Report for the Commission on the Future of Surgery

Royal College of Surgeons of England

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Introduction

I would like to submit these observations regarding the future of 3D technologies in relation to patient care from my perspective as Head of Service for the West of Scotland Regional Maxillofacial Prosthetics and Technology Service. This service covers Maxillofacial Prostheses, Maxillofacial Trauma, Oncology, Ophthalmology, E N T, Plastic Surgery and Neuro Surgery and I shall limit my observations to these Specialties and the services we provide for them.

The service is in the fortunate position of owning an Objet 3D printer, Formlabs 3D printer, Dimensional Imaging 3D camera and various image manipulating software programmes. This equipment was all funded by my surgical colleagues from endowment funds indicating their commitment to pursuing the benefits this technology affords them.

Present Day

The application of 3D technologies has revolutionised the way we work within the Laboratory. Oncology cases are reviewed using computerised software and a virtual plan is formulated and visualised on screen. Various reconstruction options can be evaluated by virtually harvesting bone from the proposed donor site, positioned and adjusted to provide optimum results for the patient. This procedure is carried out with the input from the surgeon doing the surgery giving them an idea of what to expect during the live operation. From this information cutting guides are printed in steralisable acrylic to allow accurate resection and harvesting of tissue from the selected donor site. An additional benefit to this is the ability to adapt reconstruction plates to 3D models in the laboratory prior to surgery. This technique saves valuable theatre time and provides greater accuracy for the surgical outcome.

The correction of craniofacial deformities will in many cases start with the 3D model. When printed the model can be cut to mimic the proposed surgical correction allowing a rehearsal of the proposed surgery plan eliminating any surprises.

Osteotomy for the correction of dento-facial deformity is done with dedicated software programmes allowing the operator to reposition the upper and lower jaws to the prescribed new positions. The patient can be shown a before and after computer generated picture of the changes the surgery is expected to make to their face. Intra-operative positioning splints will be3D printed for use in surgery. This technique eradicates the need for face bow recordings and the use of dental articulators to perform model surgery. The anatomical errors of the articulator and face bow method are extensively published in the literature and are avoided with this technology not to mention the laboratory time saving aspect. This can reduce one to two days technical time to two hours with the same if not better level of accuracy.

The ability to produce an accurate3D model of a skull defect for the fabrication of a Ti cranial implant has proved invaluable. Previous techniques involved a certain amount of estimation for soft tissue thickness and although for the main part successful the potential for error was present. This is now eradicated, an additional benefit of such models is access to areas previously masked by muscle and soft tissue an example of this would be adapting an implant to fit closely under the zygomatic arch which was previously only estimated.

Prosthetic restoration of missing soft tissues such as an ear, nose or orbit benefit from 3D technologies. A 3D photograph or image generated from a C.T. scan can be used to create a duplicate wax pattern from which a prostheses can be created. This technique involves mirroring the patients “good side” image to provide an anatomically accurate duplicate of missing anatomy. This provides an accurate duplicate as opposed to an artistic interpretation of missing tissues.

5 Year Prediction

3D technologies are probably one of the fastest progressing specialist areas of benefit to us today. It is very difficult to predict what might be possible. The limiting factor will certainly be available finance. The one trend which seems to be apparent is the reduction in cost of printers. There are printers capable of printing steralisable resins for £4,000, these units are presently in use for fabrication of surgical cutting guides and provide a cost effective alternative to commercially available guides. The affordability of these units allows the technology to be adopted by smaller units who do not have a large volume need for 3D models but who would benefit from the information they provide on an occasional basis, however there are limitations to the size of print they are capable of.

Software packages do not seem to be reducing in price to the same degree but continue to develop allowing better prediction. This progress will continue and they will become more intuitive and user friendly. Several other printing techniques are being explored and developed and will be of use to medical specialties such as laser sintering of Ti for patient specific reconstruction plates, silicon printing for exact replication of prostheses for facially disfigured patients and the use of biomaterials and bioinks for the creation of biocompatible frameworks for reconstructive surgery.

10 Year Prediction

It becomes more difficult to predict what will be possible in 10 years time as the technology is advancing at an alarming rate. I believe the technologies presently in their infancy will be mainstream and in regular use. Reconstructive surgery will be performed with patient specific cutting guides and plates all manufactured in house eliminating the need for third party suppliers allowing a reduction in treatment time coupled to a reduction of the patient's recovery time and this will allow 1 to 1 planning and template construction directly between surgeon and technologist.

Cranial implants will be 3D printed in biocompatible materials eliminating the associated problems presently experienced during their construction.

Silicone prostheses will be printed with exact shape, colour and form for prosthetic patients without the need for impressions. This will radically cut down treatment time of bespoke prostheses. Hopefully there will be some progress with the ability to animate orbital prostheses which is the "blue sky" wish for maxillofacial prosthetists.

The implementation of central printing hubs should be established. This will allow smaller units cost effective access to these technologies and represents a sensible improvement to patient care. Each health authority should consider creating such hubs to allow all surgical specialties access to the techniques and technologies outlined. Presently 3D printers and the associated software is cost prohibitive and can only be justified by larger units with a high demand and need for this technology. The application of 3D technology is not going to go away and must be embraced rather than ignored. I would expect this to be common place in the next ten years. The hub should employ experts fully trained in the use of medical software packages, not necessarily from a medical background, but capable of understanding the needs of the surgical team. This would represent a useful time saving for surgeons releasing more clinical time for our already time stretched colleagues.

20 Year Prediction

This is definitely the most challenging prediction to consider. There will certainly be robotic surgery as a mainstream treatment mode. I believe that the accuracy of robotics will improve and allow more intricate surgery to be achieved, however I am equally certain that this, like 3D technology will be a tool in our tool box and not a replacement for the surgeon's skill and human touch.

3D technology will allow the printing of organs and surgical frameworks for transplantation and reconstruction using biomaterials and bioinks. This is quite likely to be an in house service although presently in infancy with the technological advancement continuing at its present rate this will certainly be a reality. Surgeons will be able to plan and conduct rehearsals of intricate surgery in the virtual environment with the use of haptics to allow spacial awareness and feel.

Computers and printers will have voice recognition capabilities simplifying the process of planning and production of surgical hardware which will be achieved by a simple command to the computer or printer.

It would be nice to think that for patients requiring a facial or body prosthesis the silicone technology would be able to incorporate temperature sensitivity allowing the prosthesis to change colour hue depending on the patient's body temperature providing the optimum colour match at all times. Animation of an orbital prosthesis, movement in the artificial eye and eyelids incorporated with a colour change capability would be the best we could hope for with this type of restoration and would address the most common complaint of patients who have to wear this type of prosthesis.

Conclusion

The area of 3D printing and computer prediction is an exciting addition to the "tool box" of surgeon and Scientist alike. It is a present day reality with advances occurring at an incredible speed which makes predictions of this type exceptionally difficult. Many newsworthy advancements are superseded by better techniques or methods before they become mainstream and this leads me to wonder how much of what I have predicted may fall into this category. The one fact I am certain of is that none of this technology will ever replace the human touch which is highly valued by the patients we treat.

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