During a special session at this year’s British Orthodontic Conference in Manchester, a number of internationally prominent clinicians debated the use of digital technology in orthodontics. Dental Tribune Online had the opportunity to speak with one of them, Dr Asif Chatoo from London, about his position and where he thinks the main benefits of digital technology lie.

Dental Tribune Online: Dr Chatoo, as a regular user of digital technology in your practice, where do you stand in the digital debate?

Dr Asif Chatoo: Digital technologies have been around for almost 25 years, when clinicians first started to use computers to help them manage their practices. Since then, there has been a revolution with the introduction of digital photography and later radiography. Now, we have things like digital intra-oral scanning, which means that we do not need to take impressions and keep physical models. The pictorial representations that one gets from photographs are all real and can be analysed so that they provide true representations of the patients.

With all of this technology, we have to be very careful though. Part of the counter-argument is that we are being led by the market and there are questions as to whether this is true progress. There are so many things on offer, however, and hopefully as professionals we can recognise what is beneficial and what is not.

Is the argument of the digital revolution being led primarily by manufacturers valid?

I think in the sense of making orthodontics available to everyone to treat patients with orthodontic appliances, yes. There is a steep learning curve with digital technology and one needs to ask questions when the manufacturer’s guidelines say that if one does it a certain way everything will be fine. Some might be tempted to believe that if one follows the manufacturer’s guidelines then one can throw out the rulebooks of orthodontics, but that is not true.

One still has to apply sound orthodontic principles to tooth movement. Take, for example, something like Invisalign. Despite being around for so long, there is no evidence that accuracy and predictability of tooth movement are anything better than about 15 per cent. If one looks at it like that one will say 15 per cent predictability on tooth movement is terrible. However, orthodontists are very smart people and they are cutting trays and modifying the aligners and making it the way they want the appliance to work. I think that is how we have to go forward because we cannot be dictated to by digital technology. We have to be able to control it and then we can see the value and make it work for us in a way that is constructive. The technology is there to facilitate treatment and not to take over.

Does the use of digital technology benefit the patient, in your opinion?

With digital technology, it is possible to explain to the patient what is going to happen with the digital plan in front of one. One can show the patient how his or her teeth are going to move and gain the patient’s input as one goes along. As a tool for communication, it is excellent.

The next thing is how effective it is, and whether it is better or faster. There are no studies at the moment that show that there is a significant difference. From the patient’s perspective, there is an overall benefit because it is faster and cost-effective.

As long as there is no harm inflicted on the patient, I do not think there is a problem. If one is looking for the silver bullet that is going to change one’s working life, then unfortunately it comes very slowly with digital technology. One has to learn it and master it. One has to go through 100 cases to really know how it works and whether it is good in this or that environment.

What are the main considerations for clinicians who want to start working with digital technology?

I think they have to have a great deal of patience and be willing to learn. One cannot simply close one’s eyes and rely on the fact that one knows how to move a tooth. There may be problems in the beginning and they have to learn how to overcome those problems by successfully using the technology. I would consider it a completely new way of thinking.

It does work and can be beneficial to one’s practice, but it has to be in a controlled environment and dentists should expect a steep learning curve.

Thank you very much for the interview.
Brain-guided implant reconstruction: Who makes the decisions?

By Dr Scott D. Ganz, USA

It appears that there is still a great divide between those who utilise 3-D technology for dental implant planning and surgical placement of dental implants and those who do not. Clearly, decisions as to how to diagnose and treatment plan our patients may be the difference between success and failure. Recently an internet advertisement promoting an educational programme stated that ‘Implant surgery is not complicated, easier than most other dentistry, and every dentist has the skills to surgery place implants. If you can take teeth out, you can put a dental implant in. You don’t need expensive equipment for brain-guided surgery, you can learn it with no initial investment!’ Implant dentistry has become one of the most predictable and successful treatment modalities in all of dentistry. If the only imaging modality utilised is a two-dimensional panoramic or periapical radiograph how can a clinician really know if a procedure will be complicated?

The diagnostic and treatment planning process using CBCT imaging provides for a variety of views including the axial, cross-sectional, panoramic, 3-D reconstructed volume from CBCT dataset allows for total inspection of the patient’s anatomy (Fig. 3).

The initial treatment options that could be considered for this patient included:

- Four/five standard diameter implants supporting a fixed hybrid restoration.

Figure 1 represents a beautifully rendered 3-D maxilla and mandible with the cross-sectional imaging showing the existing teeth and roots in both arches as processed within the interactive treatment planning software (NobelClinician, Nobel Biocare). This vital information allows for a complete understanding that each patient’s anatomy is individual and unique, and that each patient’s bony anatomy, root positions within the bone, and tooth trajectories may not coincide with the alveolar process. Therefore without this information, the placement of implants may be compromised, resulting in complications. Therefore it is imperative that clinicians utilise the most up-to-date 3-D CBCT imaging and interactive treatment planning software to fully appreciate the individual nature of each patient’s unique anatomy.

When evaluating potential implant receptor sites, it is not just the available bone that should be considered, as our patients are in need of teeth, not implants. Clinicians must learn to practice ‘restoratively driven implant reconstruction’—knowing where the tooth position should be in relation to the bone and potential implant. This process can be accomplished with greater accuracy with the use of 3-D imaging and software applications that have the tools to provide clinicians with this valuable diagnostic information. There are advertisements that promote concepts such as ‘Brain-guided surgery vs cone beam-guided surgery—which works better’, leading clinicians to believe that it is the computer that makes the decisions, and not the clinicians who use the technology properly to improve their diagnostic abilities.

Case presentation

A 74-year-old male presented to the clinic with a chief complaint of pain in the edentulous lower jaw, especially on the right side when trying to masticate using an existing complete denture (Fig. 4).

The denture had little or no retention due to the resorbed condition of the mandibular arch, and was almost impossible to wear without denture adhesive applied many times during the day. The patient had been seen by a local dentist with the concept of managing his mandible with the placement of dental implants.

The initial treatment options could be considered for this patient included:

- Four/five standard diameter implants supporting a fixed hybrid restoration.

Fig. 1: Three-dimensional volumetric rendering of the maxilla-mandibular relationship (l), and a sagittal section (r) of this region of interest.

Fig. 2: Frontal view of reconstructed volume from CBCT dataset allows for total inspection of the patient’s anatomy.

Fig. 3: Cross-sectional slice revealing the trajectory of the maxillary alveolus vs the trajectory of the root when planning for an implant.
The original treatment plan conceived by the original treating dentist was to place four narrow-diameter implants in the mandible to support the existing complete denture with overdenture attachments, due to financial limitations of the patient. A flapless surgical protocol was chosen, and the initial implant site located by the panoramic radiograph.

The panoramic reconstructed view of the edentulous mandible may provide the clinician with some information regarding the bony anatomy, but it is not sufficient to plan four implants in the majority of case presentations. It is essential to precisely locate the bony anatomical sites where the inferior alveolar nerve exits the mandible, and the panoramic radiography cannot provide this information accurately. To plan for the placement of implants, it would be important to understand the available bone anatomy to determine the number of implants that could be placed, and the diameter and lengths required. The 3-D panoramic radiographs cannot predict the width, trajectory, or density of the bone, as well as the thickness of the overlying soft tissue. Therefore, it can be difficult for a clinician to make truly educated decisions based on two-dimensional imaging modalities.

Upon drilling the initial pilot osteotomy preparation directly through the soft tissue, the drill immediately broke ‘in the bone’. A pericalcular radiograph confirmed that the wound bled, it was not imaged, and deemed to be ‘in the bone’. The subsequent paper print-out of the digital radiograph can be seen in Figure 6. The clinician reported what happened to the patient, and decided to abort the entire procedure and send the patient to a nearby oral and maxillofacial surgeon. The surgeon examined the patient and decided to let the bone heal, and follow-up later for a new plan of treatment. At this time a CBCT was performed by the oral surgeon. The surgical session was uncomplicated,lost confidence in the clinician, and sought another opinion.

The initial review of the CBCT data was remarkable in the depiction of the sharp knife-edged alveolar ridge (Fig. 7). The 3-D volumetric reconstruction also reveals the position of the bilateral mental foramina and inferior alveolar nerves (seen in orange).

Contrary to the 2-D view of the panoramic radiograph, 3-D imaging and interactive treatment planning software allow clinicians to truly understand the patient’s existing anatomy. For the example of the fully edentulous mandible, the CBCT scan revealed that the underlying bony ridge was quite sharp and uneven at the crest. This anatomy would certainly not be favourable to place implants with a flapless surgical approach. In fact, to facilitate the placement of implants, and facilitate the restorative phase, it would be beneficial to flatten the irregular ridge to the appropriate and desired width at the alveolar crest (Fig. 8).

The CBCT data provides us with much more information and clinicians should consider ALL of the views afforded by the CBCT scan data and use the tools of the planning software to simulate the positioning of the implants, such as the axial and cross-sectional views. The right and left inferior alveolar nerves (IAN) were traced to determine the available width in the anterior symphysis area for implant placement. It was determined that four standard diameter implants can be positioned to support an overdenture as desired by the patient (Fig. 9).

In the planning phases, clinicians should be considered the engineers and architects of the oral cavity, providing a ‘blueprint for success’ based upon the data provided by the 3-D imaging, and the ability to simulate the implant position to avoid adjacent vital anatomy. The CBCT data can often yield significant surprises that cannot be determined with 2-D imaging. The initial assessment of the CBCT data revealed that the patient was not positioned properly during the scan positioning. The inferior border of the mandible was not imaged. It was very important that patients be positioned properly to assure that all pertinent diagnostic information is available for review. Fortunately it did not impact the diagnostic phase for the purposes of implant placement.

The cross-sectional images revealed the presence of a thick buccal plate of bone in some areas, thinner in others, and a thick lingual plate of bone generally. The surprise was in the symphysis, a hollow area in the anterior central area exactly where implants would be placed! Other hollow areas and intrasosseous vessels were noted (see arrows, Fig. 10). The ‘hollow’ areas in the anterior symphysis are as illustrated in the 3-D reconstructed volumes with four simulated implants in an occlusal view.

The hollows in the anterior symphysis area of the mandible are seen in a ‘clipping’ view with simulated implants, slicing through the anatomic and radiographic reconstruction (Figs. 11a & b). This anatomical variation could not be determined with 2-D imaging modality. Once this was known, planning of implants could proceed with the knowledge of the individual patient’s anatomical presentation. The patient was informed of the issues related to the anatomy as shown in the 3-D simulation from the CBCT scan. These images are invaluable to educate the patient and improve case acceptance, and extremely invaluable for the diagnostic process in determining the best surgical approach. Proper diagnosis and treatment planning through 3-D imaging and simulation software revealed that the narrow ridge would have been a significant obstacle using a flapless approach, and the hollows in the bone may have caused significant issues in the placement and the ability to stabilise the four implants that were eventually placed.

The hollows in the anterior symphysis were carefully removed with Kerrison curettes and serrated round burs. Following the simulated plan, osteotomies were performed for four implants to support an overdenture. The two middle implants were 4.2 mm in diameter, and the two distal implants were 3.5 mm in diameter. The implants were then buried under lay-in, and the soft tissue approximated to the cover the site with tension-free closure (Fig. 13).

Once the offending element was removed, the plan was to place the knife-edged ridge to gain appropriate width for implant placement. The reduction was accomplished in a free-hand method based upon the position and location of the mental foramen on either side of the symphysis. Based upon a thorough review of the CBCT scan data the expected hollow area of bone in the anterior symphysis was exposed (Fig. 14).

Prior to implant placement, the soft tissue in the anterior symphysis was carefully removed with serrated curettes and serrated round burs. Following the simulated plan, osteotomies were performed for four implants to support an overdenture. The two middle implants were 4.2 mm in diameter, and the two distal implants were 3.5 mm in length approximately 1.5-2 mm below the bone crest as per manufacturer’s protocol (AnyRidge, MegaGen Implants). Each implant was well fixed due to three factors: (1) the anticipated thickness of the buccal and lingual cortical plates; (2) the apical length of the implants engaging native bone; and (3) the thread design of the implant type (Figs. 16a & b).

Each implant was tested by resonance frequency analysis through an implant stability quotient (ISQ) value (旭川株式会社). Clinicians might consider the implant stability for every implant placed using a non-destructive and objective protocol well-documented in the scientific literature. Additionally significant and differing entirely from insertion torque values is that ISQ values can be monitored over time which is especially important when a two-stage surgical approach is anticipated as in this case example.

To fill the voids around the implants and over the alveolar crest, a small particle-sized synthetic resorbable calcium apatite grafting material was used (OsteoGen, Implant Ltd., Fig. 18a). The implants were then buried under layers of platelet-rich fibrin (PRF) and the soft tissue approximated to cover the site with tension-free closure (Fig. 18b). The drilling was unremarkable.

After the site was allowed to mature for three months, a midline incision carefully split the narrow band of keratinised tissue over the uncovered graft site and the underlying four implants, which were all covered with a small layer of immature bone. Once fully exposed, each implant was once again fitted with a Smartpeg to assess an ISQ value, which was then compared with the initial values to determine the progress of osseointegration and to confirm implant stability (Figs. 19a & b). The ability to measure stability over time provides invaluable information for the clinician about the health of each implant. A favourable ISQ value imparts a level of confidence and knowledge of when an implant can be loaded.

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and restored. Healing collars were positioned to allow for the soft tissue to be approximated and sutured.

The patient’s initial desire was to help relieve the pain associated with a denture that was not retentive due to the topography of the arch and proximity of the mental nerve to the alveolar crestal bone. The restorative phase continued with the impression phase, and placement of overdenture abutments to secure the denture and prevent pressure on the nerve. The limitation of available keratinised tissue was initially managed to the comfort and cleansability for the patient.

At the time of implant placement, the RFA/ISQ values were recorded. The initial values were actually acceptable if immediate loading was desired (over 70), based upon the excellent stability afforded by the thread design of the implant engaging the buccal and lingual cortex, and apical length into native bone. A two-stage approach was elected due to the large hollow areas in the symphysis, which were grafted and covered with PRF. At three months, the implants were found to be covered with a thin layer of immaturity bone, and the intermedullary area seemed solid. A second series of measurements were recorded to reflect the status of integration. All values increased significantly, verifying that the process of osteointegration was progressing positively, and loading was appropriate. Overdenture abutments (Meg-Rhein) were secured to each implant, and stainless steel housings with retentive caps were embedded into the denture.

### Discussion

As technology becomes more available to clinicians worldwide, our ability to diagnose and plan with improved accuracy and consistency can only be seen as a huge benefit. The use of 3-D printing has now become an affordable option for both group practices and single practitioners, therefore making it possible to produce accuracy biomedical models that greatly enhance the diagnostic and treatment planning phase. DICOM data can be exported to standard files that can be managed in software that drives 3-D printers to fabricate models of the mandible or the maxilla. The CBCT dataset from within this article was exported as a standard triangulation language (STL) file and imported into the 3-D printer software (PreForm Formlabs, Fig. 20).

The importance of having an actual model in hand cannot be underestimated. For this particular case presentation, the 3-D printed model was fabricated using a process known as stereolithography by an in-office 3-D printer, the Form 2 (Formlabs). The surface detail is excellent, and provides not just an excellent diagnostic aid, but a method to educate our patients on the recommended treatment plan based upon the physical model that can be viewed and touched. It has been demonstrated that these models can be successfully used for guided surgery applications, and for other bone grafting guides such as a ‘sinus-lift’ or ‘harvest’ guide. The virtual 3-D reconstructed surface model can be seen in Figure 22a, and the 3-D printed model in Figure 22b. The position of the bilateral mental foramina can be clearly seen, as well as the intramedullary bone within the maxilla, and the anterior symphysis where the hollow areas were noted. These models can also be utilized to simulate the actual surgical approach to validate the procedure and for surgical guide fabrication.

This singular case illustrates many important aspects about treatment planning for dental implants. To minimise the diagnostic phase, and to suggest that clinicians do not need to use ‘expensive’ equipment as an aid to implant planning is not appropriate in today’s world of the digital work environment. As such, one of the main advantages of CT scanning is the ability to utilise the computed tomography data in conjunction with treatment planning software, which allows for an accurate three-dimensional view of the surgical area.

### Table 1: RFA/ISQ values over time

<table>
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<tr>
<th>Implant Site</th>
<th>At Placement</th>
<th>3 months</th>
<th>6 months</th>
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<tr>
<td>RFA / ISQ Values</td>
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<tr>
<td>At Placement</td>
<td>78</td>
<td>85</td>
<td>85</td>
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<tr>
<td>3 months</td>
<td>74</td>
<td>80</td>
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<td>84</td>
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Every clinician knows the situation of having a patient waiting for an implant impression. Unfortunately, sometimes the individual tray does not fit and has to be modified because the technician wrongly calculated the direction of the insertion. It is even more problematic when the individual tray cannot be found. Explaining this mishap to patients is embarrassing and annoying because it takes valuable time away from other patients, who may have to wait longer for their treatment.

Since I started working with the Miratray implant impression tray (Hager & Werken), these problems have become a thing of the past. The implant impression tray consists of a plastic structure and a transparent foil. Its secret lies in the patented foil technology, which is skilfully balanced. The foil is stable enough to hold the impression material secure inside the tray and allows impression posts to be clearly visible.

The main advantages of Miratray

- A perfect and open implant impression
- Impression-taking in only one session
- No laboratory costs
- Controlled and safe impression with an unobstructed view
- Clean working thanks to the foil precisely closing on the impression post
- No overflowing impression material
- Individual, practical and economical
- Suited for all implant impression materials and common implant systems

The Miratray is available in three standard sizes (S, M and L) and can be used for both dentate and edentulous patients. Blocking with plastic splints, recommended for some types of implants, is possible and unproblematic. The use is similar to that of the individual impression tray, but offers the advantage of having full visibility when gently pushing down the tray until the foil is perforated by the impression post. Owing to the durable foil, this becomes an unproblematic and clean procedure, as overflowing impression material can be avoided. After the material has been cured, the screws of the impression posts can be easily removed. The result is an extraordinary impression with the fixed posts within.

Studies led by the late Prof. Hubertus Spiekermann from RWTH Aachen University in Germany proved that the Miratray is as accurate as an individual tray. It makes handling of converging or diverging implants easier because the impression posts do not have to be lead through the sometimes-small notches of the individual tray. Our patients are glad that they do not have to go through another impression-taking session. In some cases with healthy oral mucosa, impressions can be taken directly after the uncovering.

Even with financial constraints, the Miratray is a perfect alternative. According to Hager & Werken, the tray costs less than €5. Furthermore, it can be claimed as an individual tray, at least here in Germany, because small adjustments need to be made, for example when there are problems with the vestibular space.