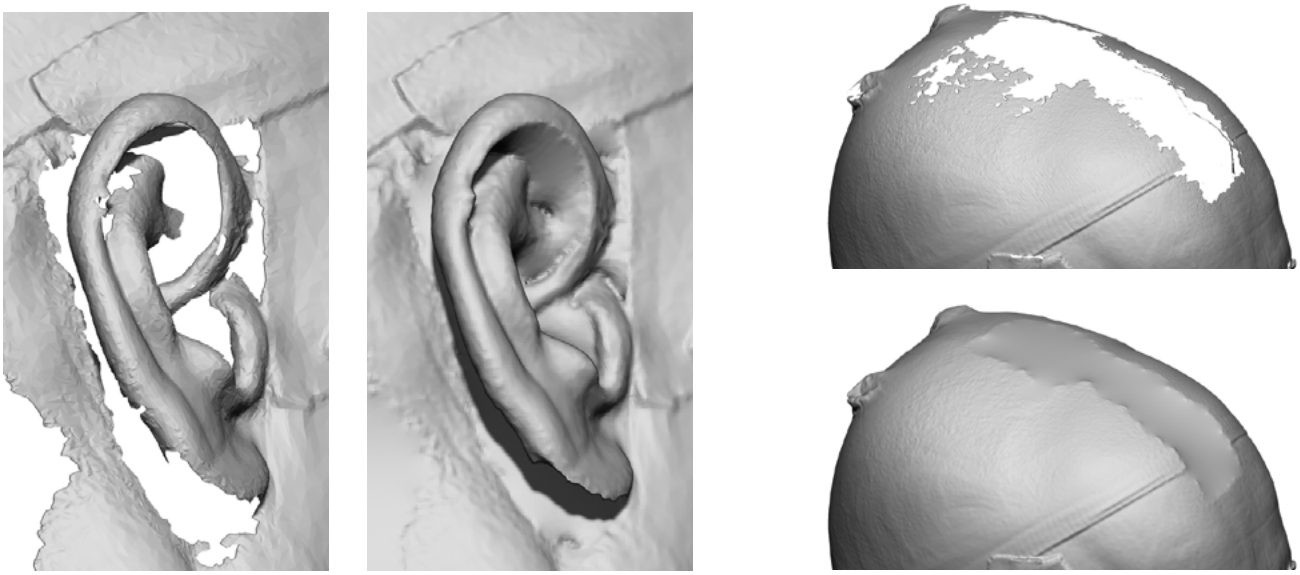
So it is with software. Really, it is the novelty of seeing unfamiliar things which feels scary, when in reality most people don't use more things than they need.

Because this is a relatively new use of computers, there isn't really a single piece of software than can do everything we need for prosthetics. As a result, we pick and choose from what is available, and typically have some which are used only for a specific job.

An example is the mighty ZBrush, with it's mesmerising and panic-inducing interface of menus can seem terrifying.

However, once you use it for the same ten things you always do over and over again, you can ignore everything else quite happily.

Over time you will find out new things about it bit by bit. When those discovery of those things happen, you will absorb them and welcome the new information as you gradually grow into it.

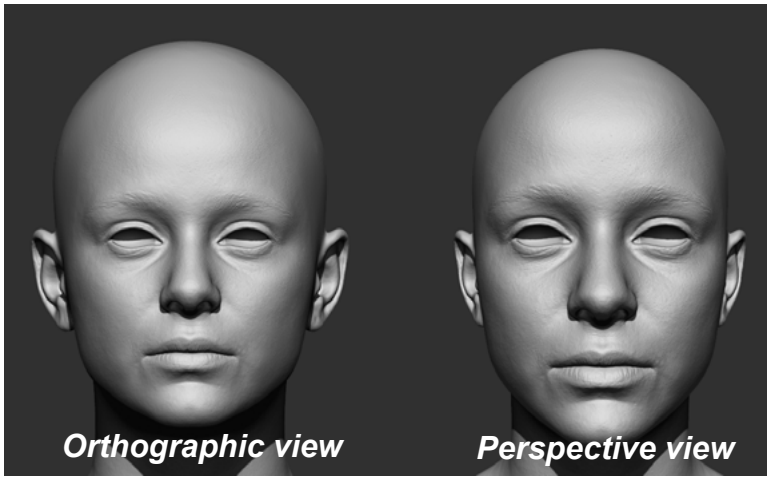


Some things are hard to understand if they are part of a world you have not been involved in. One example may be the missing areas of a scan, common behind ears or under a chin where the scanner didn't 'see' the surface. The resulting scan has gaps which can be filled in automatically by the software to make a single, 'watertight' shape or 'mesh'. It is a best guess though, and you can see the automated fill in these examples isn't anatomically correct. Therefore, an artists eye is still needed to make things right. Software can do some things, and as an artist you use them to work for you, making creative decisions and finalising the work. As you become familiar with what you can do, you will enjoy making software work for you.

DIGITAL SCULPTING

Sculpting on a cast in ZBrush is pretty straightforward once you become familiar with the tools and interface. There is a disconnect if you are familiar with purely tactile sculpting, so learning how to judge the sculpt requires a bit of practice.

One thing that is new when working in ZBrush is the ability to work in Orthographic and Perspective views, so you can see an undistorted view from all sides.



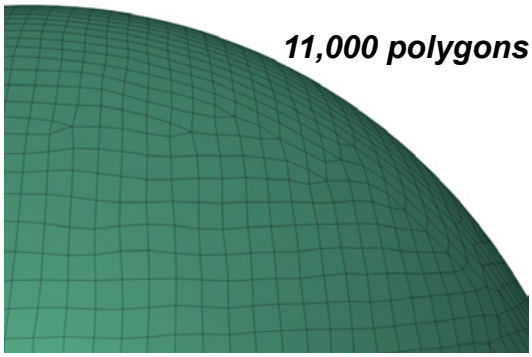
Three dimensional digital forms use geometry to build shapes which can be manipulated in real time. Programs like ZBrush feel like pulling around a block of digital clay. The lower the resolution the object, the easier it is to move around as it is asking less of your computers processor and graphics card. The fewer polygons it has to handle the easier it is on the machine.

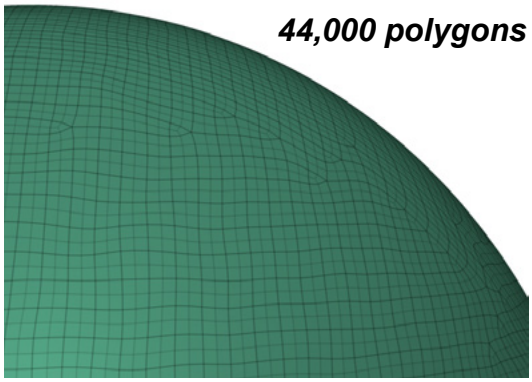
This is great for blocking out form, as you can't focus on details at these lower resolutions. Then, as you want to add secondary forms and details, you can increase the resolution of the model by dividing the polygons, so each one is cut into 4 more smaller polygons, whilst keeping the overall shape of the model.

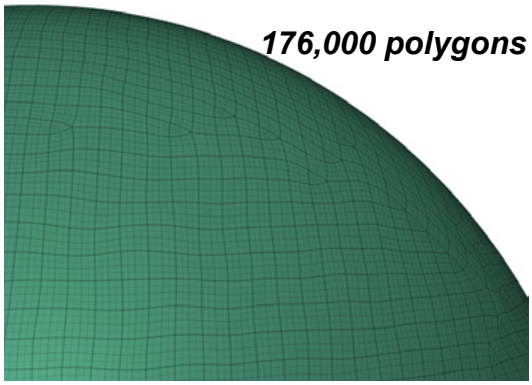
Looking to the right, you can see a basic sphere, created in ZBrush. The top image shows it a to a lower resolution, in this case 11,000 polygons.

If you 'subdivide' it splits each of those polygons into 4, making a total of 44,000 polygons in the same shape.

Subdividing again will now create 176,000 polygons. The denser the mesh, the more detail you can achieve on your sculpt. The trade off is you need a powerful computer to be able to handle the data, as each move of the brush will mean many thousands of polygons needed to be recomputed instantly so the image on the screen keeps up with your sculpt actions in real time.





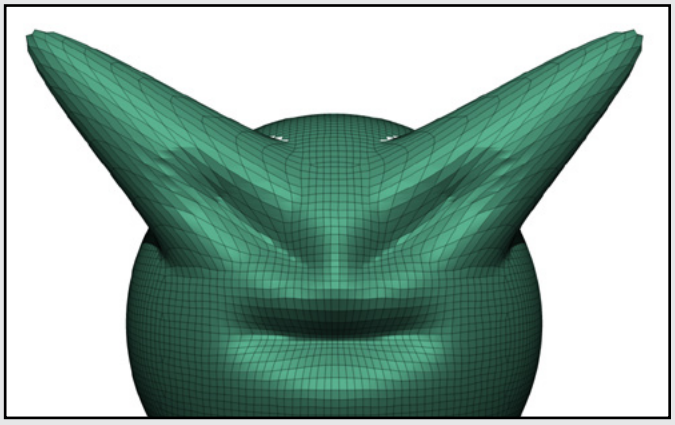


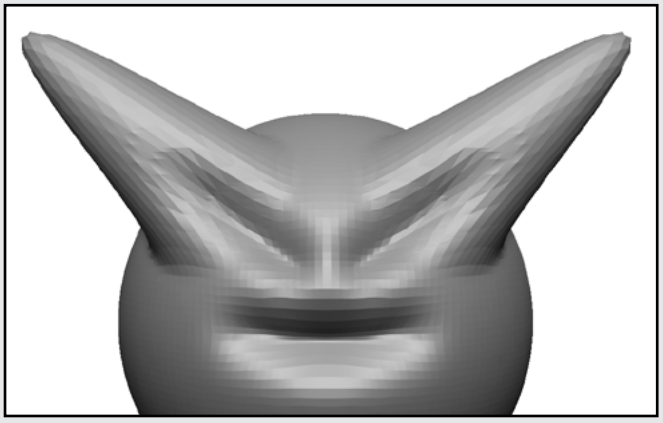
DIGITAL SCULPTING

The resolution of a 3D object is important to creating the shapes you want. Below, you can see the same sphere distorted by pulling out two horns and pressing in some lines with tools or 'brushes' in ZBrush.

On the left is the object with the wire-frame switched on so you can clearly see the polygons present. When sculpting in ZBrush, the polygons are pulled and pushed around, as you are basically moving a surface around like a fabric bag.

If you pull it too tight, the polygons there will stretch too far and become distorted, creating the faceted shape you see below. To pull the shape around more and have a smoother finish, you will need to increase the polygons - basically give it more geometry.

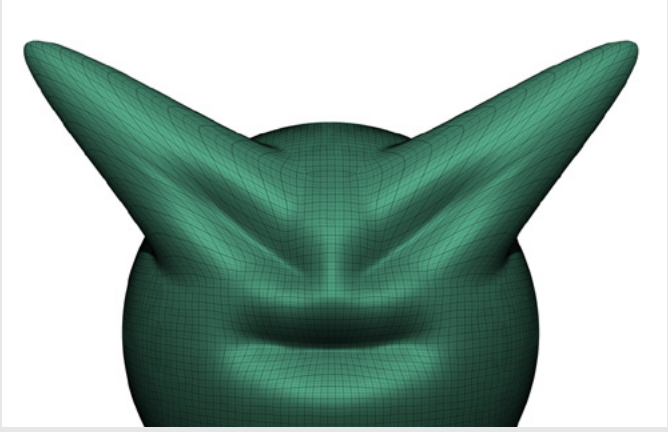




The same shapes below but with more geometry show a much smoother shape with less noticeable facets. Again, by having the same shape shown with and without the wire-frame on, you can clearly see how the geometry has been stretched out and distorted.

One great tool that ZBrush has is 'Dynamesh', which will rebuild the model so it keeps the same shape, but now it has evenly placed geometry, replacing stretched polygons with neat, evenly spaced polygons.

You can see that there is a whole set of considerations when handling 3D data, and it isn't always obvious or intuitive at first. As you become familiar with the way geometry is handled in the software, you begin to think about it more naturally.



DIGITAL SCULPTING

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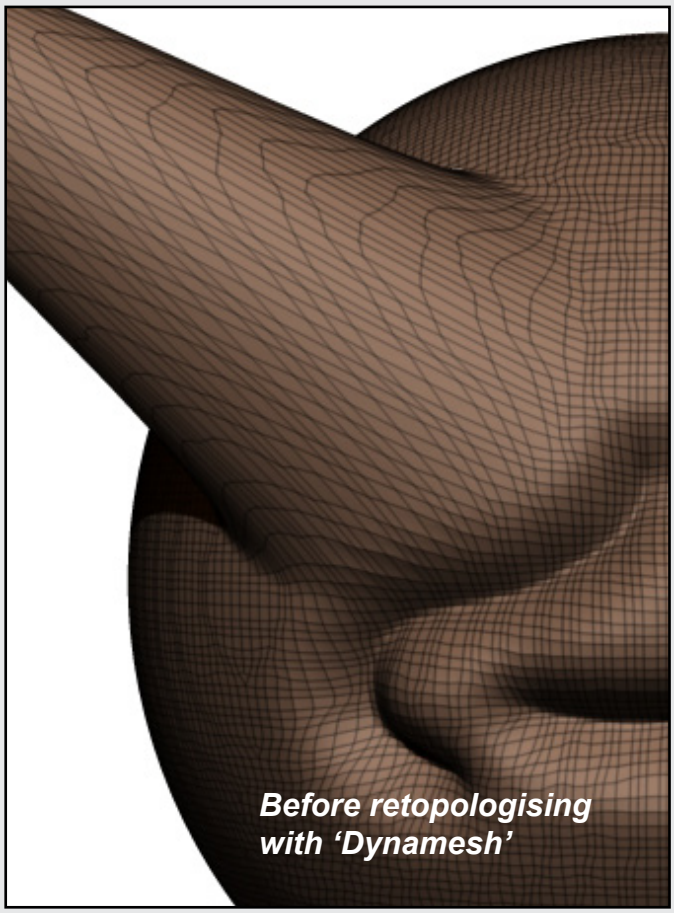
On the left is the object with the wire-frame switched on so you can clearly see the polygons present. When sculpting in ZBrush, the polygons are pulled and pushed around, as you are basically moving a surface around like a fabric bag.

If you pull it too tight, the polygons there will stretch too far, just like the holes of a knitted jumper, and become distorted, creating the faceted shape you see below.

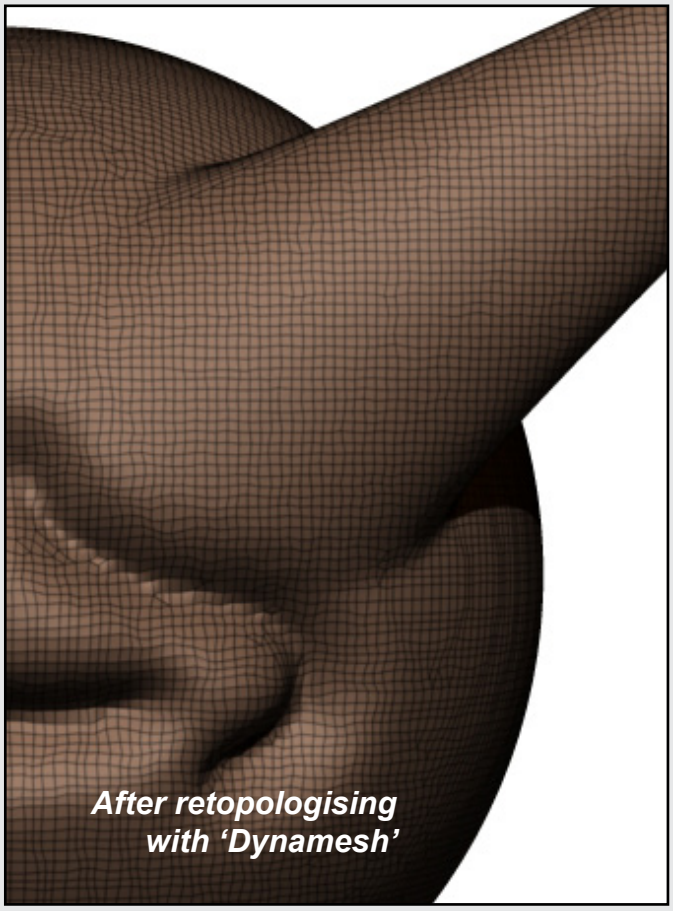
To pull the shape around more and have a smoother finish, you will need to increase the polygons - basically give it more geometry. In ZBrush, there is a tool called Dynamesh which rebuilds the surface with evenly spaced geometry, as you see on the right.

In *Nomad Sculpt*, they have something called Voxel Remesh which does the same thing, and most sculpting programs will have something similar. This is what is interesting, regardless of the program.

The way geometry is handled is largely similar owing to the way computers handle information. In the case of 3D information, it can be quite complex and processor-heavy.



Before retopologising with 'Dynamesh'



After retopologising with 'Dynamesh'

DIGITAL MOULD MAKING

As well as sculpting, 3D digital tools can be used to help make moulds. This could be to help design a mould which will be made using traditional techniques, or to completely create a mould (or a part of a mould) using 3D printed objects.

Complex moulds such as collapsible cores or multi piece moulds can be very complicated, so the chance to do dry runs digitally to check if something will work is a great benefit.

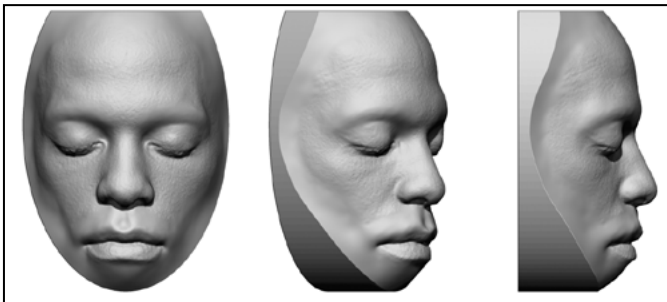
A clay sculpture could be quickly scanned and sent to the other side of the world for a mould maker to design the best method for where the dividing lines of a mould may be, for example.

Perhaps the jacket for a matrix/silicone & jacket mould could have the jacket 3D printed and then reinforced on the outside with layers of fibreglass to add strength.

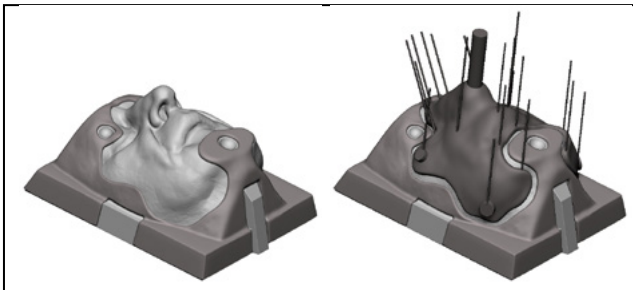
All of the jacket pieces could be being printed simultaneously and before the sculpt was finished. By scanning the blocked out shape, the sculptor could detail the clay, and the finished jacket be assembled around it as soon as they are finished and pour up the silicone.

Making cores digitally is fantastic as you can get precise, clean sides and keys, and check for undercuts using the orthographic view. This all requires you to know mould making FIRST, however. All those material skills and practical abilities are very useful for digital sculpting and moulding.

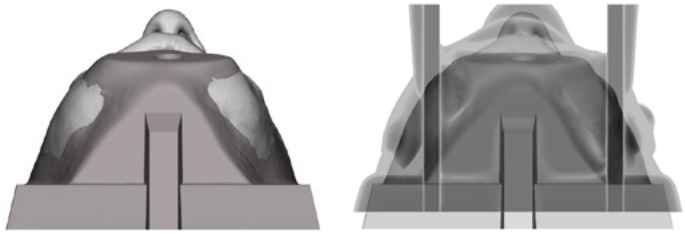
Remember, the computer is just a tool, and the craft comes from how that tool is used.



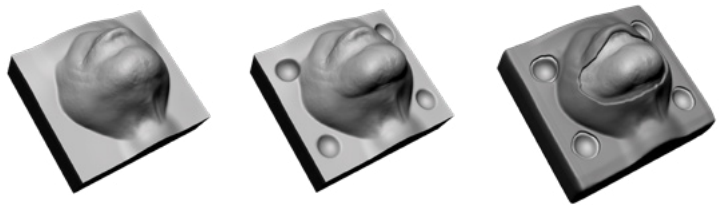
This core was created from a scan using the Revopoint Pop2 scanner.



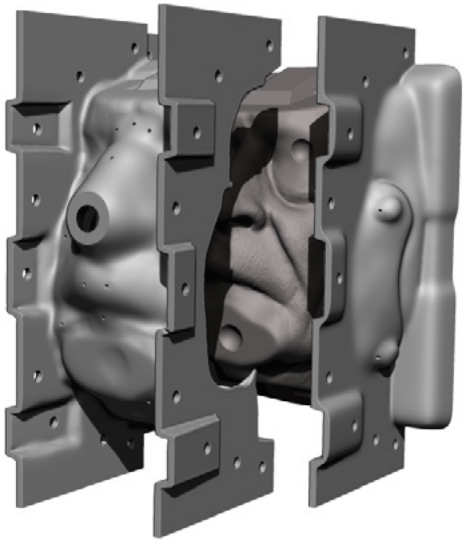
A silicone jacket designed in ZBrush over a sculpt. The thickness is even, the undercuts removed and air vent placements all created digitally for printing.



A core and sculpt with the mould jacket built around it, all digitally to be printed.

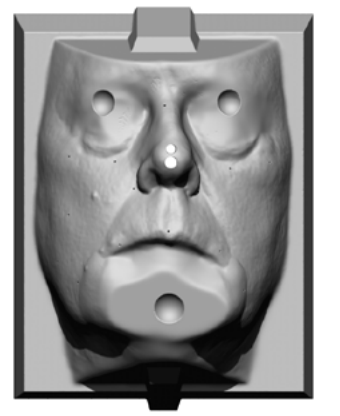


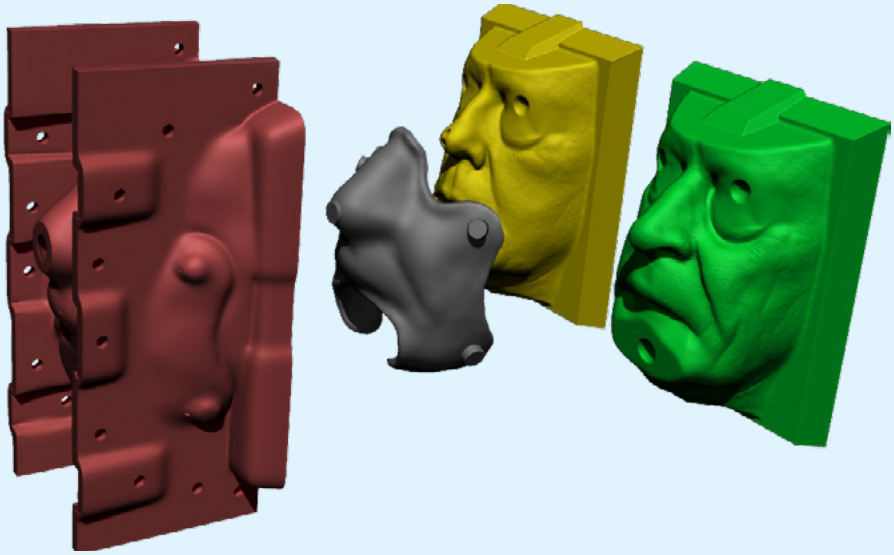
A chin from a head scan correctly oriented, extended for keys and flashing.



A multi-piece jacket for 3D printing designed over the sculpt and core. All pieces can be printed at the same time.

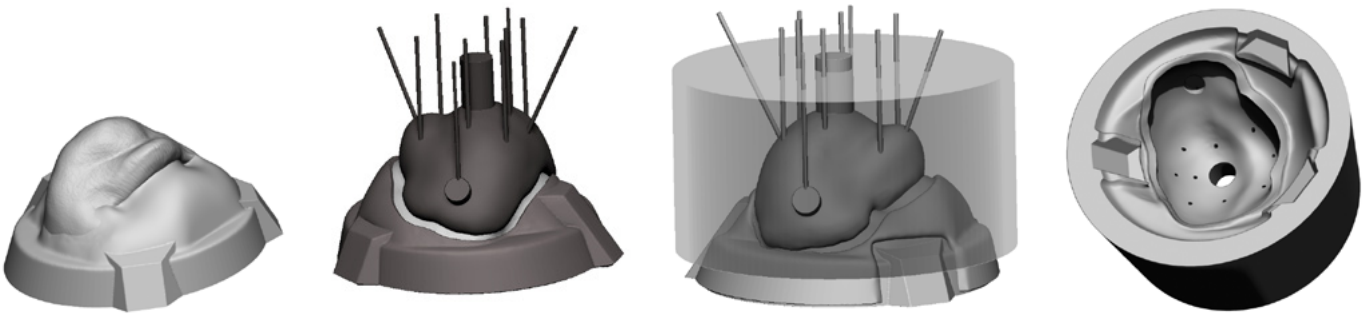
DIGITAL MOULD MAKING



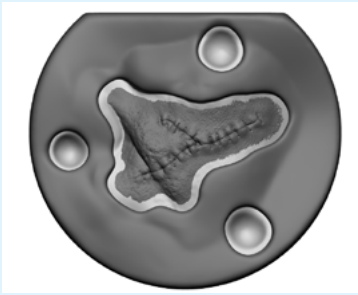



For the presentation, a number of pieces were made especially to demonstrate the kinds of things digital work is already being used for in some workshops. It is designed to showcase the benefits to current practical effects artists.

This sequence of images shows the sculpt and cores for the upper part of the face. This was all sculpted and created on ZBrush on a scan of Todd's head. The colours are used to help identify the pieces when describing - the green is the sculpt, the yellow the core, for example.



Above you can see the chin appliance from sculpt, silicone jacket with vents, and finally the mould jacket in place.

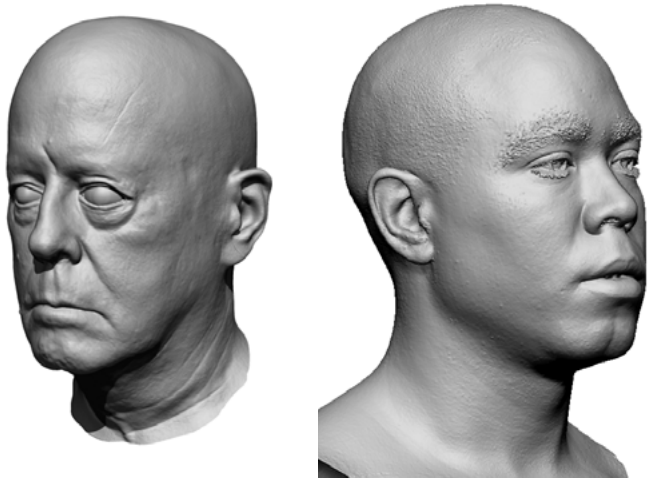

The suture appliance sculpt on the head, then isolated on the core and the printed mould.

MANUFACTURING PIECES - AN APPROXIMATE WORK-FLOW

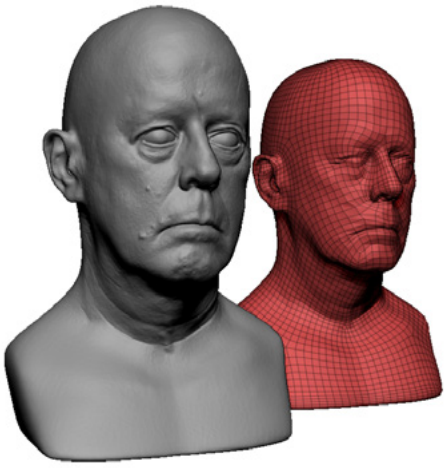
I was recently asked 'How does a printer that makes hard objects create soft, silicone appliances?' Which is a good question.

Here, then, is a rough description of the step by step process I used with my current setup. This is likely to change as I adopt new practices, materials and kit.

1. Start with a clean scan.
In this case, Todd sent me his head scan already cleaned and ready. Scans often need a clean-up, just like a life casts as artefacts are collected in the scanning process which are side effects of hair management, missing scanned areas or fills made during the 'watertight' process created in the scanning software.

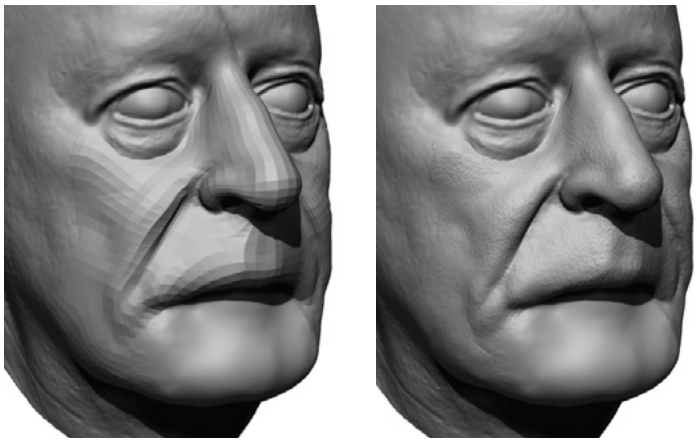


2. Duplicate scan sub-tool.
Work on pulling out face to create appliance. This is where ZBrush sculpting is unlike regular sculpting, and I think this alone is the main difference and obstacle to overcome. ZBrush sculpting is more like pulling and pushing a surface as opposed to adding blobs or carving back as with clay.



3. Sculpt.
As with any sculpt, starting requires primary form, blocking out the general mass in the right places. This is quick to do in ZBrush, and having a low resolution mesh means no detail can be added, helping to focus on the form.

Use reference, I really like having a 3D head as reference if there is such a thing, just as one uses photos. I also like ref images in books or screen and use these to inform the sculpt just as wit clay - the process of interpreting real shapes and applying them to an object you are making is the sculpting state I enjoy so much - you can feel the action as a conduit.



MANUFACTURING PIECES - AN APPROXIMATE WORK-FLOW

4. Refine & Texture sculpt.
Using various brushes and alphas, show how quickly skin texture can be applied.

5. Make cores.
This means forming the scan into a usable core shape. It is crucial to point out the sculpt is a separate sub-tool and undamaged or modified in any way during this process. I start by orienting the subtools together to the best angle. This is so easy to do in ZBrush.

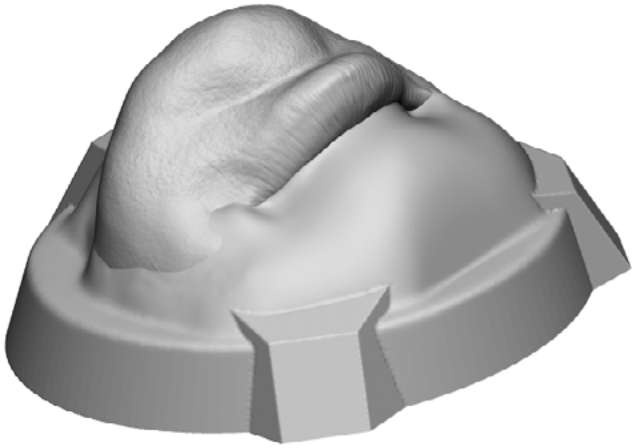
Then cut away excess using KnifeRect or KnifeCurve. Then set in a new subtool or cube/cylinder and reshape to create undercut-free base and fill/carve/tweak scan so it provides a smooth core surface wherever the sculpt is not.

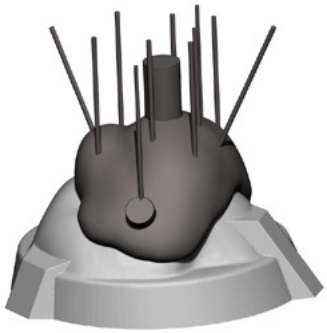
Add keys and dynamesh the whole thing so it is now a finish core with the untouched sculpt subtool sat atop. Have this as an object on the bench.

6. Create silicone insert, vents, cutting edge and overflow. Currently, I do this with masking and extract. You can use Polypaint to mark out where you intend to make extract, and then 'mask by polypaint', especially if it is a complicated shape which may take a long time (masking is easy to do but you can't save a mask midway through).

7. Make Jacket.
Create Boolean of core with sculpt and flashing in place. Use this to create the rigid jacket which can be FDM printed.

This will be used to make the silicone negative mould. Save this as a separate subtool. This will be output as a print, so export as STL/OBJ/3DM.





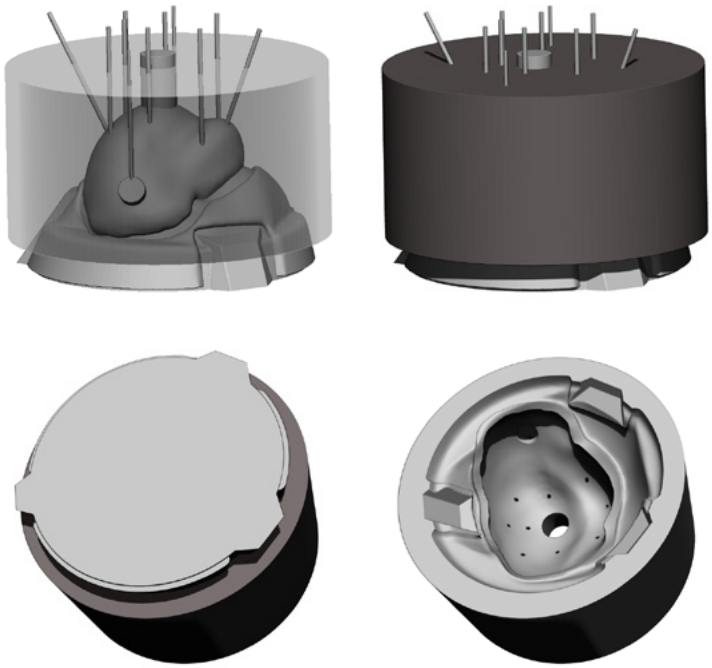
MANUFACTURING PIECES - AN APPROXIMATE WORK-FLOW

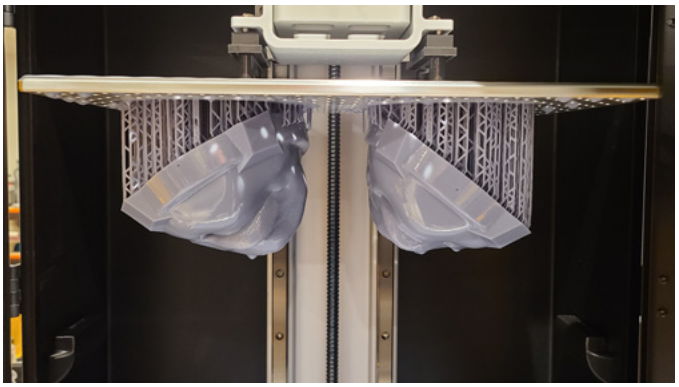
8. Create jacket
Mask out section on core which has the sculpt and flashing baked in. Extract. Add pour tube and any bleed vents at this stage.

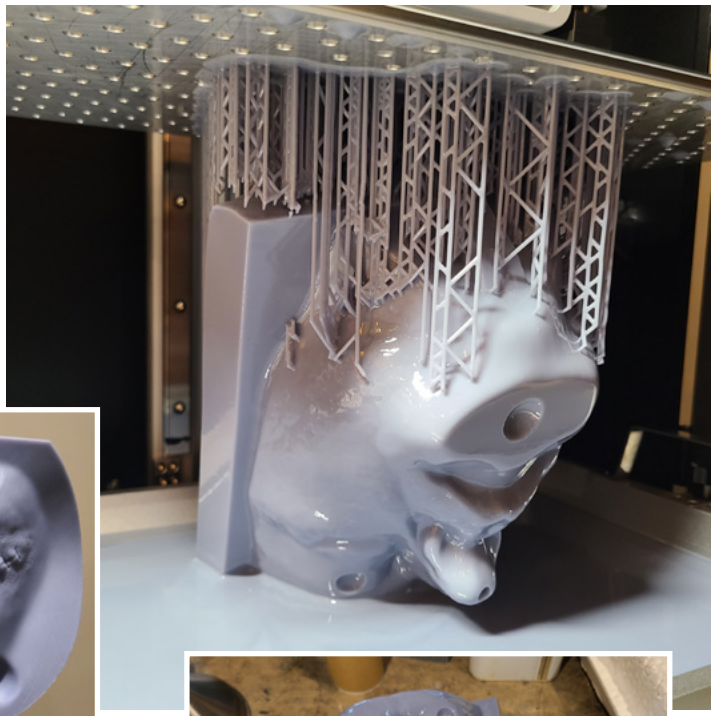
Boolean that so now we have a complete model subtool of this whole shape. Mask/extract this to create jacket or as I did, sink a block subtool on there and subtract the core. This creates a block shape which sits nicely on a bench and doesn't wobble etc.

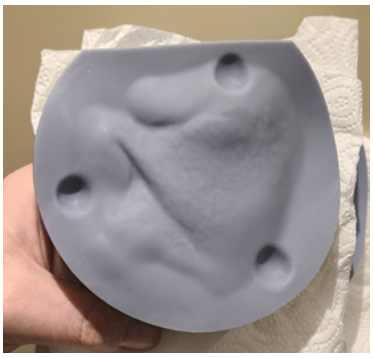
9. Print cores and mould jackets
Clean and prepare finished prints. Use release agents and Inhibit X to reduce inhibition.

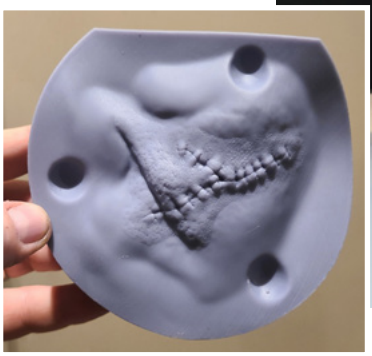
Pour up any silicone inserts and run appliances as required.

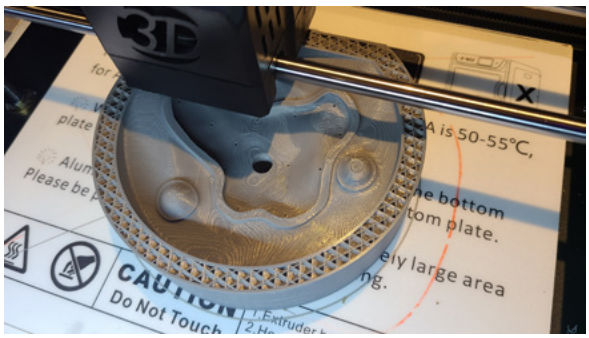


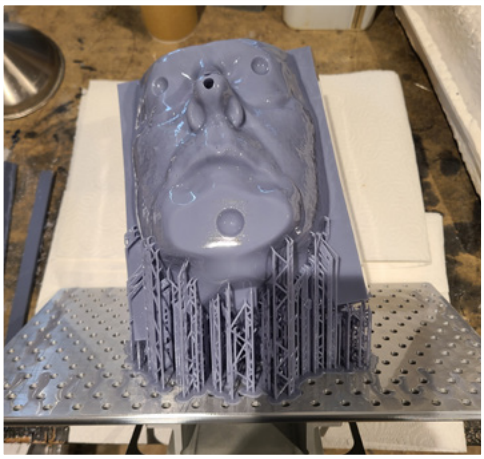








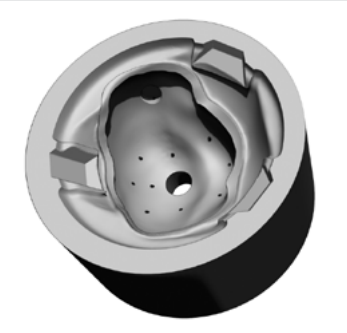




MANUFACTURING PIECES - AN APPROXIMATE WORK-FLOW

1. The chin core has thickened platinum silicone (Zhermack HT24 for the curious) as a seal around the gap created by the overflow.

2. Once the silicone has set, the mould is inverted and grey pigmented silicone is poured into the large opening made in the jacket. The silicone fills the cavity, and air can escape through the vent holes.



3. Next morning, the silicone is checked and excess lifted and snipped off with scissors.

4. The mould is opened and we have a silicone insert which is a perfect mould of the chin sculpt print.

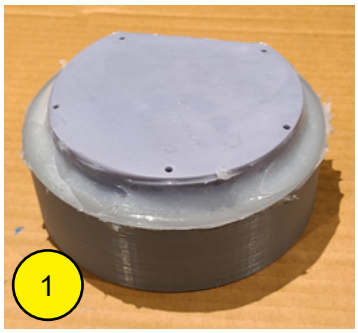
5. You can see the silicone inert before the excess is trimmed away. A fair bit slipped out the side so the edge is a little thick, but it should work reasonable well regardless.

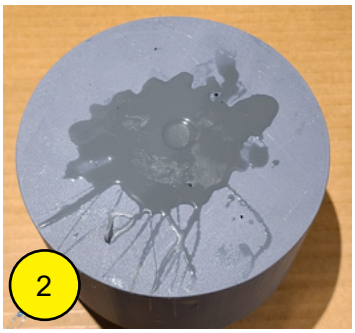
This thickness is because I did not clamp the mould during the pour, and was suspected.

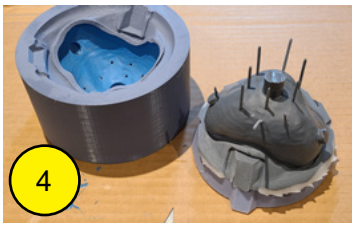
6. Here you can see the back of the face core, complete with pour tube socket visible, and the two holes which will allow the silicone to get inside the mould to run the appliance.

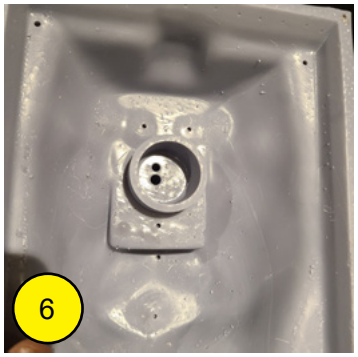
7. The 35mm pour tube in place - it is a perfect fit so should hold the tube snugly during use, prevent leaks and be easy to pull out and reuse.

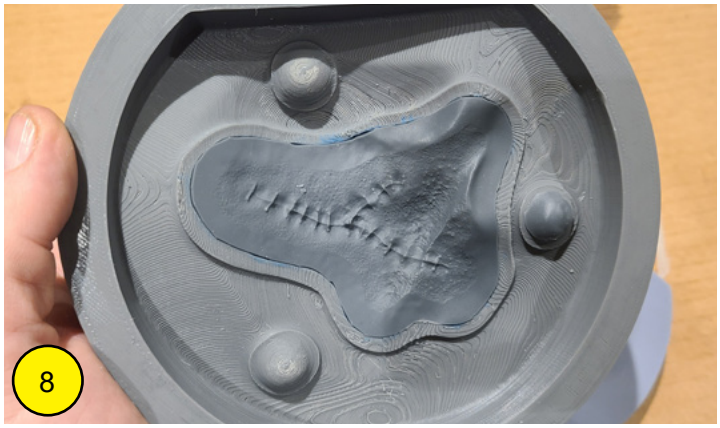
8. Close-up of the suture appliance mould - an FDM printed jacket with a silicone insert that captures the high level of detail created in the resin print of the core with sculpt in place.











CONCLUSIONS

Print materials are optimised for the act of printing rather than for any specific task required of the finished part.

Therefore there is no reason for any printed part to be guaranteed fit for purpose. I can model and print a coat hook, but in an attempt to speed up print times or economise on materials I may decide to make it thinner, hollowed with 10% infill and angle it so fewer supports are needed.

Then when fitting this hook to a door, either the screws used to attach it to the wall could break it or a reasonably heavy coat could bend and snap it straight away.

Just because I can make a shape digitally and render it's form in physical reality doesn't mean it will be fit for purpose. Now it has manifest itself in the real world, forces and demands are made of it which it will either succeed at or fail.

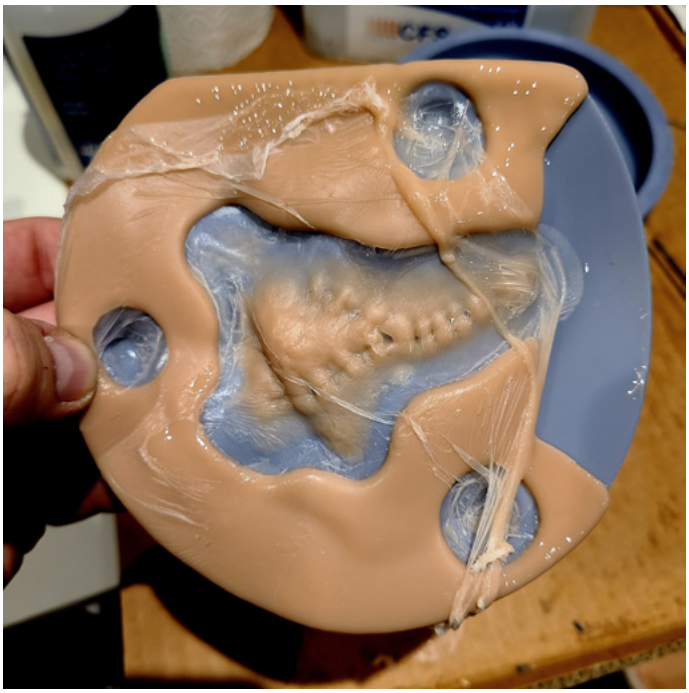
Moulds can have great stresses placed upon them during use, particularly during closure and opening where large amounts of pressure from clamps, straps or bolts will squeeze things together. This can cause distortions at best or permanently damage the mould at worst.

During opening, leverage from screwdrivers can place lots of pressure on single spots in the mould, testing its integrity and perhaps cause damage as the fulcrum point chips or is crushed.

This can be mitigated by good mould design and considerations, as well as using strong materials. In the past the strength of materials has been a huge factor in a moulds success.

With 3D printed moulds, whilst it can be safely assumed that over time better materials will come along, in the interim it is clear that many of the currently available materials must be used wisely to include their limitations.

For example, ensuring a mould has no undercuts, is made in more pieces or employs a silicone insert, or is remoulded in a stronger material better for the job.



The cheek suture piece was horribly inhibited, and failed utterly. The cap plastic is peeling back because the silicone isn't set where it is in contact with the mould surfaces. The bulk of the silicone has set to become a solid, but the surfaces are just a sticky mess.

The chin piece wasn't inhibited, but the method of closure with the clamp meant over-tightening and consequently a touch-down where the core was pushed sufficiently to meet up with the mould surface. This isn't an issue with typical moulds made from a solid resin, but is something a more flexible material such as thinner printed pieces.

CONCLUSIONS

Making these choices means awareness of traditional materials and techniques as well as the new. We'll need to keep an eye on developments and test out new materials and techniques as better solutions are discovered.

Like open source software, we will keep updating with the latest ideas and those ideas will come from people like you who will find things out and hopefully share it with others. Feed and be fed.

With these moulds, I had lots of inhibition from the resins. Some more that others but largely enough to be a problem.

At the time of writing, there seems to be a regular pattern of helpful suggestions from other users. Many suggest washing prints in a caustic soda mixture. Others suggest washing and soaking in water, as well as curing underwater.

Some suggest adding a protective layer of spray paint, lacquer or resin which will act a barrier. Once site suggested melting perspex in acetone and dipping printed pieces into that in order to apply a protective coat.

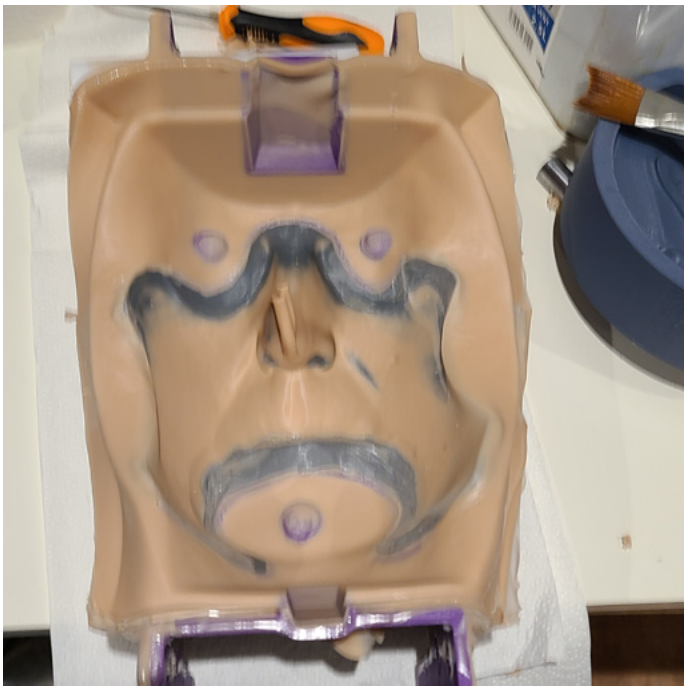
Some suggest a better resin which happens to not inhibit, or if it does so, it happens for less. A good dose of Inhibit X will stop it or adding that too the silicone itself or even airbrushing Inhibit X onto the cap plastic before closing the mould.

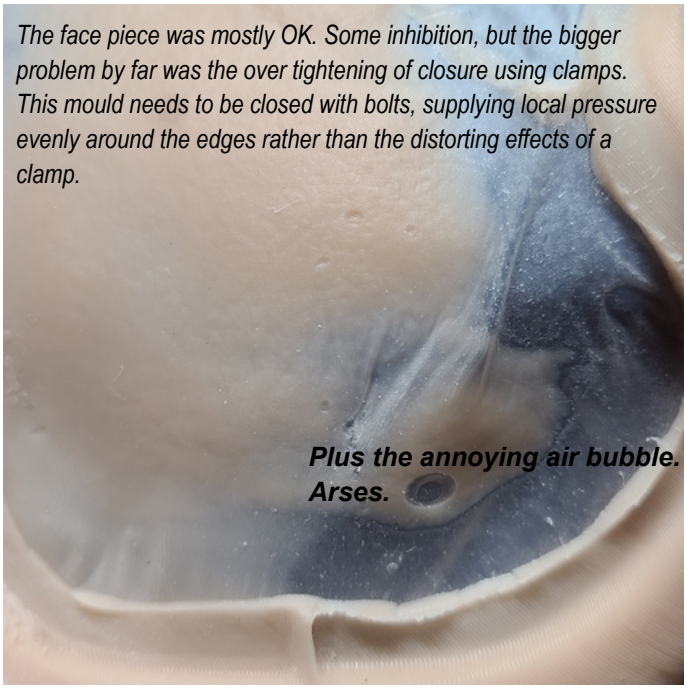
All these are great ideas and could help, but I'd have to try these myself to know and its a lot of work which takes time and effort to do.

Sadly, I hadn't time before today to do all these, so the results of my pieces are not perfect. I figured that could happen.

I will get there. I know what works traditionally because that's what I'd normally do. However, things are developing in a way that staying in one place while everything around you is moving isn't going to work.

If waters rise, better to learn how to swim or at least how to float. Waters then create currents which you can learn to sail upon.





The face piece was mostly OK. Some inhibition, but the bigger problem by far was the over tightening of closure using clamps. This mould needs to be closed with bolts, supplying local pressure evenly around the edges rather than the distorting effects of a clamp.

CONCLUSIONS

I think that is where we are at now. I'm still learning how to navigate while falling overboard, but it's been exciting and I enjoy learning more every day.

I fully expect trade specific materials will come along as manufacturers seek to satisfy their customer demands. That then requires people like us to have demands. We'd need to do what we can to make these materials work for us, and then materials will be required in sufficient quantities for it to be worthwhile to suppliers to make those materials.

In the mean time, what moves this forward is competent users making demands of the material and processes.

We make this technology work for us, not the other way around. The traditional materials we use are still here. You won't need to know all of it but be aware of it and see what interests you and what affects your work flow.

This new stuff is in addition to, not instead of. Therefore it is wise to learn the language of it so you can take part in the conversation and contribute to it.

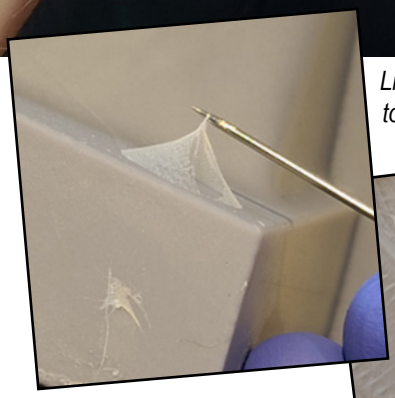
Like learning any skill or language, there is an initial steep curve, but then that information is sufficiently a part of you that you no longer notice that you are using it.

Instead, you now focus on the outcome you are trying to achieve instead of the actual mechanism of how that is to be done. The more you do it, the more natural it becomes.

Like talking. You once couldn't. You had to learn, and now it's so common it probably never crosses your mind that there was a time you could not articulate yourself in order to get information across to someone else.

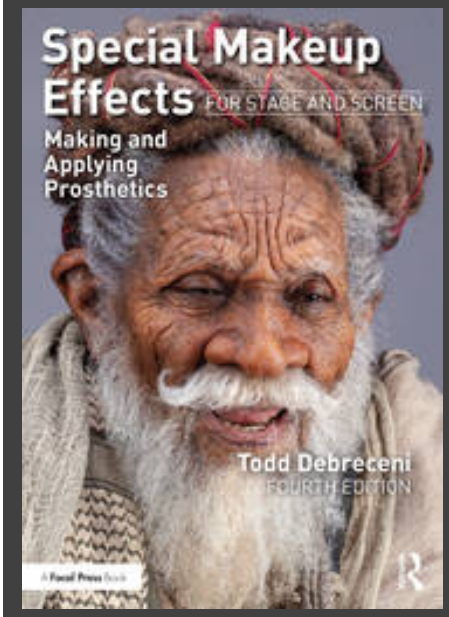
Digital is a language, and I urge you to learn it in whatever way you can. You will enjoy the conversations and where they will take you.

The face mould works well in principal, but needs redesigning to be closed by bolts instead of clamps. Having the jacket in 3 parts isn't strictly necessary, but makes demoulding much easier so is worth doing - I will keep that. I don't think I need the button like keys either - so onwards with version 2 as soon as I can.



Lift the cap plastic with a pin to check it lifts away easily.

The cap plastic worked well applied with an airbrush. This means the acetone evaporates almost instantly and will not have time to engage and mess with the mould surface.



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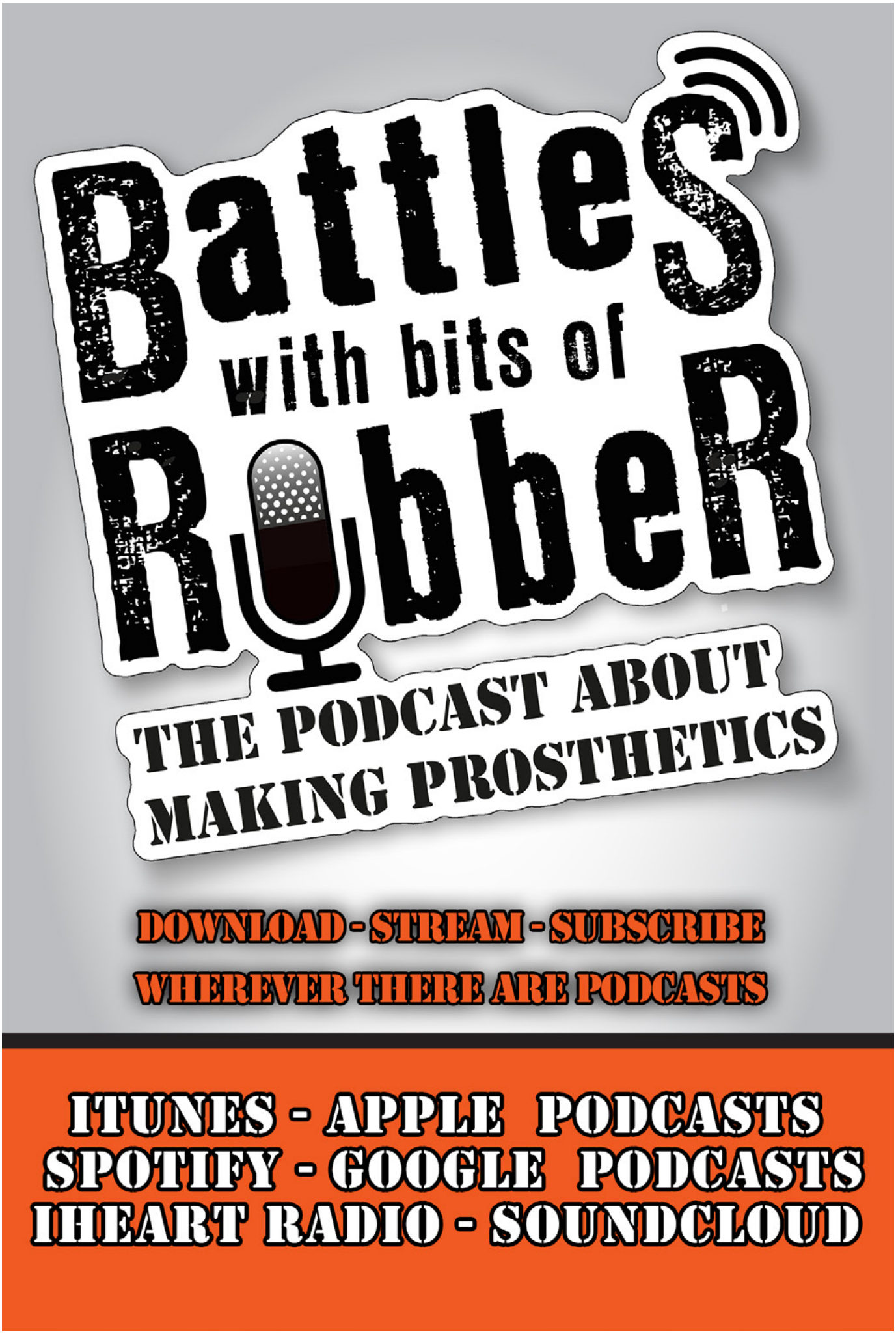
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