

3D Printing in Dentistry

by Andrew Dawood,
BDS MRD RCS MSc



Andrew Dawood, co-founder of Dawood & Tanner, Digits2widgets and Cavendish Imaging, presents four projects demonstrating the varied uses of 3D printing in dental and facial treatments

Case 1

Advanced implant reconstruction for a patient missing half of her upper jaw and all her teeth (Fig. 1-4).

A 3D-printed replica of the jaw gives the surgeon a feel for the surgical demands of the situation. In this case, the patient is missing one side of her upper jaw and all the teeth and supporting bone. A resin model has been used to rehearse innovative surgery, and a white nylon model was sterilised and taken to surgery to help guide the surgeon in the course of an innovative implant procedure.

This patient lost half her upper jaw because of cancer. Because of the loss of a great deal of bony structure, and the type and thickness of soft tissue that was grafted into place to fill the resulting cavity, using ordinary dental implants to replace the missing teeth or support a prosthesis was possible. The patient was unable to open her mouth fully after surgery and radiation treatment complicated treatment still further.

My approach was to image the remaining structure with a CT scan and to plan implant positions in implant planning software (Fig. 1). Although software simulation is useful, it does not offer the same tangible and intuitive feel as a 3D printed model.

The 3D printed model allowed the left half jaw, cheekbone, and both eye sockets to be 'handled',

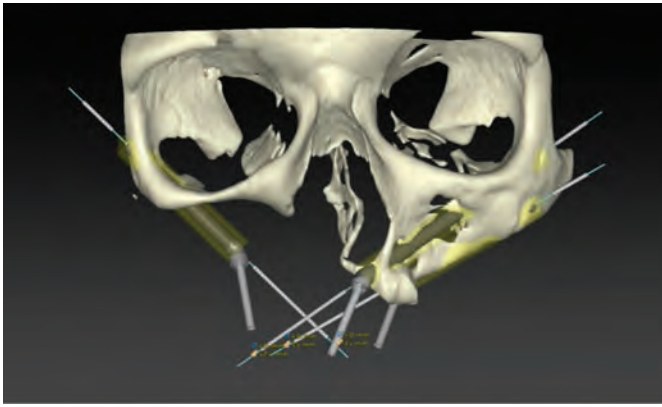


Fig. 1 — Planning in software

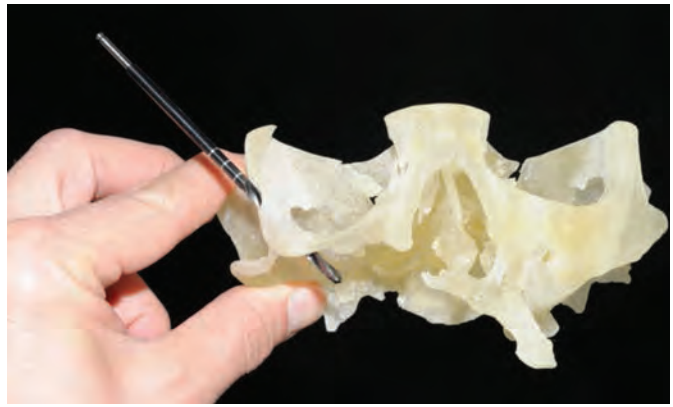


Fig. 2 — Physical planning with 3D printed model



Fig. 3 — 3D milled titanium bar fitted to implant



Fig. 4a — Final smile post-op



Fig. 4b — Prosthesis in place

implant, only conceived and implemented with the help of 3D printing - the procedure was tried out by actually 'operating' on a resin model before surgery. Figures 4a and 4b show the result.

Implant design and surgery: Dr Andrew Dawood
 Prosthetic reconstruction: Dr Susan Tanner
 Facial surgery: Mr. Jonathan Collier and Mr. Simon Eccles, Chelsea and Westminster Hospital
 3D modelling: Dr Veronique Sauret, Cavendish Imaging.

Case 2

Computer-guided replacement of upper teeth in 30 minutes with a 3D printed template (Fig. 5-7).

Implant planning software (Nobel Clinician) is used to plan the position of dental implants for a patient missing all his teeth. To transfer this virtual planning information to the patient, a drilling template is designed, and 3D printed.

This 3D-printed drilling template acts as an interface between the virtual and the physical, transferring the virtual plan to the patient's mouth.

This planning also enables a physical model of the jaw

and for different approaches to surgery to be trialled and other novel options to be considered (Fig. 2).

On the left side of the jaw, two special 'zygomatic' implants were placed into the cheekbone. These are a type of dental implant used to anchor implant bridgework for people who have lost all their teeth and have little remaining jawbone.

For the right side, a new, specially designed custom 3D milled implant was fabricated, which could be inserted backwards into the rim of the eye socket, through a small existing scar. I believe this is the first ever use of a 'reverse'



Fig. 5 — 3D printed drill guide



Figs. 6 — Pre-prepared 3D milled titanium/resin prosthesis



Fig. 7 — Implants and prosthesis in place



Fig. 8 — At time of injury



Fig. 9 — 3D printing for planning



Fig. 10a



Fig. 10b

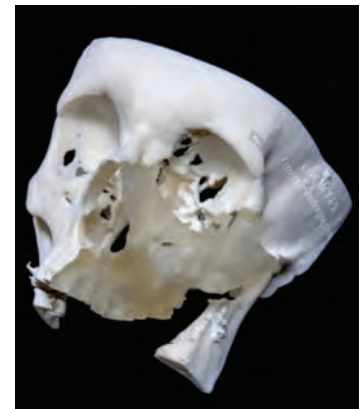


Fig. 11 — 3D printing to understand the defect

Fig. 10a - 10b — 3D milled titanium prostheses in place

to be made with implants in place before surgery actually takes place - and this means that the patient's bridgework can be completed before surgery and fitted immediately upon completion.

Treatment that used to take months can be completed in minutes!

- Planning and dental implant surgery: Dr. Andrew Dawood and Dr Susan Tanner.

Case 3

A new jaw, dental implants and replacement teeth following a shotgun injury to the face (Fig. 8-10).

This patient received a dramatic shotgun injury to his jaw during a robbery in Nigeria, and was airlifted to London (Fig. 8).

Three-dimensional printing allowed a replica of his jaws to be produced before surgery. The position of a vascularised bone graft to be taken from his shoulder blade was planned using the 3D model.

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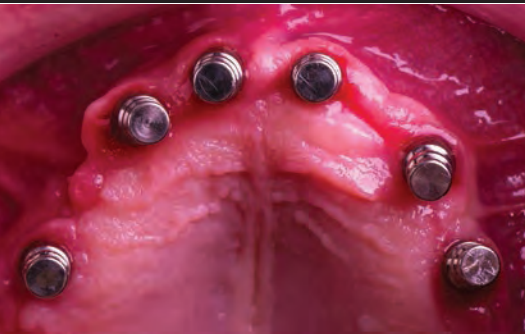
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Dr. Allen Aptekar, B.Sc., DMD

Dr. Allen Aptekar studied at the University of Toronto, earning his Bachelor of Science degree in Biology. He received his Doctor of Dental Medicine degree with distinction at the University Of Saskatchewan College Of Dentistry. Dr. Aptekar complete a hospital residency at Sunnybrook Health Sciences Center and the University of Toronto. He is a Board Certified Diplomate with the American Board of Oral Implantology and a diplomate of the ICOI. He is also a Fellow of the American Academy of Implant Dentistry. Dr. Aptekar is the editor in chief of the Spectrum Implants. He has authored and co-authored several articles in refereed professional dental journals. Dr. Aptekar is involved in lecturing on implant related topics to both dentists and denturists. He practices in the greater Toronto area, where he limits his practice to surgery, with a focus on the surgical and restorative phases of dental implantology and bone augmentation.



David Istzer, DD

David Istzer, DD, has over 10 years of experience and has developed a reputation for creating high quality, aesthetic solution in the field of Dentures. Specializing in both removable and fixed Dentures including "All on 4 Permanent Teeth in a Day". David strongly believes that his personalized one on one service and a proper treatment planning is the key to his patient's success.



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The position of replacement teeth was also planned, and a fixation plate prepared, all prior to surgery (Fig. 9).

The patient received, to my knowledge the first immediate jaw reconstruction with simultaneous dental implant placement and provision of implant-supported dental bridgework.

In the course of just one procedure, a vascularised bone graft was transferred from his shoulder to the jaw to fit within the contour of the fixation plate. Implants were placed into the new jaw, and a simple implants were supported prosthesis was fitted, replacing the missing teeth, the gums and some of the supporting bone, providing suitable support for the lip, which was later further reconstructed using complex plastic surgery.

Three months later, the temporary prosthesis was replaced with definitive dental bridgework based upon 3D milled titanium frameworks, fitted to the dental implants (Fig. 10a - 10b).

- Maxillofacial surgery: Prof Iain Hutchison
- Implant surgery: Dr. Andrew Dawood
- Implant prosthetics: Dr. Susan Tanner
- Modelling: Dr. Veronique Sauret, Cavendish Imaging.

Case 4

Three-dimensional printing for the planning of complex facial/dental implant surgery and oral/facial prostheses (Figures 11-14),

I was part of the team that developed the incredible facial prosthesis for cancer patient Mr. Eric Moger. My work as an early adopter of 3D scanning and printing has made me an adviser for surgeons wishing to integrate these technologies into their surgical field.

Three-dimensional printed models from a CT scan of jaw and



Fig. 12a



Fig. 12b

Fig. 12a - 12b — Digital modelling of the prostheses



Fig. 13 — Oral prosthesis in place

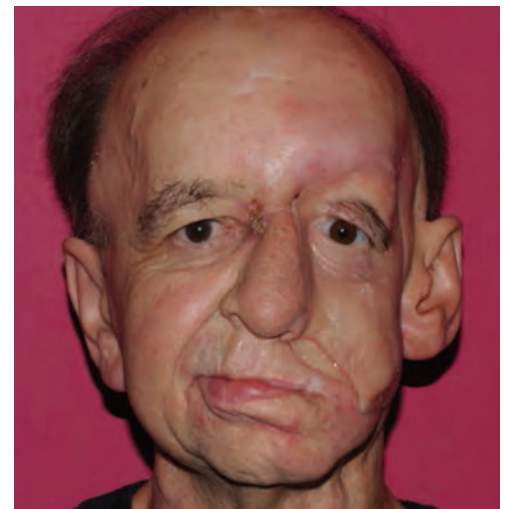


Fig. 14 — Facial and oral prostheses in place

skull were used to plan and rehearse implant surgery. It was printed in resin for simulation of surgery, and in sterile nylon for use during surgery.

Three-dimensional printed models from an optical scan of face, with 'replacement part' modelled from right side and mirrored to left side, provided a template for the silicone prosthesis.

The patient had advanced cancer of the face/sinus, for which he was referred to University College London Hospital where he received life-saving surgery, having lost his left eye, cheek, jawbone and much of his skull.

He could not have a surgical reconstruction due to the extraordinary size of the defect, and the radical radiation treatment, which limited his capacity to heal.

For four years, he endured life with gauze dressing covering a defect that extends from the forehead down the left side of the face and into the mouth. He was not able to speak clearly, and had to be fed through a tube going into his stomach.

As reconstructive surgery was not an option, my approach was to use implants to anchor oral and facial prostheses. Three dimensional image, simulation and printing

technologies were used to plan novel treatment.

Extra-long dental implants ('zygomatic' implants) extend across from the remaining right cheek bone, through the remaining part of the jaw, and these act together with dental implants placed into the rim of the eye socket to anchor a metal 'scaffold' that extends through the face to provide retention for an oral plate, crucially sealing the defect, and a silicon prosthesis, which provides a much improved appearance.

Three-dimensional printing was a critical part of the treatment, allowing us to rehearse surgery on replica models of the small residual part of the jaw, plan and design the implants and components, predetermine the positions and orientation of the implants, and


finally model the contour and shape of the prosthesis, which was made in silicone by clinical dental technician David Thatcher.

This treatment is only the start of what is a lifelong process, as the prostheses will need regular, constant updating, with work already in progress on a more sophisticated internal structure and prosthesis.

Most importantly, Eric is able to eat and drink through his mouth, and speech and appearance is much improved - a huge boost to self-confidence and quality of life.

Implant treatment: Dr Andrew Dawood

- Implant and facial prosthetics: Dr. Andrew Dawood, David Thatcher and Dr Mark

- Barratt (University College London Hospital)
- Cancer surgery: Mr. Nicholas Kalavresos University College London Hospital
- Modelling: Dr Veronique Sauret, Cavendish Imaging 

About the author:

Andrew Dawood BDS MRD RCS MSc has been pioneering the use of 3D printing in dental implant treatments. He lectures extensively, devotes time to research and development in implant dentistry, 3D imaging, and 3D manufacturing; several of his innovations have been patented. He has honorary appointments at University College, St Bartholomew's, the Chelsea and Westminster and the Royal London Hospitals, where he is involved in advanced implant treatments for patients requiring facial reconstruction.



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