In a rapidly unfolding and ever evolving digital dental landscape, we have seen tremendous advances in 3D imaging, modelling, and manufacturing which have transformed the fields of restorative dentistry and implant surgery. There has never been a more interesting time to be working in dentomaxillofacial imaging and 3D technology.

Cone beam computed tomography

Those working in implant dentistry were perhaps the first to appreciate the benefits of three-dimensional imaging, which then took the form of Computed Tomography (CT) scanning as provided by hospital CT scanners. When I started out in implant dentistry, I reserved the use of CT scanning for only my most challenging surgical cases, perhaps scanning just one in 30 to 50 of my patients. At this time, x-ray doses were high and “flap” surgery was the norm. Back then, I often found it hard to justify the x-ray dose, which of course was considerably higher, even compared to the hospital scanners nowadays, but perhaps what really prevented me from more frequent use of this powerful imaging modality, was that it was hard to see how access to the image data would actually alter treatment, or substantially benefit my patient.

Presented with a folder of murky printouts, which often told me little more than I already knew from my two-dimensional radiographic and clinical exam, I felt that there was only marginal benefit. (I still believe that “seeing” with your fingertips has a lot to offer, as does examination under local anaesthesia at the same time as close-by procedures such as extractions.)

Years ago it was so exciting to carry out second-stage surgery and find that my first implants had osseointegrated. Our patients were thrilled to be rid of their dentures, and had few, and low expectations. Now a fine nuance of positioning makes all the difference to the results we achieve for our much more cosmetically aware patients, who expect so much more from us.

Transforming the practice environment

Embracing recent developments in imaging, particularly the use of Cone Beam Computed Tomography (CBCT), has transformed my own implant and restorative practice. Firstly let’s...
look at x-ray dose. Dentomaxillofacial CBCT scanners have been designed specifically for hard tissue imaging. There can be little or no justification at all for using hospital CT scanners for this purpose, as studies have shown that CBCT can offer at least as good, if not better imaging than a hospital CT scanner, but at a considerably lower x-ray dose. As it happens, the dose is actually rather similar to that of conventional tomography, which also makes conventional tomography obsolete as 3D imaging has so much more to offer.

Dose can be still further reduced by carefully selecting a scan volume which captures the region of interest only, and this has the further benefit of allowing for the resolution of the imaging in this smaller volume to be increased (Figure 1), without raising doses to an unacceptable level. This means that CBCT is also becoming important in endodontics and periodontics, revealing the 3D intricacies of convoluted root canals and infra bony lesions. So images are clearer, and x-ray dose is lower, particularly with newer generations of CBCT scanners, which are faster and are equipped with higher resolution sensors.

Viewing and studying 3D image data on screen helps to familiarise the surgeon with the actual clinical situation, reducing intraoperative uncertainty, improving accuracy and speed. To be able to achieve this with a substantially lower x-ray dose makes me that much happier to refer for imaging.

But what has really changed the landscape for me, is that we can now do so much more with the image data than simply hold a film up to the light or ‘left click’ to make an on-screen measurement; we have the ability and the tools to allow us to interface with our patients.

Computer Aided Design

With recent developments in computer aided design (CAD) software, our imaged volume of three-dimensional data will act as an interface between the patient data on screen. We are able to construct an on-screen virtual environment, with which we can interact.

SimPlant and NobelGuide (Figure 2) are examples of implant planning software packages that allow you to “design” your surgical treatment. This is all very well, but of limited benefit if you are not able to make your design reality, though slightly more useful as a diagnostic tool than simply viewing the data.

Here too, recent developments have transformed our capabilities.

Because, if we can transfer our computer planning back to the patient, then what we are doing on-screen really represents an interaction with our patient. To put it another way, it represents an interaction between machine and human.

Rapid manufacture

As a keen potter, (I am sure all dentists are potters, or sculptors, or should be), when I see an object I want to gauge its size, walk around it, hold it in my hand, have a sense of its texture, caress it... interact with it.

Simply viewing on-screen, even in a simulated virtual environment, just does not do enough for me.

I now see the scan as a portal. A portal to a virtual environment in which I can immerse myself intellectually, if I am working on-screen. But also tangibly. We can become intimate with our surgical planning, because on-screen planning need no longer be just an intellectual exercise; not an end-point of its self, but just a beginning.

Just a beginning, because the abstract on-screen data can actually be realised. We can interact and then we can fabricate.

What we see in our minds eye, and what we design on our two-dimensional monitor can actually be fabricated. We can move from real to virtual, and virtual to real, at the touch of a button. We do this using our scanners as a mechanism to input data to our CAD software; we alter this data and then use Rapid Manufacturing (RM) to fabricate the result of our interaction.

We can use the CAD data to directly fabricate a drill guide, for minimally invasive implant surgery (Figure 3).

And most exciting of all we can prefabricate (Figure 4).
We can make a model of our patient’s jaw, and study that, and practice the surgery on this before we carry out the procedure (Figure 5). I am prone to keeping models of my more complex patients’ jaws in my pocket, for contemplative moments. Or we can use the model to make a drill guide that can be fitted in a patient’s mouth, to allow us to interact with our patient more directly.

Further examples of CAD
Elsewhere in our brave new digital dental world, there are many examples of the use of CAD in the dental Laboratory. NobelProcera and Lava software are examples of CAD systems, which allow prostheses to be designed for teeth or implants, and then manufactured using various RM techniques. It is only a matter of time before these types of parallel CAD systems are ‘merged’: plan your implant placement, design the bridge; implement!

With the right level of care and attention to detail, we will be able to move from an on-screen surgical plan to finished implant prosthesis without impressions, without flaps and with total accuracy.

In the course of a series of short articles, I look forward to exploring some of the current and future possibilities offered by developments in our digital world.

About the author
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