Experts advocate using low-dose CBCT imaging protocols

By DTI

Dr Michael Bornstein is Clinical Professor in Oral and Maxillofacial Radiology and Associate Dean for Research and Innovation at the University of Hong Kong in China. He has followed the ongoing evolution of low-dose CBCT imaging closely, encourages all clinicians to increase their use of dose limitation measures, and has said that the radiation dose to the patient will continue to become lower. Dr Bornstein is one of the leading CBCT imaging experts in the dental community. He was one of the speakers at Planmeca’s booth at the 2019 International Dental Show (IDS) in Cologne in Germany and gave a presentation titled “Low dose CBCT protocols in dental medicine and their impact on daily clinical practice”. It covered the changes and paradigm shifts that have taken place in the field of dental 3D imaging, with a particular emphasis on low-dose protocols. Highlights of this presentation are given in this short article.

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Cone beam computed tomography (CBCT) is an imaging technique that has been a game changer in dentistry over the last decades. It has allowed clinicians to easily acquire 3D images that have a significantly higher diagnostic value than traditional 2D images do. However, this improvement is not one completely without downsides, as the additional dimension comes at the cost of higher effective radiation doses to patients. Their exact biological effects have been difficult and sometimes even impossible to measure, but potential harm from high radiation dose levels should not be ignored.

Although the risks of CBCT imaging are very small to individuals, they are still significant when examined in the context of large population bases. Dr Bornstein states that six to eight patients per million are at risk of developing cancer related to dental imaging in their lifetime. This is why ways to reduce patient doses without losing diagnostic image quality are considered so valuable.

Over the past five years, there has been an ongoing shift in the minds of radiologists from ALARA to ALADA—from capturing images that are as low as reasonably achievable to as low as diagnostically acceptable. One could even say that finding an optimal balance between image quality and dose is at the core of modern dental imaging. Dr Bornstein’s own research has indicated that images can be used for diagnosis as intended also when using ultra-low-dose imaging protocols.

From low to ultra-low

The Planmeca Ultra Low Dose imaging protocol has been leading the way in patient dose minimisation over the last five years. According to research done by John Barrett Ludlow and Juha Koivisto several years ago, a mean dose reduction of 77 per cent can be achieved using it as part of CBCT imaging. This figure is set to improve further with Planmeca’s research and development team steadily working towards new technological breakthroughs.

Dr Bornstein views low-dose imaging not only as a mere technological question but also as one intricately related to usability. “We all talk about digital workflows, but they
are not always that easy to implement. That is why they need to be straightforward and intuitive. I think it is safe to say that our smartphones, for example, would never have become so popular if they were very difficult to use."

It was always possible to manually adjust the dose levels of various radiographic units, but it was not that easy. Various manufacturers have also struggled to maintain a diagnosis-acceptably acceptable image quality at lower doses. Activating Planmeca Ultra Low Dose, however, is as easy as pressing a button. Furthermore, it can be used with any resolution or volume size, as the protocol does not rely on taking fewer frames or using a smaller rotational angle to lower the patient dose.

“Planmeca was one of the first to come up with a preset modality that makes it very easy to apply dose limitation measures. By doing this, they were also leading the way for many others.”

The broad field of radiology

Dr Bornstein went to dental school at the University of Basel in his native country of Switzerland and went on to become an oral surgeon. Working as a dentist further expanded his interests and led him to the world of oral and maxillofacial radiology and diagnostic imaging. He soon discovered that radiology is quite an extensive discipline that encompasses not only 2D and 3D radiographic imaging but also ultrasound and magnetic resonance imaging in some countries.

“Radiology is a broad and challenging field. Because it is so technically driven, it is also very innovative. I think these factors together have kept me so interested and enthusiastic about it,” Dr Bornstein elaborated.

Although he now resides in Asia, for Dr Bornstein, IDS still holds a special significance—as is the case for countless dental professionals worldwide. In fact, he has witnessed the international atmosphere significantly strengthen at the exhibition over the years. "Being from Switzerland, IDS has always been on my agenda, although I don’t go every time. In contrast to many other fairs and exhibitions, it seems to still be growing, and has become more and more international," Dr Bornstein commented. “Twenty years ago, IDS was still very European- and German-centric. Now, I think it has become much more of a global village for dentistry.”

No limit to how low doses can go

Although significant strides have already been made in lowering patient doses to levels unimaginable in previous decades, Dr Bornstein still sees much room for improvement. “I would say there is no limit really to how much lower doses can go. Ten years ago, nobody would have even said that ultra-low-dose imaging would provide reasonable image quality, so I hope this shift will continue,” he said.

“Maybe in ten or 20 years, the term ‘low dose’ will not even be applied anymore, because all 3D imaging will be low dose. Maybe the low doses we talk about today will be the regular doses of the future.”

Reference

1 Ludlow JB, Kivistö J. Dosimetry of orthodontic diagnostic FOVs using low dose CBCT protocol. Poster session presented at: 93rd General Session & Exhibition of the International Association for Dental Research; 2015 Mar 11-14; Boston, MA.
In recent years, the technology associated with endodontic therapy has undergone a veritable revolution. For years, intraoral radiographs were used as the basis for diagnosis and for planning root canal therapy, despite the fact that these images did not provide a faithful reproduction of the endodontic anatomy. This created a series of technical problems, which, although they could be partly overcome by the operator’s personal experience, to some extent remained unresolved, especially in the field of diagnosis.

I personally started using cone beam computed tomography (CBCT) for endodontic purposes more than ten years ago. Although the machines that I used then were far from ideal for this specific purpose, the possibilities offered today by increasingly sophisticated technologies have greatly improved my diagnostic and interventional capabilities. In order to make an accurate diagnosis, an endodontist needs to perform a highly detailed assessment of the canal and pulpal anatomy, which requires high-definition examination techniques and software that enables the endodontist to rotate the tooth accurately and easily. This may seem obvious and trivial, but is not. Indeed, over the past ten years, I have had the opportunity to work with a large number of devices and dozens of software programmes, but only very few have proven to be suitable for endodontic purposes. For a few years now, I have been using ACTEON’s trium technology, with extremely satisfactory results. The imaging is very accurate and highly detailed, and above all, the user friendliness of the ACTEON Imaging Suite makes it possible to identify even slight differences between the different radiographic slices, differences that are of paramount importance for making a correct endodontic diagnosis and for the therapeutic decision-making process itself. Clinician experi-
ence alone is not sufficient for establishing the correct approach to be adopted in the case of endodontic disease, and very often clinical cases that were initially scheduled for orthograde treatment, after CBCT assessment, turn into cases for endodontic surgery or vice versa. We can therefore state that the capability we have now of performing these studies in a quick and easy manner has drastically reduced the number of incorrect diagnoses and, consequently, the number of clinical errors.

The case with which I would like to start my clinical review is a perfect example of how difficult it is to establish the origin of the patient’s symptoms on the basis of an intraoral radiograph alone. Not only does the 2D study fail to establish with certainty the presence of a lesion, but more importantly, it is impossible to establish the size, morphology and type of the lesion. An analysis of the 3D imaging, however, provides a clear picture of the clinical situation: the coronal and sagittal slices revealed the presence of a large lesion extending from the apex of the mesial root of this molar to the furcation, while the axial slices allow us to conduct a precise analysis of the endodontic anatomy and, in particular, the shape of the mesial root, which in this case was fused with the palatine
root. A full overview of the case can, therefore, guide the
decision-making process and direct the treatment plan
towards a specific type of treatment (Figs. 1–4).

In the maxillary premolar shown in Figures 5 and 6, the
fistulogram revealed the presence of an apical lesion that
extended coronally to approximately the middle third of
the root. The clinical decision could, therefore, propend
towards orthograde retreatment; however, CBCT gave us
a very different view of the situation compared with the
radiograph, as it indicated that a prior treatment had irre-
versibly damaged the tooth, which would therefore have
to be extracted.

The situation was entirely different for the mandibular pre-
molar shown in Figures 7 to 9, where, in the absence of any
radiological signs of a lesion and despite the apparently
correct endodontic approach adopted by another colle-
ague, the patient complained of persistent pain which
was both spontaneous and triggered by percussion of
the tooth. In this case, the previous excellent root canal
therapy would suggest an endodontic surgery approach,
which could guarantee a higher success rate than re-
treatment. Given this diagnostic doubt, it was decided
to perform a 3D study, which revealed an endodontic
lesion caused by an untreated lingual canal. This correct
diagnosis, thus, made it possible to perform selective in-
tervention on the remaining pulp, leading to successful
treatment of the untreated canal.

Undeniably, one of the most complex conditions to treat
is external invasive root resorption, where the extent of
the defect affects the treatment options. It therefore be-
comes sensible to perform a preoperative evaluation of
the location and extent of the resorption, and the potential
for recovery, thus, depends on correct 3D planning of the
procedure, which can only be achieved after examination
of the CBCT images. It is very important to be able to view
the slices of the tooth correctly in all three planes, focusing
in particular on the axial slices, which will prove to be stra-
tegic from an endodontic diagnosis point of view.

Comparing the two teeth shown in Figures 10 to 22
demonstrates just how important it is to analyse all the
slices of the CBCT study correctly. We can see that, in
the maxillary molar, the lesion penetrates into the pulp
chamber, starting from the root’s distal surface, but re-
 mains within the coronal third of the tooth, without sig-
nificantly affecting the integrity of the pulp chamber floor (Figs. 10–15). The clinical images illustrate the operative treatment phases, from resorption debridement through to repair using bioceramic cement (Figs. 16–19). The final radiographic images confirm the validity of the conservative and endodontic treatment of the tooth. The situation is completely different for the mandibular molar, where the evaluation of the CBCT scan clearly reveals the extent of the resorption, which invades the pulp chamber floor until the furcation, a situation that cannot be determined from observing the preoperative radiograph alone (Figs. 20–22).

Preoperative CBCT evaluation is useful in cases requiring a surgical approach, not only in order to confirm the presence of a lesion but also to plan the procedure and, in particular, identify the type of surgical incision to be used, based on its size and location (Figs. 23–25). This specific case is characteristic of this situation. The intraoral radiograph did not make it possible to ascertain
the extent of the lesion, which involved not only the apical region of the premolar but also a distal edentulous segment. This region would need to be treated with regenerative therapy in order to guarantee correct healing of the area, with subsequent insertion of a membrane, the flap must be protected using a totally different approach to that required for endodontic surgery. The intraoperative images illustrate the various stages of the procedure (Figs. 26–28). The CBCT scan performed 12 months later confirmed complete healing of the apical lesion and perfect graft integration (Figs. 29–31).

Another compelling advantage of this 3D technology is the possibility of using a minimally invasive approach for performing cavity access. For demonstration, the next case involves a dens in dente. The CBCT scan shows a separation between the two canal systems of the canine and the decay involves the portion of tooth where the dens in dente is present. The treatment plan therefore involved root canal therapy for just one portion of the pulp, while the other was to be kept vital. The image sequence of the treatment shows how it was possible, using CBCT and a surgical microscope, to perform a minimally invasive access, which spared much of the canine’s clinical crown and kept the disease-free portion of the tooth vital. The radiographic follow-up confirmed complete healing of the lesion and the vital part of the canine did not present any signs of disease six years later (Figs. 32–37).

Dr Fabio Gorni was a consulting professor in endodontics at the San Paolo hospital associated with the University of Milan in Italy. He is an active member of the Italian Society of Endodontics and of the Italian Academy of Microdentistry, a specialist member of the European Society of Endodontology and a member of the American Association of Endodontists. From 1994 to 1998, he served on the member acceptance committee of the Italian Society of Endodontics, and from 1998 to 2001, he was the society’s cultural secretary. He was president from 2003 to 2005. He has lectured at several courses and congresses in Italy and worldwide, and published numerous scientific articles in national and international journals. In collaboration with Dr C.J. Ruddle, he produced a series of scientific videos called The Endodontic Game, since distributed in Europe, the US, Canada, Australia and Asia.
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Computer-guided surgery is among the most exciting advancements made in digital dentistry throughout recent years. In this interview, Prof. Dr Ronald Jung and Dr Marc Balmer, both working at the University of Zurich, Switzerland, talk about the current state of computer-guided implantology and the advantages of dynamic navigation in particular.

With the emergence of new digital technologies, novel treatment approaches have become available to clinicians—particularly in the field of implant dentistry. However, some implantologists are still sceptical of them. Why do you think that is? And what do you think is holding back more widespread utilisation of computer-guided implantology right now?

For the utilisation of static or dynamic guidance, clinicians need to invest time to learn to use the new technology and protocols and adjust their workflow to create a streamlined process in their private practice. Clinically, static guides provide no tactile feedback, reduce access to drilling sites and delay time from scan to surgery. Dynamic navigation eliminates these disadvantages, yet it requires a higher initial purchase investment.

Let’s talk about the use of computer-guided implantology. What types of cases are you going into thinking that you must have, or are probably going to need surgical guidance? What are the advantages of dynamic navigation?

There are four major points: complex anatomy, high aesthetic demanding situation, flapless surgery and immediate loading. The big advantages are flexibility and visibility during surgery. Planning is simpler because no guide needs to be designed and fabricated. Treatment can be adapted any time during operation and the access to the operation field is unimpeded. Furthermore, a dynamic navigation system provides you with live feedback during the operation. In comparison with surgical guides, one could say that a static guide holds your hand, while a dynamic navigation system gives you more information during treatment. Moreover, with dynamic navigation there is increased safety and predictability because an accuracy check is always easily available.

Has it already proven itself in research and clinical practice? What results can it achieve compared with free-hand surgery?

Research in the field of dynamic guided implantology is ongoing. Some comparisons to free-hand and statically guided surgery, both in vitro and in vivo are already available. A recent JOMI publication showed that dynamic navigation is about two to three times more accurate than free-hand surgery, especially in angulation.
What can clinicians do to better implement a digital workflow in implant treatment?
Clinicians should educate themselves about the latest technologies available and be ready to make an initial investment in training and be open to changing work habits. Newer developments in the field of dynamic navigation facilitate the process. The new generation of dynamic navigation systems require no preparations of stents or clips during 3D-imaging and no intraoral scans. In fact, the diagnostic scan can often be used for guidance as well. Also, with much simplified planning, the clinician can now easily and quickly plan the procedure themselves, rather than delegate it to technicians.

You also mentioned postgraduate studies. Clinicians need more exposure to dynamic navigation in order to gain more skills or to determine that they want to incorporate the technology into their workflow. Can you tell us about any programme that you have at the university?
All postgraduate students in our clinic are exposed and trained to multiple systems. This way, they can gain experience in static, as well as in dynamic navigation. They decide for themselves which systems fits better in their workflow.

You also mentioned being a “mentor clinician” for the programme. Does that mean you’re still available to clinicians who complete the programme, even after it’s over?
Yes, of course. We have an alumni programme and we stay in touch with all our former students on a professional and friendly basis.

Last question: How will dynamic navigation further change digital dentistry in the future?
Dynamic Navigation has an enormous potential for further developments. Beyond handpiece guidance, it can be applied to other fields of dentistry, for example for root canal preparation and orthognathic surgery. In the longer term, it would enable the introduction into dentistry of other modern technologies such as virtual and augmented reality and robotics.

Editorial note: Watch a video recording in which Dr Balmer is teaching a postgraduate student using Navident via the QR Code below.

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Fig. 3: Prof. Jung performing a TaP registration.