Orthognatic surgery

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Dental Tribune International | Holbeinstraße 22 | 04229 Leipzig | Germany
T +49 341-48644 136 | F +49 341-48644 173
E info@digitaldentistryshow.com | W www.DigitalDentistryShow.com

PROMUNIDI
Imagine that you have discovered a wonderful property on which to build your dream home. It may be located in a wooded area, many trees, with great views of the nearby lake, surrounded by boulders and other natural landscape. You may have an idea about the size and shape of your new home; you may even know how many bedrooms and bathrooms, and what size garage would be appropriate for your family and your lifestyle. What would you do next? Hire a bulldozer, cut down the trees, level the property and start digging the foundation for your future home? Of course not, as this would be foolish. To build your dream home, it would be proper to hire an architect and an engineer, and do a geographical survey to assess the property first. Every millimetre would be accounted for, and all of the materials required to build the home inside and out would be determined prior to a shovel even touching the ground. Furthermore, it would likely be necessary for the town or city to review the architectural plans, or blueprints, for approval and proper zoning based on the laws of the land. In order to build the supporting foundation at the correct depth and width, the water table would need to be assessed, and the potential need for dynamite to remove huge boulders from under the earth may lead to extra material and labour costs. Only once all of this information has been assimilated, registered and approved, and the finances are in place can the actual building commence.

When we are assessing our patients for dental implants, orthodontics, oral surgery, or other invasive procedures, we must consider ourselves the architects and engineers of the oral cavity. Prior to touching the scalpel to the patient, it is our obligation to utilise the necessary state-of-the-art tools to assess the patient landscape, which of course includes the bone, adjacent vital structures, soft tissue, teeth, potential implant recipient sites, the need for bone grafting, pathology, and appreciation of the existing occlusion. While clinical experience is of utmost importance, it is of paramount importance to start with the best diagnosis to formulate the treatment plan. Cone beam computed tomography (CBCT) is an essential tool to help clinicians assess each patient, account for every anatomical millimetre, and develop an appropriate plan of treatment that considers all of the procedures that can benefit from a 3-D assessment, thereby removing the guesswork from treatment. CBCT combined with today's powerful interactive treatment planning software empowers clinicians to provide the basic and necessary blueprints for proper patient care.

Within the pages of this issue of cone beam International Magazine, some of the best minds in our industry have shared their treatment concepts for various multi-specialty patient presentations, based upon the knowledge gained from 3-D CBCT data. Join us for another issue and follow the evolution of technology that allows us to provide our patients with blueprints for success.
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Concepts, goals and techniques for successful orthognathic surgery

Author  Dr Theodore D. Freeland, USA

In this article, you will be introduced to the concepts, goals and techniques needed to diagnosis surgical cases, when surgical cases should be started and how to gain the knowledge needed to create successful results.

We'll delve into joint status, soft-tissue analysis, surgical treatment objectives, pre-treatment surgical setups and surgical setups. We'll then follow-up by looking at the concepts of natural head position, the axis-horizontal plane and the true vertical line will be introduced. By the end of this article, you should have:

- An overview of the knowledge needed for successful treatment.
- An introduction into what, when and how to perform successful cases.
- An overview of joint health.
- A summary of the soft-tissue analysis.
- An outline of the surgical treatment objective.
- An overview of diagnostic and surgical setups.

Remember that this article is an introduction only; it's not intended to teach you how to do surgical cases. Advanced training will be needed to master successful orthognathic surgical cases. So with no further ado, let's get started.

Functional occlusion

The goal is to obtain functional occlusion. Before treatment, you have to determine if you have an orthognathic surgery case. You don’t want to begin orthodontic treatment with the idea that if orthodontics fails, we will do surgery.

You’ll see in Figures 1–3 that this case involves every facet of dentistry. Changes occurred not only in the facial features, but also in the teeth themselves. It involved orthodontic and orthognathic surgery, but also lengthening the front teeth by the restorative dentist to achieve the natural smile in balance (Figs. 1–2). To this end, we need to look at five areas:

- joint status,
- soft-tissue analysis,
- surgical treatment objective,
We'll give you a brief overview of the goals for each of the areas, then do an in-depth look into each of them individually.

**Joint status**

Starting with the first area, you need to know the joint status. Is the joint healthy, is it degenerating, is there a disc problem? This means you'll need to apply not only a good clinical exam, but also articulated models that can measure the difference between centric occlusion and centric relation.

**Soft-tissue analysis**

You'll need to know how to analyze the soft tissue. You'll need this because you are looking at everything from a soft-tissue standpoint, or put another way, you're recording the basic measurements that come from soft tissue, not hard tissue. If you deal with hard tissue only, then you will come up short in the soft tissue. Ignoring the soft tissue will result in a face that's not improved, just different.

**Surgical treatment objective**

You need to know how to do a surgical treatment objective. You'll need to know the technique, and you'll need to know how to apply it because the surgical treatment objective allows you to treat the face, the occlusion, in a two-dimensional medium.

**Pre-surgical setup/surgical setup technique**

Once you have established what you'll need to do from the surgical treatment objective, you will need to do what we call a pre-surgical setup. Otherwise you'll need to apply the knowledge you've gained from the patient, soft-tissue analysis and the surgical treatment objective, and perform a three-dimensional workup to make sure what you have planned will work with the joints, muscles and nervous system.

**Surgery**

Finally, you need to know surgery. I recommend that the orthodontist be in the operating room so you know what the surgeon is doing, and how the surgery goes. It's very important to know that the surgeon gets the joints seated in a passive manner. If the joint is stressed, then there's a good chance that we'll have some surgical relapse.

**Joint status**

Joint analysis will include three portions: history, a clinical examination and imaging.

Building a history will be similar to traditional patient assessment. We need to know if there are any family members who exhibit TMJ problems. If yes, then there's a good chance that the patient will develop significant joint issues that will affect the outcome of treatment.

After an oral investigation, a thorough clinical examination of the joints will need to occur. We'll be on the lookout for any type of injuries to the mandible. If the patient has had any injury that involves the chin, there's a good chance that the joint may have been damaged.

Finally, we need to look into any past treatment. Has the patient had orthodontics before? Has the patient had a lot of restorative dentistry? This is important because all of the above have a tendency to affect joint status.
Clinical examination

Next is the clinical examination. Clinical examination includes the following:

- range of motion,
- symmetry of jaw motion,
- palpation,
- auscultation,
- muscle splinting,
- CR position.

Range of motion should be between 45 mm and 55 mm on opening and includes assessing movement. We’re looking for a symmetrical mandible motion—meaning the chin should not deviate to the left or right on opening—and it should be relatively free of dental interference.

Now check for palpation of the muscles of mastication. If you don’t check the muscles that move the mandible, then there’s a good chance that you’ll miss some sort of functional bite issue.

We also listen to the joint with a stethoscope, and we apply some anterior pressure to the disc through external auditory meatus to make sure the disc is functioning properly.

When trying to manipulate the mandible, one can feel the muscles. If the muscles will not let you obtain a centric joint position, then we cannot do a diagnosis because the muscles aren’t holding the condyle out of the socket. This is usually due to some inflammation.

Finally, we’ll check what we call the centric relation position, which you should be able to feel. It should feel solid and the patient should be able to open from this position with relative ease, and there should be no noises.

Imaging

The clinical examination will tell us a lot about the joint status. The use of imaging will help us build our base of case-specific intelligence. We’ll use two types of imaging: MRI and cone beam.

LCBCT

Most of the time, we start with cone beam because it’s easy to obtain a 3-D image of the joints. Thanks to the work of Rickets and Dr Ikeda, we have a way to measure joint position and get an idea if the condyle is basically seated. With cone beam, we can measure the health of the condyles.

Our imaging showed a joint that is in a state of degeneration. The condylar head has changed in vertical height. Therefore, we would expect to see an asymmetrical opening where the chin deviates to the affected side. In all three views (sagittal, coronal and axial), we have a condyle that is actually changing, especially when you make a comparison to the left condyle (Fig. 3).

In a side-by-side presentation, you can see that the left side is definitely in a lot better shape, having a more rounded effect to it. The size of the coronal view is one that shows a definite symmetric outline to it as compared to the other side. The axial view confirms this; you see that the shape is better and has a more dense outline.

Thus, our basic imaging system helps us determine that, in this case, one side is going to be the problem side, especially as it pertains to orthognathic surgery.

If we go to the two-dimensional images created in the cone beam, we can see that the right joint has definitely lost vertical height, and we definitely have a joint spacer that is excessive (Figs. 4 & 5).

In the coronal view, we can even see that there may be some sort of cyst formation. When you compare the right side to the left side in the coronal view, you get a more traditional image, which is what we’d like to see. However, there have been some changes that have occurred, because we’re starting to see a “bird-beaking” effect in the left joint. The images of the joint are ones that are important in determining if we should proceed with any kind of a surgical correction.

In the sagittal view, the right side, the joint looks pretty normal. However, if we look at it in a transverse direction, you’ll see less joint space laterally than you do medially, something we see in both the left and right joints (a much bigger joint space). That’s why it’s important that you not only look at a sagittal view, but you also need to look at the coronal view to see if you have a transverse problem occurring in the joints.

Soft-tissue analysis

When we’re trained in orthodontics, we’re trained in hard-tissue analysis, otherwise all of our cephalometric analysis are based on hard structures.
If you use hard structure to determine soft-tissue corrections, then you’ll come up short of good facial aesthetics. That’s why a soft-tissue analysis is so important.

Using soft-tissue markers with 3-D facial mapping, we are able to diagnose the soft tissue, and we can also relate it to the hard tissue.

In Figure 4, we’ve overlaid the soft tissue on top of the hard tissue. With the markers on, after we convert it to a two-dimensional X-ray, we can see where the sub-pupal area is, where the cheekbones are and where the alar base is. In addition, you will see a marker that we call a hinge access marker, which comes from establishing the true hinge axis of the patient. There is also a marker that’s placed on the nose that we call the horizontal point.

We are going to analyze everything from a basic coordinate system of a true vertical to an axis horizontal.

The image is orientated from the axis horizontal plane and the true vertical plane, which is based on the patient’s natural head position.

Figure 5 shows how these two corners are at 90 degrees from each other. In this analysis, we’re going to record all the soft-tissue measurements, both horizontal and vertical, and we’re going to base them on the line that runs through the subnasale (SN). This establishes the true vertical line based on natural head position.

Furthermore, we’re including a few hard-tissue measurements that will tell us about the architecture of the mandible. These come from Rickets and from the Jarabak analysis. With this analysis, we can cover the basis that we need for orthodontics, but we can also cover what we need in a surgical workup.

We also need a frontal analysis, which is taken from the patient’s face. Most of the frontal workup is done in examining the patient clinically. This enables us to look at the orbital rim, cheekbone, sub-pupil, alar bases, nasal bases and canthus of the eyes.

All of this enables us to assess if we have transverse asymmetries, where the occlusal plane is canted instead of level. This also holds true with the mandibular plane, which we may also find is canted. This is especially true in cases where there’s a degenerative process happening in one joint.

**Head position, profile and frontal analysis**

The natural head position is different for each individual patient. This will make the distance recorded for Glabella to the true vertical line different.

To measure how far Glabella is from SN (true vertical line), we first need to establish the patient’s natural head position (Fig. 6). To do so, we have the patient stand in front of a mirror. First, the patient is asked to close his eyes and bob his head up and down three times.

![Fig. 5 Establishing the true vertical line based on natural head position.](image5)

![Fig. 6 Glabella to subnasale (SN).](image6)

![Fig. 7 Establish the horizontal position.](image7)

![Fig. 8 Surgical treatment objective.](image8)

![Fig. 9 Completed the extrusion of the maxillary segment and balanced the occlusal plane.](image9)

![Fig. 10 Establishing the true vertical line.](image10)
After this is complete, the patient is asked to open his eyes and look himself directly in the eyes in the mirror. After we have established the natural head position, we then use the measurement gauge. Our goal is to make sure the leveling bubble is in the lines. This will allow us to take a measurement from the true vertical line to Glabella.

Keep in mind that everybody’s head position is a bit different. The further that Glabella is from the true vertical line will affect how we look at the lower third of the face.

Now we need to establish the axis-horizontal plane (Fig. 7). First, we establish the horizontal position using the ear bow. We’ll use the pointer on the ear bow to make a mark on the nose when the bow is level.

We have previously established, through axio-path tracing, the hinge axis position on the patient’s right and left sides. In combining the horizontal point with the two axis points, the axis-horizontal plane can be established. The axis-horizontal plane is then transferred to the articulator. This allows us to orientate the CBCT data with the articulator mounting.

Now we have the true axis-horizontal plane and the true vertical line combined, and now facial, skeletal and functional issues can be assessed.

In the example we are using, the patient has a mandible that has an architecture problem, which causes her to occlude only on the molars with an anterior open bite.

This is precisely the kind of case where you should be looking for degenerative joint disease. All of the above enables us to establish the parameters and coordinates we need to analyze the face and occlusion and then apply the correct treatment so the patient will have a functioning stable occlusion with the necessary facial improvements.

_Soft-tissue analysis_

The treatment objectives are based on the soft tissue. You perform the surgical treatment objective in this order.

1) Establish the position of the upper lip to the true vertical line in a vertical and horizontal manner.

2) Determine what you need to do with the anterior teeth to create the correct upper lip position.

3) Once you established the anterior part of the maxilla, then proceed to the posterior part of the maxilla and determine if you need to do an intrusion or extrusion of the posterior segments to level the occlusal plane.

In most cases where there’s a retrusive chin and a skeletal open-bite, the patient has an occlusal plane, measured from the true vertical line that is somewhere between 102 and 108 degrees. By leveling the occlusal plane, based on the anterior tooth position, you can set the mandible to the maxilla. This will usually balance the lower third of the face. If you still find the chin is too
far forward or too far back, you may need to do genioplasty.

In the example case (Fig. 8), we have performed a surgical treatment objective, established the true vertical line and we have our axis-horizontal plane. In this patient, we need to move the anterior teeth up because in the frontal analysis the patient showed too much tooth structure and too much gingival tissue. To fix this, we balance the maxillary anterior teeth based on the upper lip position.

Once we've established the correct tooth position in the anterior, we're able to set up our occlusal plane at 95 degrees, showing us what we need to do with the posterior segment. In the example case, we need to extrude the posterior segment.

Figure 9 shows how we've completed the extrusion of the maxillary segment, and we've balanced the occlusal plane. The next objective is to place the mandible with the correct overbite. This is not 2 mm but 4 mm. This is because you want to have an adequate overbite to create adequate disclusion. In establishing the mandible, you can see in our example how the lower part of the face is placed normally enough with the true vertical line (Fig. 10).

In establishing the surgical treatment objective, we see that we want to place the anterior section in the superior direction and the posterior in the inferior direction. These are all the measurements we need to establish a surgical setup. Hopefully, this is performed pre-treatment so the patient has a good idea of what needs to be done.

**Pre-surgical and surgical setups**

The pre-surgical and surgical setups are techniques that do require the clinician’s time. It's not something that can be outsourced to a lab. You need to spend the time in doing these setups to determine if it's something that can be treated. Remember, there are cases where you cannot achieve the goals.

Before we get to the setup, it's worth examining the three basic concepts that this whole system is based on. That's not just orthognathic surgery, but orthodontics itself.

**Concept No. 1:**
*You need to start with a seated condylar position.*

You will need to learn techniques to know when you have a seated condyle, and if it's in a stable position.

**Concept No. 2:**
*You can't believe what you see in the mouth.*

This is foreign to what we're taught in the orthodontic profession. We're trained that when we finish a case we have the patient bite down, and we say that the occlusion looks good or it doesn't. However, you need to understand that this is a learned muscle position. It's not a position that is usually conducive to normal joint function.

**Concept No. 3:**
*Quit trying to do the impossible with orthodontic tooth movement.*

This is where orthognathic surgery comes into play. Don’t try to fix skeletal aberrations with orthodontic tooth movements. Too often cases are treated with a compromised treatment plan, but due to the skeletal dysplasia it is impossible to establish a functioning occlusion, thus resulting in failure.

We need a ruler to measure how we come up with a diagnosis and then we need the same ruler to measure our successes. So in the sample case, the ruler consists of five goals: joints, face, perio, teeth, and function.
In a pre-surgical diagnostic setup, which is a trial treatment, the case can be diagnosed and treated before you start. This way you have the result in mind before beginning (five goals). The orthodontic, surgical and restorative modalities can all be combined pre-treatment. This way the patient knows what is needed to solve his or her particular malocclusion.

These pre-treatment setups are based on the VTO (tooth movement) and the STO (skeletal movement). Once all treatment modalities have been tried, the clinician will know if orthognathic surgery will work for the patient.

The surgical setup is performed just before surgery to determine the skeletal changes needed to correct the skeletal malocclusion and see if the prediction setup is correct. We use our ruler again to make certain that the five goals are obtainable.

The surgical splint can also be constructed from the surgical setup. The surgical splint is used to place the skeletal parts in their correct position.

**Steps in pre-surgical setups**

First, we need to get the maxilla positioned in the articulator. We still recommend that you use the articulator as a tool to do your setup. Virtual setups tend not to include the patient’s true functioning hinge axis. If you don’t have the axis, you’re liable to setup an arc of closure that distracts the condyle.

We establish the functioning terminal hinge access of the patient on both the left and right. We’re then transferring the hinge access to the side of the face. Once we have it on the side of the face, we can do our axis-horizontal transfer. The dot shows the functioning hinge axis on the patient, represented on both the right and left sides.

The axio-path tracing that we created while trying to find the terminal hinge axis of this patient allowed us to look at the angle of eminence. What we like to see is a steep angle of eminence as that helps disclude the posterior teeth in lateral border movements. Moreover, we like to see nice, smooth curved lines in the jaw motion, as that tells us the condyle and disc are working in harmony with each other.

We determine the best centric relation position in the mouth. Nevertheless, remember, you can’t believe what you see in the mouth. That means this may even be worse, especially when we do a true hinges-axis mounting.

Figure 11 shows a true hinges-axis mounting. We have the true hinge axis, we have the axis-horizontal plane and we have the teeth position according to this setup. That means the pin, which was removed for the photograph, would be the true vertical line. The articulator mounting is now the same as the CBCT imaging.

What we see in the next image is that this patient only hits on the left side. Nothing touches on the right. As you can also see, the open bite is even worse on hinge-axis mounted models (Fig. 12).
What you should find when you compare the pre-treatment setup with the surgical setup is that the bony part should look very similar on the articulated mounting as the pre-treatment. In this case, we’ve leveled the occlusal plane as part of our surgical setup. In doing so, we gained a large correction of the mandible without doing genioplasty. Again, this is based on the axis horizontal and the true vertical line.

Now that the surgical orthodontics has been completed, and the patient is now ready for surgery, we go back and do the natural head position and measure how far Glabella is from SN. We then do our axis transfer and place the markers. Then we double check that we have the natural head position (Fig. 14).

Next, we do our axis transfer, placing the maxilla exactly how it’s related to the axis-horizontal plane. This is important because it enables us to place the maxilla on the articulator exactly as it exists on the patient, to the functioning axis.

Figure 15 shows the surgical models mounted according to the axis-horizontal plane. We use a centric bite to position the mandible to the maxilla, allowing the musculature to seat the condyles up and forward.

We then get into our surgical correction. We’ve corrected the maxilla. To maintain the proper torque of the anterior teeth, we’ll need a four-part maxilla. Now we have our anterior segment (lateral to lateral) and two posterior segments (cusp to second molar) and the palate. The anterior segment is positioned vertically and horizontally to the maxillary relaxed lip position. In addition, we take into account the tooth and gingival display the patient exhibits.

We've done the correction in the maxilla, putting the uncorrected mandible on. This shows the discrepancy you see once you’ve leveled the maxillary occlusal plane. Now we position the mandible. If we’ve done our pre-treatment surgical orthodontics correctly, things should fit together. Thus, after the mandibular correction is completed in the setup, an uncorrected maxilla is placed on the articulator. You should see a large posterior open bite.

This is also an easy way to construct our intermediate surgical splint, which you can see in Figures 16a & b. Note how we changed the plane of the mandible. This is based on doing the mandible first. By placing the mandible correctly in all three planes of space, we can establish the functional axis of the mandible.

This helps eliminate some of the errors that occur in orthognathic surgery. If we do the mandible first, and we know the vertical measurement that we need, it’s easy to place the maxilla correctly to the mandible.

There are certain surgical techniques that need to be applied to accomplish the surgical corrections. By following the proper surgical techniques, the postsurgical relapse can be kept to a minimum.

The other thing that we can do is establish even centric stops, according to the axis position. That’s why in Figures 17a & b the models are painted red. We can do an occlusal analysis and equilibration and establish a stable tooth fit before surgery; all of which is based on the true terminal hinge axis.

We’re able to get a Class I and we’re able to gain enough overbite. We will need to do some postsurgical orthodontics to finish the occlusion, but the image shows the hinge axis closer on the articulator.

If you were able to hold the model, you would notice that there’s no rocking. Everything is stable.
You don’t want the patient to come out of burger and find that the patient has trouble finding a stable maximal intercuspation with the joint seated.

In order to gain even stops, we had to remove some tooth enamel around the upper and lower arches. That’s what we do in the operating room before we begin the operation. We do the equilibration when the patient is asleep and before the operation begins.

As you can see in the post treatment intra-oral and extra-oral photos (Fig. 18), the facial changes include a shortening of the lower facial third. An adequate overbite has been established so a mutually protected occlusion can seen. The proper disclusion, where the back teeth separate by at least 2 to 3 mm, has been established.

If we apply the second concept (“you can’t believe what you see in the mouth”), we need to go to post treatment hinge-axis mounted models. Figure 19 shows the cone-beam data, both pre- and post treatment. Note the double plates on the mandible to establish a stable platform to position the maxilla.

_Surgery_

One of the most important take-away lessons from this article is that you need to know your surgeon. Establishing a one-on-one relationship with your surgeon can be challenging. If the orthodontist does not know what the surgeon goes through, then in the planning stage pre-treatment, the teeth may be placed in a position that the surgeon will have trouble establishing in the correct skeletal position. This is a relationship that simply takes time.

Once you have knowledge of the surgeon, then you need to know what happens at the hospital because this becomes an important part, especially during recovery.

The people who are handling recovery need an exceptional level of compassion, and they need to be able to handle emergencies. Oftentimes the patient will get sick, and his or her teeth are held together with elastic and wires. The healing period normally lasts ten weeks. It may be longer depending on how the segments are healing. The point is that we don’t get into post-surgical orthodontics before the segments have stabilized.

_Additional considerations_

We know that you need to know the joint status. You’ll need to know how to do a soft-tissue analysis and how to establish a surgical treatment objective. You’ll need to know how to do pre-treatment setups and surgical setups. You need to apply all of these techniques on all patients (mixed dentition, adolescent or adult).

If the teeth aren’t in the correct position in the jaw, then there’s no way the surgeon can place the parts correctly, resulting in surgical failure. Most surgical failures happen because of orthodontics.

One of the things you need to keep in mind in your pre-treatment surgical orthodontics is that you established the correct arch form. Without the correct arch form, it’s difficult to put the parts together.

The other thing to keep in mind is the actual 3-D position of the teeth. If you have up-righted
the upper anterior teeth, the surgeon will have a
difficult time fitting the mandible to this.

If you have tipped the lower anterior teeth back
too far—such as in a Class III—then you cannot
obtain a good maximum intercuspation because of
the incorrect torque of the anteriors. The setup part
of the procedure will give you this information.

_Age_

If it's an adolescent patient, you can do the
presurgical orthodontic and establish the correct
axial position of the teeth in each jaw. However,
do not try to fix the occlusion. That means the teeth
will be in the proper positions when you approach
the surgery.

As a rule, I won't get into a surgical case before
a female is in her early 20s, and with males in their
mid 20s. I've seen cases where they were done
earlier and actually grew out of the correction.

_Learning these techniques_

We all need to be taught to do these things, and
it needs to be from someone who has done them for
a number of years so you can be certain that the
methods you are learning will work. They are taught in
the Advanced Education in Orthodontics (AEO)
course, and we do practice them.

That includes surgical setup, orthodontic setup,
soft-tissue cephalometric analysis and surgical
treatment objective. They need to be practiced a
number of times. It's not something you can learn
on your own. You need a mentor who will teach you
all the characteristics you'll need.

In the lab phase of the AEO class, we do get into
mounting cases on the true hinge axis. You will
learn how to establish these on patients. They are
not time consuming. Normally, establishing a hinge
axis in the axio-path tracing and transfer takes no
more than six or seven minutes, so the clinician is not
using a lot of his or her time to establish a correct
hinge-axis mounting.

The instructors will demonstrate how it's done,
and then have you perform the procedures. Under
the proper guidance, you can learn these techniques
and apply them in an office setting in an economi-
cal manner.

Without the coaching, these procedures can
feel like too much of a chore. Moreover, without
coaching, there's no way to do a surgical workup
for the benefit of the patient, which of course, is
the main reason you need to know these
procedures.

It also helps if you work with the surgeon
and the restorative dentist because it's the
restorative dentist who
obtains the final out-
come, and he or she
needs to finish the case
from where you left it.

It takes some time
and it takes some effort
to learn these proto-
cols. But once you do
learn them, and you have the technique, your sur-
gical cases will be more stable, and you'll cut down
the instances of surgical relapse that you see.

Above all, remember this is all for the benefit
of the patient. You need to spend time learning and
you need to spend time in the operating room to
know the problems the surgeon encounters. Then
you need to spend time in the diagnoses and
workup.

However, the benefit is for the patient, who winds
up with a functioning occlusion and improved face,
and the gingival tissues are healthy and the jaw
functions correctly._

Dr Theodore D. Freeland,
DDS, MS, is a board-certified
orthodontist in Gaylord, Mich.
After graduating from Albion
College in 1967, he attended
the University of Detroit Mercy,
earning a dental degree in
1971 and his master’s of
science in orthodontics in 1978. Freeland has
completed Dr. Gene Williamson’s course in
occlusion and TMJ and the Roth/Williams course
in advanced orthodontics. In addition, Freeland
has served as an adjunct professor in orthodontics
at the University of Detroit Mercy, and held
appointments at the University of Detroit in fixed
prosthetics and orthodontics; the Roth-Williams
Center as a clinical instructor; and the Advanced
Education in Orthodontics Group as director and
instructor. Freeland is an accomplished author
who lectures nationally and internationally.
Why using CBCT in orthodontics is necessary

Author: Dr Andrei Iacob, Romania

Cone-beam computed tomography (CBCT) should be the imaging technique elected for comprehensive orthodontic assessment. With the progresses made in the field of CBCT imaging, clinicians can perform exact measurements without the errors induced by radiographic projection and landmark identification or location. The most important argument for the use of CBCT on a daily basis in orthodontics is the accuracy of image geometry. In contrast to 2-D images, CBCT achieves a 1:1 ratio of image geometry, which allows adequate linear and angular measurements.1

The quality of CBCT images allows the orthodontist to analyse bone, teeth (even unerupted teeth) and soft tissue three-dimensionally. The accuracy of the measurements of the hard and soft tissue on CBCT images permits more comprehensive and precise diagnostic and treatment planning. It has been proved that landmarks can be located reliably on cephalometric images generated from CBCT data.2

CBCT images can and should be used in different areas of orthodontic interest. With the help of these 3-D images, it is simpler and more accurate to evaluate the cortical and alveolar bone, the periodontal status of the patient, the teeth (including unerupted and supernumerary teeth) and their relation to the adjacent structures, and the temporomandibular joint (TMJ). Furthermore, from CBCT images, it is easy to extract very precise 2-D images, such as panoramic radiographs or cephalograms.

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**Fig. 1** Narrow alveolar crest in a 23 agenesis site.

**Fig. 2** Very thin symphysis with the mandibular anterior teeth in contact with the buccal and lingual cortical plates.

**Fig. 3** Deep periodontal pockets around the maxillary and mandibular first molars.

**Fig. 4** Bone fenestration and dehiscence.

**Fig. 5** Anterior condyle–fossa luxation. The condyle passes anterior to the articular eminence on full opening of the mouth.

**Fig. 6** Opened functional spaces in a TMJ with a flat condyle.
The position and volume of the alveolar bone

In order for orthodontic movement to be performed, the teeth have to be moved through the cancellous bone of the alveolar bone. The buccal and palatal cortical bone can reduce or block the tooth movement, and root resorption or bone dehiscences may occur when the root is pressed against the cortical bone.

This process can occur regardless of the direction of movement (mesiodistal or buccolingual direction) and even in the alignment phase of treatment if the volume of the cancellous alveolar bone is not taken into consideration (Fig. 1).
A discrepancy between tooth size and arch length is one of the most common problems in clinical orthodontics. This can be resolved by means of extractions, interproximal enamel reduction, distalisation of the posterior teeth, or expansion of the dental arches. In orthodontics, where non-extraction is becoming increasingly popular, the use of CBCT has become mandatory. Expansion of the dental arches is very often associated with root resorption and causes significant buccal tipping of the teeth. It is known that tipping of the teeth is associated with root resorption and buccal cortical bone dehiscences. CBCT allows the clinician to evaluate the volume of the cancellous alveolar bone and the position of the root in relation to the cortical plates (Fig. 2). This information helps the orthodontist establish the limitations in tooth movement, so that the treatment will not induce root resorption or the decline of the periodontal system.

Periodontal bone level

The periodontal status of the patient should always be verified prior to orthodontic treatment. This should be done on a regular basis for patients diagnosed with periodontal disease, as well as for all adult patients and young people over the age of 18 years (in accordance with the American Board of Orthodontics’ requirements) who are about to undergo orthodontic treatment. Usually, periodontal status is checked using a panoramic radiograph or a full-mouth series of radiographs. With CBCT, this kind of radiograph is no longer necessary, because the information can be extracted from the 3-D volume. In addition, CBCT images have the advantage of being 3-D, allowing the clinician to observe and quantify the exact amount of bone surrounding each surface of the tooth, lingual and buccal, as well as interproximal defects (Figs. 3 & 4).

The state and condition of the TMJ

Clinical examination alone is usually not able to establish the condition of the TMJ or diagnose temporomandibular joint dysfunction syndrome. For this reason, images of the TMJ are essential for evaluating the condyle–fossa relationship (Fig. 5) and the functional joint spaces (Fig. 6) to determine the morphological changes in the osseous structures of the joint and to assess their severity. The morphological changes associated with temporomandibular joint dysfunction syndrome include wear, loss of cortical bone, flattening of the articular surfaces (Fig. 6) and osteophytes (Fig. 7). Recent studies recommend CBCT as the most appropriate radiographic investigation tool for evaluation of TMJ morphological changes.

Cephalometric analysis

Cephalograms can be extracted from CBCT images (Fig. 8) and the measurements performed on CBCT synthetic cephalograms have proved to be on average similar to those on conventional cephalograms.

Transversal discrepancy between the maxillae and mandible

Owing to the accuracy with which the landmarks representing the widths of the maxillae and mandible can be identified on CBCT images, it is far
more precise for the orthodontist to assess transversal plane discrepancy using 3-D data. For this purpose, one simple method is the University of Pennsylvania’s CBCT transversal analysis (Fig. 9). This transversal analysis uses CBCT to locate the points that define the maxillary and mandibular skeletal base width. For the transversal dimension of the mandible, the measurement is taken at the level of the furcation of the roots of the first molars. For the maxillae, the measurements are done from Mx to Mx points. The ideal difference between the width of the jaws should be 5 mm.6

_The size and position of impacted teeth_

In clinical practice, the predictability and the quality of the orthodontic treatment outcome are uncertain with an impacted tooth. This is because it is very difficult for the orthodontist to assess clinically the correct position of the impacted tooth, both the crown and the root, and proximity to the roots of the adjacent teeth (Fig. 10). The 3-D images allow the orthodontist to analyse those aspects, as well as the eventual morphological anomalies, pathology of the impacted tooth, and resorption of the root of an adjacent tooth, and to determine the direction of the necessary orthodontic forces that will permit the recovery of the impacted tooth (extrusion, rotation, tipping, or root uprighting; Fig. 11).1

_Root resorption_

With CBCT images, the orthodontist can determine whether root resorption has been caused by ectopia, or by orthodontic treatment. Figure 12 shows the external root resorption of a crowded central incisor.

_Localisation of teeth_

The location of ectopic or supernumerary teeth can be determined with CBCT images. Figure 13 shows a third premolar impacted between the roots of the first and second premolars.

_Sinuses and teeth–sinus relationship_

In many clinical cases, the close proximity of the roots of the posterior teeth and the maxillary sinus cortical bone cannot be properly assessed on 2-D images. When the roots are blocked by the sinus cortical bone, movements such as intrusion or mesialisation of the posterior teeth cannot be performed, or may cause external root resorption. With CBCT images, this shortcoming of 2-D images is easily overcome. Various incidental sinus findings on CBCT images may be made, including polyps, sinusitis and complete opacification of the maxillary sinuses (Fig. 14).8

_Airway assessment_

On CBCT images, it is possible to measure the airway volume of the patient because the clinician can trace and analyse the contours and form of the...
Iopinion _CBCT in orthodontics

Placement sites for temporary skeletal anchorage devices

Cortical bone thickness and bone depth are the criteria usually used to assess sites for the placement of temporary anchorage devices. Based on these criteria, various studies suggest various placement sites. For an individualised and patient-oriented approach, the bone quality and the distances between adjacent teeth can be determined based on the patient’s initial CBCT data, with no need for further radiographic investigations (Figs. 15 & 16).

Surgical treatment planning for orthodontic surgical cases

Another important clinical application of CBCT in orthodontics concerns surgical predictability with 3-D. Orthodontic surgical cases are very challenging, and 3-D images allow the clinician to plan the treatment virtually and to predict the changes in the hard and soft tissue with more accuracy than with 2-D radiographs. CBCT images allow the surgeon to perform virtual surgical osteotomies and to translate the bone segments to the desired position for better control and predictability of the results.

Various endodontic findings

Occasionally various endodontic findings, such as internal or external root resorption, apical periodontitis or retained root tips, can be observed based on the CBCT data taken for the orthodontic diagnosis and treatment planning (Fig. 17). These are important findings in the diagnostic phase of treatment because they can influence the treatment plan.

Conclusion

It is now easy to accept the advantages that CBCT has over 2-D images. In the context of new technological achievements, 3-D images give the clinician information that is more detailed compared with that of 2-D radiographs and at a lower dose of radiation. Because of its lower radiation dose and growing availability, CBCT is likely to become the modality of choice for the evaluation of, diagnosis of and treatment planning for orthodontic patients.

Editorial note: A complete list of references is available from the publisher.
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Abstract

The digital smile design (DSD) concept is an innovative protocol through which clinicians are able to optimise communication with patients and laboratory technicians by using digital photography, virtual analysis and design. In the following article, we present a clinical case in which DSD was utilised in combination with guided implant surgery software. The digital simulation performed using DSD aided the fabrication of an aesthetic wax-up and a personalised radiographic template. The information obtained from CBCT scans of the patient and the template was imported into the implant surgery software for the planning of flapless guided immediate implant placement with full-arch immediate loading.

Introduction

Digital photography and video recording were primarily introduced to the dental field for legal documentation of treatment. Later, the incorporation of these resources into clinical practice provided the opportunity to precisely evaluate static and dynamic information that could contribute to diagnosis, prognosis and treatment planning.
Today, the valuable information obtained by these methods can be digitised via computer software to aid patient case analysis and communication between all parties involved in a patient’s treatment.2

In 2007, DSD was introduced to the dental field. DSD is an innovative protocol through which clinicians are able to manipulate patient’s digital photographs and simulate future complex treatment outcomes by virtual analysis. The calibration and superimposition of intra- and extra-oral photographs and the application of fundamental aesthetic and functional occlusal concepts allows the creation of a customised virtual restorative design and allows this information to be shared with laboratory technicians and patients for their feedback.3, 4 The concept was developed to assist the dentist in three major aspects: (a) planning and designing an aesthetic smile; (b) communication between all participants involved in the clinical case; and (c) communication with the patient, increasing his or her participation and motivating and educating him or her about the benefits of the treatment.5, 6 This design concept is applicable to the restorative field and has been shown to be useful in surgical planning.5 In suitable clinical scenarios, DSD can be utilised to determine the ideal teeth position to obtain the best aesthetic and functional result.

It is well known that visualisation of the surgical field with flap elevation may reduce the risk of occurrence of bone fenestration and dehiscence during implant placement. However, flap elevation is always associated with some degree of morbidity and discomfort, and requires suturing to close the surgical wound.3 The use of non-invasive surgical techniques like flapless implant placement may provide several clinical advantages, while maintaining similar survival rates to conventional implant placement procedures.3 The concept of computer-guided implant surgery was developed to overcome the limitations associated with conventional surgical templates10, 11 and to improve the accuracy of surgical implant placement with a flapless approach.10, 11 More importantly, the computer-generated surgical guide provides a link between the virtual prosthetically driven treatment plan and the actual surgery by transferring the simulated intervention accurately to the surgical site.12

In this article, we present a clinical case in which DSD was utilised to guide treatment and combined with guided implant surgical software to achieve the proposed digital restorative simulation. The digital restorative simulation was used in fabricating cone beam | 23
Case report

Diagnosis and planning

A 39-year-old female patient presented to our clinic with the request for full-mouth rehabilitation. She was most unsatisfied with her oral health and anaesthetic smile, and was very apprehensive of dental treatment owing previous negative experiences in this regard. The extra-oral examination did not establish any significant findings. She had no systemic conditions and did not have a history of smoking, and was thus classified as ASA 1 (healthy).

Comprehensive clinical examination found partial edentulism and a failing dentition as a result of moderate periodontal disease and severe caries probably induced by mild enamel hypoplastic that could be observed in the remaining dentition. She presented with congenitally missing maxillary lateral incisors (teeth 12 and 22). Teeth 17, 16, 15, 24, 25, 26 and 27 had been extracted several years before owing to severe caries. The remaining maxillary right premolar presented with severe caries with deficient resin restorations. Both canines presented with moderate carious lesions and Grade I mobility. Teeth 11 and 21 presented with extensive recurrent decay.

In the mandible, the periodontal examination provided a diagnosis of gingivitis. Teeth 36 and 46 had been extracted several years before after sustaining a vertical root fracture. Tooth 44 had been extracted three years before owing to a severe...
carious lesion. The patient presented with severe caries in the remaining teeth. She had no contraindications for dental treatment (Figs. 1–4).

After complete diagnostic evaluation, including clinical, radiographic and photographic analyses, maxillary and mandibular impressions were taken for study model fabrication and triplication (Tropicalgin and Elite Rock Fast, both Zhermack). Using a maxillary wax rim, the vertical dimension of occlusion was determined based on anthropometric and phonetic methods. A facebow was utilised to set and transfer the maxillary 3-D orientation. After the use of an occlusal jig for three days, an interocclusal relation was registered utilising a bite impression material (Zetallabor, Zhermack) and the wax rim, establishing the mandibular centric relation and keeping the vertical dimension of occlusion determined previously. The cast models were positioned in an articulator (Fig. 5). The triplication of the models allowed the modification of two pairs of casts with laboratory procedures, while maintaining the initial information in the remaining pair (Model 2340 Articulator, Whip Mix).

The intra-oral and extra-oral photographs were imported into Keynote (Keynote 5.0, Apple) and a complete DSD analysis was performed following the concept’s protocol (Figs. 6–9). The digital restorative simulation was presented to the laboratory technician with the specific indications for preparation of a wax-up (Fig. 10). The wax-up was fabricated on one of the articulated study models replicating the original DSD information. On the second pair of casts, a translucent acrylic template of 2 mm in thickness was fabricated spanning only the palate and edentulous regions of the maxillary model. Using a silicone index, acrylic teeth were added to the template in the edentulous regions of the maxillary model. A 1 mm round bur was utilised to create perforations and gutta-percha marks were placed in the palatal region. In order to avoid any movement of the radiopaque material, the perforations were sealed with a translucent light-cured resin (Triad, DENTSPLY; Figs. 11 et 12). The radiographic guide was then checked on the patient for stability and an initial CBCT scan was performed. The template was then removed and a second CBCT scan was performed, but this time only of the radiographic template in accordance with the double-scanning protocol described by Verstreken and Van Steenberghe.15–20

The DICOM files obtained from both CBCT scans were imported into the NobelClinician software (Nobel Biocare). The surgical planning was then performed according to an aesthetically and prosthetically driven approach, following the DSD and the NobelGuide concept and protocol (Nobel Biocare; Figs. 13–15).

At the next appointment, the DSD analysis and the guided surgical plan were presented to the patient. A virtual superimposition of the implants and the digital restorative simulation was done to give the patient a more comprehensible treatment explanation (Fig. 16). After discussion of the therapeutic options, a non-invasive surgical approach was selected based on the patient’s requirements.

In the maxillae, the proposed treatment entailed pre-operative periodontal treatment, extraction of...
case report _ smile design combined with guided implantology

the remaining maxillary teeth and placement of six regular-platform (4.1 mm) implants (Titamax EX Ti, Neodent) in accordance with a guided surgical protocol (NobelGuide). The implants were to be inserted in the edentulous regions, avoiding immediate implant placement in fresh extraction sites. A one-piece acrylic titanium-reinforced immediate-loading prosthesis was proposed as a provisional. The titanium-reinforced structure consisted of several titanium bars welded to a provisional titanium cylinder compatible with the Mini Abutments (Neodent). Finally, a zirconia CAD/CAM structure was planned as the definitive prosthesis. In the mandible, the proposed treatment entailed complete pre-operative periodontal treatment, multiple resin restorations of the remaining mandibular teeth, and placement of three regular-platform implants (Titamax II Plus, Neodent) for three porcelain-fused-to-metal crowns at regions 36, 44, and 46.

After the patient's acceptance of the proposed treatment, the pre-operative clinical procedures were performed in the following weeks. The guided surgical template was ordered based on the virtual design (Fig. 17) and, after its delivery, a master model with the implant replicas was fabricated (Figs. 18 & 19). Six straight Mini Abutments were placed on the implant replicas and a screw-retained provisional structure was ordered from the laboratory based on the wax-up. Owing to the patient's personal reasons, the mandibular implant placement was postponed until the completion of all of the maxillary treatment.

Surgical and restorative procedure

After a mouth rinse with chlorhexidine (Oralgene 0.12 %, Laboratorios Maver) for 2 minutes and the disinfection and preparation of the surgical field, local anaesthetic was delivered to the edentulous area and the remaining maxillary teeth by buccal, crestal and palatal infiltrations (2 % lidocaine hydrochloride and 1 : 100,000 epinephrine; Henry Schein). After a few minutes, the atraumatic extractions of the maxillary teeth were done using periotomes and
forceps. The radiographic template was positioned in the mouth to verify correspondence between the virtual plan and the actual clinical situation (Fig. 20). Using a bite splint, the surgical guide was secured with three anchor pins. The drilling protocol was performed according to the Brånemark System Mk III guided surgery kit specifications (Nobel Biocare). The six regular-platform Titamax EX Ti implants were placed through the guide’s master cylinders, obtaining more than 50 Ncm torque (Figs. 21 & 22). Six straight regular-platform Mini Abutments (height: 1 mm; Neodent) were placed over the implants and torqued at 35 Ncm.

The provisional acrylic titanium-reinforced prosthesis was then mounted over the Mini Abutments, the screws were hand tightened after occlusion evaluation and the screw’s exit holes covered with Teflon plugs and a temporary light-cured resin (Fermit N, Ivoclar Vivadent; Fig. 23). Follow-up appointments were scheduled for three, ten and 14 days post-operatively (Figs. 24 & 25). Thereafter, the patient was recalled at one, two, three and four months and no adverse findings were made at these appointments. After four months, the conditioned healing of the soft tissue achieved with the provisional provided a favourable situation for the beginning of the definitive restoration process (Figs. 26–28).

Discussion

DSD has been met with tremendous acceptance by clinicians worldwide. This can be explained by the simplicity of the process and the ease of transmission of clinical information. As reported by Reddy et al. and Espana et al., the perception of dental aesthetics can vary from dentist to dentist, from dentist to laboratory technician, and from dentist to patient because of their differences in dental education and the subjectivity of what an aesthetic treatment implies.21, 22 One of the major advantages of the DSD concept is visual communication. The active involvement of the patient in his or her treatment plan and the feedback that can be provided may improve the treatment result and help to realise the patient’s expectations. Furthermore, several applications are being explored in the reconstructive surgical field4 and have thus far shown promising results for a restoratively driven surgical procedure. As has been demonstrated in this case, the personalised analysis of DSD helps to determine the position of the teeth in the anterior edentulous region. The fabrication of the wax-up and the radiographic template were based on the digital evaluation, and this guided the implant virtual planning.

Flapless surgery appears to be a safe treatment modality for implant placement, demonstrating both efficacy and clinical effectiveness,8 and the guided implant surgery concept has definitely improved the protocol mentioned. It is also well documented that patients treated according to this approach may have faster tissue healing and a better post-operative course.23–26

Figs. 26a & b_Frontal view at the four-month follow-up (a). Lateral left view at the four-month follow-up (b). Note the maturity and health of the soft tissue, and the natural integration of the provisional.

Figs. 27_Radiographic follow-up at four months.

Fig. 28_Comparison between the initial clinical situation and four months after the surgical restorative procedure.
As has been reported by various authors, the double-scanning of the radiographic templates allows virtual superimposition of a dental set-up on to the 3-D CBCT reconstruction. The utilisation of DSD for the creation of an aesthetic wax-up and a personalised radiographic template may improve the prosthetically driven virtual planning, determining the ideal tooth position in the anterior edentulous region. The virtual design can also provide the foundation for the fabrication of the provisional and definitive restorations.

Various authors have described immediate implant functional loading over time. Today, it appears to be an acceptable treatment modality especially recommended in full-arch reconstructions with a one-piece provisional structure. Some of the variables to consider are high implant insertion torques, and the number and distribution of the implants placed. Furthermore, high survival rates have been reported when immediate loading is combined with guided flapless implant placement. Thus, immediate loading with fixed prostheses in edentulous patients results in similar implant and prosthesis survival and failure rates to early and conventional loading. The use of tapered implants with a special compressive design allowed for torque values of greater than 50 Ncm for each fixture. Furthermore, the placement of six implants permitted favourable distribution, allowing the creation of a polygon to absorb occlusal forces.

Conclusion

The use of DSD as a prosthetic and surgical planning tool may help to communicate the proposal treatment to patients and to include their feedback and opinions in the clinical treatment design. The communication of the clinical information to all of the participants may also improve the treatment outcome and optimise the time taken to perform the treatment. The combination of DSD with guided implant surgery technology may offer an aesthetic and functional prosthetic approach to the design of radiographic templates, providing a guide throughout treatment. However, the conventional functional and aesthetic analysis of oral rehabilitation are still mandatory, and should be a requisite to managing this kind of treatment, especially in advanced and complex cases.

The guided implant placement and loading protocol utilised in this clinical situation appears to be a predictable treatment option for the clinical situation presented in this article; however, randomised studies are needed to confirm this. Careful consideration must be given to case selection to achieve a successful outcome.

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About the Authors

Alejandro Lanis, DDS, MS, received his DDS from the University of Valparaíso in Chile and performed his residency program in Oral and Maxillofacial Implantology at the University of Chile. The International Team for Implantology selected him as an ITI Scholar for the University of Michigan in the US. He is a member of the Academy of Osseointegration and International Team for Implantology, a constituent member of the International College of Prosthodontists, and a fellow of Sociedad de Implantología Oral de Chile (Chilean society of oral implantology). He works in a practice in Santiago in Chile specialised in implant dentistry, prosthodontics and aesthetic dentistry. He can be contacted at dr.alejandrolanis@gmail.com.

Orlando Álvarez del Canto, DDS, MS, is Associate Professor in Oral Implantology at the dental school of the Universidad del Desarrollo and is in private practice in Santiago. He received his DDS degree from the University of Chile and his MS degree in implantology and Oral Rehabilitation from the Andrés Bello University in Chile. He has a diploma in Health Institutions Management from the Pontifical Catholic University of Chile. He is a member of the Sociedad de Prótesis y Rehabilitación Oral de Chile (Chilean prosthodontics society), Sociedad de Implantología Oral de Chile, LAAO, International College of Prosthodontists and International Team for Implantology. He works in a practice in Santiago specialised in implant dentistry, prosthodontics and aesthetic dentistry. He can be contacted at dr.alvarez@oseointegracion.cl.

Drs Alejandro Lanis & Orlando Álvarez del Canto
Office 601
Av. Presidente Kennedy 7100
7650618 Santiago, Chile
Advantages of 3-D planning for implants

Authors. Drs Andrea Grandoch & Peter A. Ehrl, Germany

Introduction

Implantology is predominantly a surgical and prosthetic subject area. Its aim is both functional and aesthetic restoration. Today, one can place an implant in the jawbone with a high probability of success if there is good bone support. There are, however, concerns with regard to bone defects, optimum aesthetic and functional positioning of the implant and the soft-tissue situation, possible requiring partial reconstruction. The ideal number of implants for large superstructures is still a matter of debate.

Functionality, durability and aesthetics are aims that should, in general, be achieved as simply as possible using favourable and conditionally reversible techniques with minimal damage, even in problematic cases. Restoring teeth today has become easier to achieve but whether the cost–benefit ratio is satisfactory must be established for each case. There is still no consensus on these aims and perhaps success can be defined only individually. Expectations regarding implantological solutions have increased owing to significant technological advances. One may distinguish between general success criteria valid for all implants and criteria for special indications. While some scientific societies recommend replacing lost teeth with implants as the optimal treatment, and bearing in mind that the goal is restoration of natural conditions, one has to ascertain whether this is valid for single-tooth and multiple-tooth replacement for each case. Reasons for suboptimal solutions are manifold, ranging from poor initial conditions associated with a higher treatment risk to socio-economic limitations.

One cannot write about implant treatment in general, as too many parameters play a role, particularly because each case differs from another. Moreover, there are no general recommendations with regard to methodology. This is hardly surprising, since various methods are used, of which many have limited application and quickly become out of date. There is no widely agreed upon gold standard.

Methods

In 2000, CBCT was introduced to our clinic with hesitation initially and limited to more extensive problems and progressive diseases. It was used increasingly and has been used for almost all implant surgeries since 2008. Three-dimensional diagnostics undeniably offer greater insight, thus increasing the quality of the treatment. Three-dimensional planning, however, always means considering the prosthetic planning and the anatomical substratum. This is done digitally or via conventional casts.

Even before the introduction of 3-D technologies, backward planning demonstrated that viewing the desired treatment result is helpful in achieving the result. Here too, we initially applied backward planning to cases requiring extensive treatment at first, until we learned that planning is useful for single-tooth replacement too. Each of these techniques—conventional casts and CBCT scans—can be helpful, contributing to a distinct improvement in the treatment results in the hands of the experienced implantologist. The next step would therefore be to connect these two techniques. After purely digitally controlled navigation was found to be inaccurate, surgical guide systems, based on planning software, became available.
Currently, we are making the step from plaster cast and wax-up to digital model and digital reconstruction. This interesting new approach has to prove its worth in the practice first. Therefore, we have to determine which of the many digital features are essential in treatment of the patient.

Main features of 3-D planning

Only by the evaluation of 3-D data does a preoperative decision on how the desired prosthetic result can be obtained become possible. With the final result in view and mind, a solid basis for deciding upon the necessity and type of augmentation and whether removable or fixed dentures are indicated in edentulous jaws is provided. There are often bone defects, whose extent must be evaluated. They are classified according to Fallschüssel and Atwood and the classification demonstrates that, as a rule, horizontal bone loss occurs first, while vertical bone is lost gradually.

Restoring horizontal bone is important for prosthetic restoration primarily for aesthetic reasons in the anterior area and primarily for functional reasons in the lateral areas concerning the position of the implant in the dental arch. These defects can be optimally corrected via surgical restoration of the original bone volume. For each case, measurements for positioning the implant (such as inclination—to be performed by the surgeon) and measurements for the prosthesis (to be done by the dental technician) must be taken. The latter, for example, buccal crown overhangs or mucosal facings, prevent hygienic design of the superstructure and quite often result in aesthetic deficiencies.

If restoration of vertical bone volume is necessary, for instance with Fallschüssel Class 4 frontal or 2 lateral or Atwood Class 4 defects, a more costly two-step technique has to be followed in most cases. At this point, it should be noted that almost all the atrophy patterns mentioned only involve the jaw and do not concern the functional components of the dental arches. Arutinov et al.\(^3\) postulate that this must be compensated for by angled implants. Kinsel et al.\(^4\) conclude that only the length of the implant is significant for implant loss. This means that as great a bone volume as possible must be used. All of the above-mentioned planning decisions can only be made soundly if information about both the 3-D anatomy and the desired prosthetic solution is available.

The guidelines of the European Association of Dental Implantologists\(^5\) offer a critical discussion of angled and short implants. Angled implants require a bone quality above 3, 3-D planning and guided implantation, among others. Planning based on an impression with fabrication of a planning cast is critical for the final outcome of implant placement and thus for the procedure. This will determine the required treatment steps and desired treatment outcome. Quite often, this step is not accorded the necessary importance in daily practice. Adequate planning should be done by the dentist and a special appointment with the patient should be made to obtain consent. With two-step procedures, repeating planning after augmentation and a second 3-D radiograph may become necessary.

Digital 3-D planning

Today’s prosthetic planning possibilities offer alternatives to conventional casts. Two digital prosthetic planning tools will be discussed here, SimPlant (Materialise Dental) and SICAT/CEREC (Sirona). Both these tools are alternatives to the conventional approach described above via digital planning. With both methods, the surface of the neighbouring teeth and soft tissue is scanned and matched to the radiological 3-D data. This can be done from a cast (SimPlant and SICAT) or an intra-oral scan (SICAT OPTIGUIDE procedure). Then, a digital cast is created with the prosthetic planning programme. The objectives of these methods are simplification and shortening of the workflow (Graphs I & II).
The precision of these methods is particularly noteworthy and figures for the overlap of the radiographic data and the optical scan obtained with the SICAT CAD/CAM method are available. The difference between CBCT data and the optical surface scan is between 0.03 (0.33) and 0.14 (0.18) mm. After scanning, crowns can be planned with the help of the CEREC crowns and bridges planning software. The precision of the digital SICAT method depends on the resolution of the respective data. For analogue impression techniques, for example, a precision between 0.1 and a maximum of 0.2 mm is required, as well as a gap of 0.027 to 0.101 mm between the crown and natural tooth.

The precision of the two methods therefore is similar. This holds true if all error sources are taken into account: CBCT scan, the transfer to the surgical guide, the repositioning of the guide, the play of the drill and deviation when placing the implant. The surface scan improves precision. The advantage of this procedure is that the production of a planning cast is unnecessary (Graph II). The OPTIGUIDE method makes an important step towards the digitisation of prosthetic and implant planning, resulting in greater planning reliability and precision. Unfortunately, there are restrictions concerning partially edentulous jaws and cases with extensive metal artefacts.

**Single-tooth replacement**

Expectations are high with single-tooth replacement. The target is to achieve a state equal to the conditions before tooth loss. Tooth replacement in the aesthetic region is particularly demanding. Anatomical prerequisites primarily determine the treatment method. For example, an implant may be placed into a particular alveolus immediately without 3-D planning. For delayed implantation, a cast and 3-D radiograph should be used. By planning the implant inclination and relation to the neighbouring teeth, the emergence profile and the positioning of the crown can be favourably planned. Guided implantation is particularly helpful in individual implants when several individual implants have to be placed or neighbouring teeth are endangered where there is only limited space. In addition, the patient’s wish to see the expected outcome can be met. However, visualising optimum results involves the danger of arousing expectations that cannot be guaranteed.

**Shortened row of teeth**

In reconstruction of a shortened row of teeth, the function and particularly the support of the temporal prernquisites primarily determine the treatment method.

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Figs. 4a & b Three-dimensional planning in an edentulous maxilla (a). Prosthetic loading with good initial conditions (b).
poromandibular joint is important. The number of teeth necessary for prostheses has not been determined definitively. Within the last few years, reconstructing up to the first molar, and up to the second premolar in cases with an extension, has been usual. Generally, alveolar atrophy progresses most rapidly horizontally in the lateral jaw area, starting buccally, and frequently is later followed by atrophy of the vertical dimension.

If one avoids augmentation or performs only minor augmentation, longer prostheses are necessary for short implants, which are situated more lingually than the natural teeth. The use of short implants in the lateral jaw is subject to several restrictions, such as good bone quality, primarily connected crowns or caps, no extension bridges, no lateral excursion contacts and no para-functional habits. Angulation is limited to 20 degrees. Furthermore, angled implants are not recommended for a shortened row of teeth according to the guidelines of the European Association of Dental Implantologists. If alignment is carried out with respect to antagonists in the natural dentition, positioning the new implant-borne crowns will not lead to any functional losses, unless the antagonists were not functionally situated in the dental arches originally.

Space towards the cheeks must be regained, even if patients with a long case history sometimes complain about spontaneous cheek biting and bolus retention. One must choose carefully between the more pleasant approach of using short and angled implants with long crowns and the more difficult approach of bone augmentation. Three-dimensional planning provides indispensable information in cases like these. With reference to typical defect patterns, Figure 2 demonstrates that restoring bone volume for very different defects can be problematic. A typical reconstruction using a surgical guide for pilot drillings in a shortened row of teeth with good initial conditions is depicted in Figures 3a and b.

**Edentulous jaw**

Three-dimensional planning is of vital importance for determining the treatment approach for implantation in edentulous jaws. For instance, one has to decide upon whether and which augmentative measures are required and whether a removable or fixed prosthesis is suitable. With regard to the last point, it must also be decided whether extensive single-tooth replacement is possible, whether small or large bridges must be used, and whether a greater intermaxillary distance must be filled prosthetically by longer crowns or by a mucosa substitute.

The number of implants for fixed dental prostheses include the All-on-4 concept (Nobel Biocare), the consensus conference recommendations of six
Implants in the mandible and eight in the maxilla, and tooth-by-tooth reconstruction up to the first molar. The multitude of planning information and treatment possibilities requires a great deal of planning, which is always justified because of its significant consequences. Planning based on digital casts is not appropriate in these cases, since the support of the cheeks and lips by the prosthesis is important and this can only be determined with the help of and for each patient. Here, the advantages of prosthetic planning are particularly evident.

Edentulous jaws often require a special approach (see Figs. 4a & b for an example). Extensive augmentation is frequently necessary (Figs. 5a–f). The required length of the teeth, however, has to be clarified with the patient before treatment and depends on the amount of tooth displayed during lip repose (Fig. 5e). Quite frequently, implants are placed inter-foraminaly in the mandible, often because extensive augmentation is still problematic in the lateral mandible. Figures 6a and b show a patient with six implants and an extension bridge.

Even in cases of seemingly simple implantation for removable dentures in an edentulous jaw, 3-D planning and a planning cast are needed to verify functional reconstruction and soft-tissue support. In addition, they can aid determination of the positions of the implants in consultation with the dental technician and planning for adequate space for the attachment box.

Discussion

Three-dimensional planning for implants holds the advantage of higher quality owing to (a) risk identification; (b) planning reliability; (c) production of near-natural structures; (d) targeted and fast work; (e) patient compliance; and (f) cost transparency. These advantages are largely due to the greater amount and quality of information gained. Three-dimensional diagnostics enable us to obtain reliable information about the condition of the alveolar process and important anatomical structures. With the additional planning cast, information about the restoration of function and aesthetics is obtained. Combining both information sources will result in optimal treatment planning. In addition, an experienced surgeon can address surprises if the patient is flexible. Intra-operative decisions may also need to be made if unexpected situations arise. Knowledge of 3-D data permits planning, which entails devising a well-considered procedure and obtaining the necessary tools and substitute material, for example suitable implants and bone substitutes. Owing to the traceability of diagnosis and treatment, as well as the resulting safety, patients will regard the procedure particularly positively.

A disadvantage is the higher initial outlay, but this is balanced by increasing use owing to a targeted and quicker workflow and thus less reworking. Implantation always requires a 3-D radiograph. These new techniques have greater logistical requirements than conventional dental procedures do and require extensive involvement of the teams involved in order to achieve treatment success.

It should be borne in mind that every surgery is accompanied by a certain risk in spite of the safety precautions taken. In addition, too much confidence in methodologies may lead to carelessness. Errors may even arise with 3-D planning, which may hold negative consequences for treatment. Therefore, it is important to be familiar with each step and error source and thus expert training is crucial. In addition, maintaining a critical attitude throughout treatment is necessary to avoid errors. The advantages of 3-D planning are so significant that it has become indispensable.

Editorial note: A list of references is available from the publisher.

Contact

Dr Peter A. Ehrl
andepend
Berlin, Germany
peter.ehrl@andepend.com

Cone beam

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The process of accumulating patient information to determine which course of dental implant treatment should be considered can be described under the category of pre-surgical prosthetic planning. The first step in patient evaluation involves conventional periapical radiographs, panoramic radiographs, oral examination, and mounted, articulated study casts. These conventional tools allow the clinician to assess several important aspects of the patient’s anatomical presentation, including vertical dimension of occlusion, lip support, phonetics, smile line, overjet, overbite, and ridge contours, and to obtain a basic understanding of the underlying bone structures. The accumulation of preliminary data afforded by conventional diagnostics provides the foundation for preparing a course of treatment for the patient. However, the review of findings is based upon a 2-D assessment of the patient’s bone anatomy and may not be accurate in the appreciation of the spatial positioning of other vital structures, such as the
incisive canal, the inferior alveolar nerve, or the maxillary sinus. In order to understand each individual patient’s presentation fully, it is essential that clinicians adopt an innovative set of virtual 3-D tools. Through the use of advanced imaging modalities, new paradigms have been established that, in the author’s opinion, will continue to redefine the process of diagnosis and treatment planning for dental implant procedures for years to come. Without the application of computed tomography (CT) or lower radiation dosage cone beam computed tomography (CBCT), an understanding of the 3-D anatomical reality cannot be accurately determined, potentially increasing surgical and restorative complications.

The utilisation of 3-D imaging modalities as part of pre-surgical prosthetic planning can take several paths as demonstrated in the flow chart. The first involves acquiring a 3-D scan directly, without any prior planning or ancillary appliances. The scan process can be accomplished at a local radiology centre or via an in-office CBCT machine, now widely available. The scan itself can be completed within several minutes. Once the data has been processed, it can be viewed via the native software of the CBCT machine used and evaluated for potential implant recipient sites, followed by the surgical intervention. A second path requires the fabrication of a radiopaque scanographic appliance that incorporates vital restorative information and will be worn by the patient during the acquisition of the scan. In this manner, the tooth position can be evaluated in relation to the underlying bone and other important anatomical structures, such as the maxillary sinus or the inferior alveolar nerve. The scan data can again be visualised via the CBCT machine’s native software and a plan can be determined based directly upon the restorative needs of the patient.

The scan data is formatted into a non-proprietary data interchange protocol referred to as DICOM (Digital Imaging and Communications in Medicine). The DICOM data can be exported for use in third-party software applications that incorporate additional tools to aid clinicians in the diagnosis and treatment planning functions.

The use of interactive treatment planning has expanded dramatically in the past ten years as computing power has increased exponentially. There are at least two paths that can be taken once a virtual plan has been established. The first allows the data to be assessed, providing important information to the clinician who will perform the surgical intervention free-hand based upon the software plan. This has been termed CT-assisted intervention by the author. The second path involves the fabrication of a surgical guide or template that is remotely constructed from the digital plan usually through rapid prototyping or stereolithography. This method has been described as CT-derived template-assisted intervention and is considered to be more predictable than any previous methods. The use of advanced imaging modalities for pre-surgical prosthetic planning is essential for any type of implant surgical and restorative interven-
special 3-D planning for implants

3-D planning concepts for the mandible

Regardless of the image acquisition process, there are four standard views that need to be fully appreciated in the diagnosis phase. These include the cross-sectional (A), the axial (B), the panoramic (C), and the 3-D reconstructed volume (D) as seen in Figure 1. The ability to interact within these images differs from software to software. It is the ability to visualise 3-D data with improved tools that empowers clinicians to assess individual patient anatomy. The cross-sectional slice is important for the assessment of the facial and lingual cortical bone plates, the intramедullary bone, and the positioning of teeth within the alveoli. The axial view allows inspection of the entire upper or lower jaw, the maxillary sinus volume, the position of the incisive canal in the maxillae, and the mental foramina in the mandible.

The panoramic view is an overall scout image, and can be helpful in tracing the mandibular nerve, and assessment of the maxillary sinus floor near the nose region. The 3-D reconstructed volumes are invaluable in the planning process and in communicating information to the members of the implant team, including the patient and the dental laboratory technician who will fabricate the final prosthesis. These images are especially useful, as they are most readily understood and appreciated.

As represented in the flow chart, a patient may be sent to a radiology centre for a CBCT scan of the mandibular arch without a scanning appliance. The 3-D reconstructed volumes are easily understood and interpreted for the mandible (Figs. 2a–c). In the case demonstrated, there were several hopeless anterior teeth that were planned for extraction. The extent of the bone loss can be appreciated by the clinician and demonstrated to the patient as an excellent educational and communication tool. The virtual mandible can be rotated to reveal all views of the patient’s individual anatomical presentation (Figs. 3a & b). With innovative software tools, the teeth can be virtually extracted in the 3-D reconstructed volume, aiding the clinician in understanding the local anatomy to identify potential implant recipient sites (Figs. 4a & b). In this example, the alveolar ridge narrowed considerably at the crest. In order to facilitate implant placement, the ridge required an alveectomy, reducing the ridge by approximately 8–10 mm.

Advanced software applications allow for the bone to be sectioned based upon the desired plan. A bone reduction template pioneered by the author can be simulated by the software and then fabricated to assist in the bone removal (Figs. 5a & b). The reduction template fits over the ridge, allowing complete visualisation of the residual bone to be sectioned from the alveolar ridge. The flattened ridge can also be simulated, greatly enhancing the clinician’s appreciation of the remaining...
bone topography (Figs. 6a & b). The amount of bone to be removed can be visualised as shown in Figure 7a and then assessed with realistic manufacturer-specific implant placement in the bone (Fig. 7b). The occlusal and facial views reveal the new width of available crestal bone for implant placement (Figs. 8a & b). The visualisation of the bone crest can aid in the determination of ideal implant recipient sites. However, it must be noted that all other views must be considered to appreciate adjacent vital anatomical structures and the remaining topography of the anterior mandible before any plan can be finalised. Several different options can be quickly simulated and then discussed with the patient and all members of the implant team. The use of a bone reduction template can facilitate the accurate removal of bone and the immediate placement of implants, eliminating the need for two separate surgical interventions and thus minimising patient morbidity.

The initial plan in the case demonstrated was for the patient to receive an implant-retained overdenture. Therefore, recipient sites were determined based upon the available bone in the mandibular symphysis between the right and left mental foramina, which were assessed in the axial and cross-sectional views. While it is possible to fabricate an overdenture design with implants in the posterior region of the mandible, the usual position of implants is within the symphysis region. The choices were to place two implants, three implants, or four implants between the two mental foramina (Figs. 9a–d). The symphysis area is not free from risk. A cross-sectional view is necessary for an appreciation of the thickness of the facial and lingual cortical bone plates, and for assessment of the trajectory and topography of the anterior mandible. In addition, there are important vessels in the region that have been shown to cause severe haemorrhaging if perforated. These vessels may differ from patient to patient and underscore the importance of a 3-D diagnosis. In this case, two such vessels were found in the midline area of the symphysis (red arrows) as seen in the cross-sectional view, which also revealed the extensive bone loss surrounding the hopeless teeth (yellow areas; Fig. 10).

Virtual realistic implants were simulated in the residual alveolar bone (Figs. 11a–d). A simulated surgical template was fabricated for the desired implant positions and rested on the reduced bone both facially and lingually. At the midline, where the vital vessels resided, it was elected not to place an implant to avoid potential surgical complications (Fig. 12). The simulated bone-borne surgical template was visualised in various 3-D reconstructed volumes (Figs. 13a–c). The first two revealed a midline horizontal stabilisation screw (Figs. 13a & b) and the last showed a standard bone-borne template without fixation (Fig. 13c). Had additional implants been required for improved stability or had a fixed detachable hybrid restoration been indicated, supplementary recipient sites could have been located based upon the available anatomy.

In order to demonstrate the capabilities of the new digital paradigms, five virtual implants were placed into the initial anterior alveolar ridge after the teeth had been extracted virtually (Fig. 14a). The positions of implants can be further enhanced by placing yellow abutment projections that extend above the occlusal plane. Using selective transparency, the various structures can be adjusted in opacity and translucency. Using advanced software simulation, horizontal osteo-
tomies to allow the implants to be placed in the same vertical position in the newly reduced ridge were illustrated (Fig. 14b). Implant-to-implant relationships can be evaluated in all dimensions (Figs. 15a & b). In addition, it is important to provide ample clearance between the most posterior implants and the inferior alveolar nerve and mental foramen. Once the positions of the implants have been finalised, a surgical guide can be simulated (Figs. 16a & b). Note that the implants were all parallel, which can aid in laboratory fabrication for overdentures and in achieving passive fit for fixed frameworks (Fig. 16c). The relationship between the original tooth position and the simulated implants can be appreciated in Figure 16d. If a fixed detachable hybrid, full-arch CAD/CAM zirconia restoration, or an immediate restorative protocol is desired, the ability to simulate implant position with an accurate consideration of the desired tooth position will enhance the surgical, restorative and laboratory phases of treatment.

**Conclusion**

The advent of complete denture fabrication has evolved into the adoption of overdenture concepts for both natural and implant-retained restorations. Conventional prosthodontic protocols have been developed to aid in the diagnosis, treatment planning and laboratory phases of the reconstruction. These include conventional periapical radiographs, panoramic radiographs, oral examination, and mounted, articulated study casts. Using these, the clinician can assess several important aspects of the patient’s anatomical presentation, including vertical dimension of occlusion, lip support, phonetics, smile line, overjet, overbite, and ridge contours, and can obtain a basic understanding of the underlying bone structures. The accumulation of preliminary data afforded by conventional diagnostics provides the foundation for preparing a course of treatment for the patient. However, the review of findings is based upon a 2-D assessment of the patient’s bone anatomy.
In order to understand each patient’s presentation fully, advanced 3-D imaging modalities are essential. This article has illustrated the use of various innovative virtual 3-D tools.

The application of CT or lower radiation dosage CBCT provides clinicians with an accurate understanding of the 3-D anatomical reality of our patients as an aid in providing state-of-the-art treatment. Implants will be better positioned, with fewer surgical and restorative complications, and reduced laboratory remakes based upon these diagnostic tools. The benefits will enable clinicians to better understand the relationship between patient anatomy and the desired restorative outcomes in the process of achieving true restoratively driven implant reconstruction. The ability to utilise digital imaging and treatment planning technology is now within the reach of many clinicians through the various software products on the market. In addition, there are many third-party outlets online that enable clinicians to upload their DICOM data for evaluation, processing, treatment planning, and even surgical template fabrication.

In many case presentations, a reduction of the alveolar crest is an essential part of the surgical phase to achieve adequate width of the bone for implant placement. It is now possible to plan for accurate bone reduction with the full knowledge of the impact on the inter-arch space and occlusal requirements. The advent of the bone reduction template provides one additional digital solution that can also result in reduced patient morbidity, especially when the process can be completed in one surgical procedure. New paradigms have been established that, in the author’s opinion, will continue to redefine the process of diagnosis and treatment planning for dental implant procedures, both removable and fixed implant-retained alternatives, for years to come.

**Dr Scott D. Ganz**

Dr Ganz maintains a private practice for prosthodontics, maxillofacial prosthetics and implant dentistry in Fort Lee in New Jersey in the US. He appears in the Best Dentists in America list by Woodward/White and in the Top Dentists list by the New Jersey Monthly. He has served as President of the New Jersey Section of the American College of Prosthodontists and of the Computer Aided Implantology Academy.

Dr Ganz delivers presentations worldwide on both the surgical and restorative phases of implant dentistry, and has published extensively on these topics. He is considered one of America’s leading experts in the evolution of computer utilisation and interactive software for diagnostic and treatment planning applications using CT and newer-generation CBCT imaging modalities.
Two years ago, Seppo Villanen, a Finnish specialist in physical medicine and pain treatment, visited Planmeca’s stand at the Finnish Medical Convention and saw a CBCT image of a patient with an obvious sequel of a fracture in the neck area. This gave him the idea of using Planmeca’s 3D imaging device for imaging patients with neck problems. The idea turned out to be a success, and nearly 30 patients have now been imaged in cooperation with Pantomo Oy, a company offering dental X-ray imaging services.

Seppo Villanen has his practice at Mehiläinen medical centre in the Helsinki metropolitan area. The patients he has referred for a CBCT examination have mostly been patients suffering from pain in the upper neck. “During a routine MRI scan of the neck, the upper neck is usually left outside the image, since the scan acquires transverse slices from the C3 vertebra downwards. What’s more, a regular X-ray examination of the neck is routinely performed in a manner that also leaves the upper neck outside the image. CBCT imaging, on the other hand, covers the entire upper neck, from the base of the skull to the C4 vertebra, which is precisely the area that is often missing from routine studies.”

Villanen’s neck patients are referred to Oral and Maxillofacial Radiology Centre Pantomo Oy for imaging with Planmeca ProMax 3D, and the images are interpreted by Radiologist Raija Mikkonen at Terveystalo medical centre. “We have cooperated with Raija for years”, says Villanen.

In most cases, CBCT imaging is done to support MRI imaging, since the methods complement each other. In some cases, however, a CBCT scan is all that is needed: “It does not provide an insight into soft tissues, but if the image is sufficient to provide an answer to the current question, other methods are not needed.”

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<th>Table 1</th>
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Conversely, bony structures do not show up well in MRI images, and small bones can be easily confused with scar tissue. “In a CBCT image, even small changes in the bone are plainly visible”, describes Mikkonen.

_Thin slices, low radiation doses and a natural head position_

One of the many benefits of CBCT imaging is the low radiation dose compared to a traditional CT scan. Moreover, the method produces very thin slices, down to 0.16 mm. In hospitals, trauma CT scans are usually performed with a slice thickness of 2 mm, and MRI scans are sometimes performed with a slice thickness of up to 5 mm.

“The thinner the slice, the more reliable it is when you are studying small things”, says Villanen. “Thin slices have better resolution and afford better measurements. A 2 mm slice does reveal large fractures, but small avulsion fractures might remain undetected.”

Furthermore, a CBCT scan can be post-processed to include all required slice thicknesses. “They can also be acquired in a high resolution CT scan, but that would produce an even higher radiation dose”, describes Mikkonen.

Also, the patient position is better in a CBCT scan than in a CT scan. A CT scan is acquired with the patient lying down, whereas in a CBCT scan, the patient is sitting up, allowing a more natural head position. “In a lying position, the load of the head is not completely natural. All in all, radiologists should make more use of functional imaging, so that patients could be imaged in their normal working positions, for example.”

_Fast imaging increases patient comfort_

From the patient’s perspective, a CBCT scan is quite pleasant—in addition to the low radiation dose, the procedure is quick. A regular MRI scan takes about 20 to 30 minutes, and a functional MRI scan up to two hours, but a CBCT scan is complete in less than a minute.

“Many patients have been surprised at the brevity of the scan”, says Mika Mattila, Specialist in oral and maxillofacial radiology, who is in charge of imaging the neck patients referred to Pantomo Oy by Villanen. “Planmeca’s device has a handy cervical spine program that sets the device automatically to the right position. The only difference in patient positioning, compared to dental patients, is that the head of neck patients must be turned with extreme caution.”

The open patient positioning also pleases patients with claustrophobia. “Some patients may be very relieved by not having to go into a tube for a scan.”

_CBCT images of trauma patients_

Some of Villanen’s CBCT patients have sustained a neck or head injury in an accident: a car accident, horse riding accident, a fall, or by a heavy object falling on their head at a construction site. The patients range from 17 to 80 years of age, and the majority of them are women.

“Research shows that, all other things being equal, women are more prone to injuries in a car crash than men. The head position is crucial in a crash, and women often make the mistake of first
turning their head to see if the children in the back seat are okay. You should not look back, but protect yourself,” says Villanen.

Villanen and Mikkonen state that the upper neck is a relatively new area of interest in imaging and medicine. “The upper neck has been somewhat of a no-man’s land, even though it is one of the most mobile joint systems in the body. A neuroradiologist examines the brain, while a radiologist usually examines the area below the C3 vertebra. Treatment of a neck injury patient is a challenging multidisciplinary effort that requires a clinician, a physiotherapist and a radiologist. If a brain or spinal injury is also suspected, the team needs a neurologist and a neuropsychologist as well.”

A CBCT scan is an economical imaging method for which many insurance companies have agreed to cover the costs, describes Villanen.

A new standard of resolution

CBCT images are also useful in examining osteoporosis and degenerative changes, since thin slices provide an accurate insight into bone structure. “Compared to the resolution of CT images, CBCT images are on a whole new level,” states Villanen.

Turning to industry news, Planmeca is looking for new applications for its imaging method, since we can now obtain additional information and examine the cause of a patient’s problems”, says Mattila.

Case presentation

Fig. 4a_ Marked loss of height at the right atlanto-axial joint (C1–C2). Calcification and small bone cysts present in the bone under the articular surface. The structure of the bone is clearly visible.

Fig. 4b_ Marked loss of height and osteophyte formation at the right atlanto-axial joint. A cyst under the articular surface on the side of the C2 vertebra.

Fig. 4c_ The dens has moved to the left in relation to the C1 vertebra. Osteophytes in the atlanto-axial joint.

Fig. 4d_ A large anterior osteophyte in the atlanto-axial joint.

The Planmeca Romexis software suite is an effective working tool for the radiologists: “The software is fast, visual and easy to use, and various measurements and scrolling work well. It is also a very useful tool in the training of physicians and physiotherapists.”

Pantomo too is very happy about this cooperation that has been going on for a few years now. What started as a pilot experiment now provides genuine benefits. “It is great to discover new applications for this imaging method, since we can now obtain additional information and examine the cause of a patient’s problems”, says Mattila.

Patient case (Figs. 4a–d)

A 58-year-old woman, generally healthy. During the past two years, her neck has become so sore and stiff that she can no longer turn her head. Dizziness spells. A lot of soreness on the right side, at the vertebral level C1/C2. No inflammatory arthritis found.

CBCT imaging indications for the neck area:

- Determining the bony anatomy of the upper neck on levels C0–C4 (not indicated for imaging ligaments);
- Fractures of the upper neck;
- Avulsion injuries of the upper neck;
- Differential diagnostics of arthrosis/rheumatoid arthritis of the upper neck;
- Subluxation and abnormal rotation positions of the upper neck.

Contact

Planmeca Oy
Asentajankatu 6
00880 Helsinki
Finland

www.planmeca.com
SOREDEX, the imaging system provider from Finland, has introduced an in-office CBCT system for head and neck imaging requiring a large field of view (FOV), SCANORA 3Dx. The system is intended for a wide range of applications, from treatment planning for a single dental implant with a small FOV up to whole skull imaging with an extra-large FOV. The system is ideal for otorhinolaryngological, oral and maxillofacial, and cranial examinations in imaging centres, otorhinolaryngology offices, and total care oral and maxillofacial clinics and hospitals.

SCANORA 3Dx is a member of the SCANORA CBCT product family. Compared with its predecessors, SCANORA 3Dx has a larger flat panel detector that enables a wider range of imaging FOVs to be used. The same smooth workflow with easily understood control panel and motorised patient positioning characterise this accurate instrument. The optional dental panoramic sensor is available as before.

In the unit, eight user-selectable FOVs are now available. The FOV can be freely selected for any region of interest in the skull area, which makes...
the system suitable for multiple imaging tasks. All the FOVs (H x D) have their typical applications. The smallest cylindrical FOV (50 x 50 mm) with the highest resolution of 0.1 mm voxel (volume element) size is intended for localised problems, such as detailed imaging of single-tooth endodontic structures or the ossicular chain of the middle ear. Two medium-sized FOVs are available for imaging, for instance, both temporal bones in one volume. The most suitable FOV for sinus and otorhinolaryngology imaging is the 140 x 165 mm with 0.2 mm voxel size. The largest FOV (240 x 165 mm) with 0.5 mm voxel size is intended for whole skull examinations, for instance follow-up of facial surgery operations. The voxel volume is isotropic, which ensures that measurements in any direction are accurate.

Owing to the wide adjustment ranges of parameters, the overall radiation dose for specific diagnostic indications can be optimised by selecting the smallest FOV for each task and adjusting the mA and resolution settings accordingly.

SCANORA 3Dx makes use of the latest imaging technology. The 3-D detector is a large amorphous silicon flat panel for acquiring high-resolution projection images. The SARA (SOREDEX Advanced Reconstruction Algorithm) reconstruction method produces 3-D volumes from these projection images.

Accurate patient positioning is achieved with improved laser lights and scout image programs. The seated patient platform ensures perfect stabilisation.

SOREDEX designs, develops, manufactures and markets quality X-ray imaging systems, with an emphasis on innovative digital solutions. Based on 35 years of experience of imaging excellence, the company offers reliable and easy-to-use systems of true diagnostic value that help clinicians focus on patient care. SOREDEX stands for innovation and value in X-ray technology.

_Sorex_ Nahkelantie 160 04300 Tuusula Finland

www.soredex.com
This year’s 5th International CAMLOG Congress was held in Valencia from June 26–28 with the motto “The Ever Evolving World of Implant Dentistry.” The Ciudad de las Artes y de las Ciencias, a unique city of the Arts and Sciences, offered the perfect scenario for the congress. Over 1,300 delegates from all over the world and 66 internationally renowned speakers and moderators had travelled to this exceptional event in the architectural highlight Palau de les Arts. In the presentations and the practical and theoretical workshops specialised topics and studies were discussed, practice-relevant new trends were presented and current practical examples demonstrated.

The scientific programme

With the International Congresses, the CAMLOG Foundation offers a unique forum for further education and discussion for oral implantologists, surgeons, dental technicians, dental professional staff, students, industry and the media. The congresses have always aspired to spark off visionary trends in implant dentistry. Against this background, Congress Presidents Prof. Dr Fernando Guerra and Prof. Dr Mariano Sanz, together with the CAMLOG Foundation President Prof. Dr Jürgen Becker, invited to an exchange of ideas among scientists, practitioners and companies. The high-level and diverse program offered a total of 28 scientific presentations over five sessions. The expert audience praised the evidence-based results and the remarkably practical approach. Common to all presentations was the persistent desire to give patients the best treatment.

The highlight of both congress days was the panel discussion on “Complications—what can we learn from them?” Four experts presented complications of implant treatment and restorations which had occurred in practice in the sixth session. Congress delegates were asked to join the panel to discuss solutions and possible approaches. The audience was involved by the moderators Prof. Dr Mariano Sanz and Prof. Dr Fernando Guerra to vote on the treatment options, while the experts presented their solutions to round off the session.

Numerous delegates also took the opportunity of attending the practical or theoretical pre-congress workshops, when renowned speakers explained scientifically proven surgical and prosthetic techniques and treatment concepts. The workshops provided excellent opportunities for a fruitful exchange be-
tween dental professionals and industry partners. The insights gained then lead to further in-depth discussions amongst colleagues on the following two days of the congress.

_The poster competition_

On occasion of the 5th International Congress, scientists, dentists and dental technicians submitted their research or case studies for the poster competition. The company’s committee accepted 37 posters from Austria, Germany, India, Italy, Spain, Portugal and Turkey. The scientific level for the posters equaled those of the presentations and the submission criteria were high. Awards for the best posters came to a worthy conclusion during the award ceremony on the podium.

The team Salomão Rocha, Wilfried Wagner, Jörg Wiltfang, Fernando Guerra, Maximilian Moergel, Eleonore Behrens, and Pedro Nicolau were delighted to receive the first prize with their topic “Platform switching versus platform matching: Two-year results from a prospective randomised-controlled multicenter study” which convinced the committee and the congress participants. After the award ceremony, the award winners presented the study. The group received 2,000 EUR as prize money.

The second prize in the amount of 1,500 EUR went to the team Monika Puzio, Artur Blaszczyszyn, and Marzena Dominiaik. The topic of their study was: “Comparative ultrasound assessment of keratinized gingiva thickness around implants after the augmentation treatment in esthetic zone—preliminary results”. The prize money of 1,000 EUR went to the team in third place, Burçin Vanlıoğlu, Yasar Özkan, and Yasemin Kulak Özkan. They presented results on the “Clinical and radiographic outcome of CAMLOG implants in partially edentulous cases after an observation period of 10 years”.

_Una gran fiesta en familia_

The legendary CAMLOG party was fully booked. The drive to a Spanish hacienda was already dominated by an incredible atmosphere of anticipation and expectations. Each participant had received a “Spanish passport” which entitled to admission. The Hacienda Masiá Xamandreu is a sprawling, meandering event location embedded in typical country-style gardens. An authentic reception with Mediterranean hospitality started the family festival “Una gran fiesta en familia” with excellent Spanish delicacies, traditional arts and infectious Spanish music. The evening reaches its climax in the party zone with dancing music and the performance of a lady soul singer.

The impressions gained and the many discussions during the two days of the congress were a convincing display of how the International CAMLOG Congress will help shape the future of implant dentistry and the ever important role of networking._
International Events

2014

ICOI World Congress
3–5 October 2014
Tokyo, Japan
www.icoi.org

ESCD Annual Meeting
9–11 October 2014
Rome, Italy
www.escdonline.eu

155th ADA Annual Session
9–12 October 2014
San Antonio, USA
www.ada.org

Digital Dentistry Show
16–18 October 2014
At the International Expodental Milano, Italy
www.digitaldentistryshow.com

AAID Annual Meeting
5–8 November 2014
Orlando, USA
www.aaid.com

8th International Congress on 3-D Dental Imaging
7–8 November 2014
Fort Lauderdale, USA
www.i-cat.com

3rd Digital Dentistry Symposium
14–16 November 2014
Istanbul, Turkey
https://blog.sirona.com

ADF Meeting
25–29 November 2014
Paris, France
www.adf.asso.fr

Greater New York Dental Meeting
28 November–3 December 2014
New York, USA
www.gnydm.com

AAOMS Dental Implant Conference
4–6 December 2014
Chicago, USA
www.aaoms.org

2015

36th International Dental Show
10–14 March 2015
Cologne, Germany
www.ids-cologne.de

AO 30th Annual Meeting
12–14 March 2015
San Francisco, USA
www.osseo.org

IMAGINA DENTAL
4th 3D & CAD/CAM Digital Dentistry Congress
1–3 April 2015
Monaco
www.imaginadental.org

BIOHORIZONS Global Symposium
16–18 April 2015
Los Angeles, USA

EuroPerio 8
3–6 June 2015
London, UK
www.efp.org/europerio/
submission guidelines:

Please note that all the textual components of your submission must be combined into one MS Word document. Please do not submit multiple files for each of these items:

- the complete article;
- all the image (tables, charts, photographs, etc.) captions;
- the complete list of sources consulted; and
- the author or contact information (biographical sketch, mailing address, e-mail address, etc.).

In addition, images must not be embedded into the MS Word document. All images must be submitted separately, and details about such submission follow below under image requirements.

Text length

Article lengths can vary greatly—from 1,500 to 5,500 words—depending on the subject matter. Our approach is that if you need more or less words to do the topic justice, then please make the article as long or as short as necessary.

We can run an unusually long article in multiple parts, but this usually entails a topic for which each part can stand alone because it contains so much information.

In short, we do not want to limit you in terms of article length, so please use the word count above as a general guideline and if you have specific questions, please do not hesitate to contact us.

Text formatting

We also ask that you forego any special formatting beyond the use of italics and boldface. If you would like to emphasise certain words within the text, please only use italics (do not use underlining or a larger font size). Boldface is reserved for article headers. Please do not use underlining.

Please use single spacing and make sure that the text is left justified. Please do not centre text on the page. Do not indent paragraphs, rather place a blank line between paragraphs. Please do not add tab stops.

Should you require a special layout, please let the word processing programme you are using help you do this formatting automatically. Similarly, should you need to make a list, or add footnotes or endnotes, please let the word processing programme do it for you automatically. There are menus in every programme that will enable you to do so. The fact is that no matter how carefully done, errors can creep in when you try to number footnotes yourself.

Any formatting contrary to stated above will require us to remove such formatting before layout, which is very time-consuming. Please consider this when formatting your document.

Image requirements

Please number images consecutively throughout the article by using a new number for each image. If it is imperative that certain images are grouped together, then use lowercase letters to designate these in a group (for example, 2a, 2b, 2c).

Please place image references in your article wherever they are appropriate, whether in the middle or at the end of a sentence. If you do not directly refer to the image, place the reference at the end of the sentence to which it relates enclosed within brackets and before the period.

In addition, please note:

- We require images in TIF or JPEG format.
- These images must be no smaller than 6 x 6 cm in size at 300 DPI.
- These image files must be no smaller than 80 KB in size (or they will print the size of a postage stamp!).

Larger image files are always better, and those approximately the size of 1 MB are best. Thus, do not size large image files down to meet our requirements but send us the largest files available. (The larger the starting image is in terms of bytes, the more leeway the designer has for resizing the image in order to fill up more space should there be room available.)

Also, please remember that images must not be embedded into the body of the article submitted. Images must be submitted separately to the textual submission.

You may submit images via e-mail, via our FTP server or post a CD containing your images directly to us (please contact us for the mailing address, as this will depend upon the country from which you will be mailing).

Please also send us a head shot of yourself that is in accordance with the requirements stated above so that it can be printed with your article.

Abstracts

An abstract of your article is not required.

Author or contact information

The author’s contact information and a head shot of the author are included at the end of every article. Please note the exact information you would like to appear in this section and format it according to the requirements stated above. A short biographical sketch may precede the contact information if you provide us with the necessary information (60 words or less).

Questions?

Magda Wojtkiewicz (Managing Editor)
m.wojtkiewicz@dental-tribune.com
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