

DENTAL SCANNING NOTES

FOR MEDICAL CT SCANNERS

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1. Introduction

These Dental CT Scanning Notes have been prepared by Image Diagnostic Technology Ltd. (IDT) to assist our customers. Please use at your own risk. While we have made every effort to ensure the information is accurate and up to date, we cannot take responsibility for any errors or omissions.

These Scanning Notes will be most useful for hospitals or imaging centres that own or operate a medical grade CT scanner. Separate Notes are provided for Cone Beam CT (CBCT) scanners, such as might be found in a dental practice.

Dental CT or CBCT Scans are most commonly prescribed for the pre-operative assessment of patients who are candidates for the placement of dental implants. Some other applications might be: impacted third molars, supernumerary teeth, TMJ assessment, and planning maxillofacial surgery. The basic requirement is to provide transaxial images of the region of interest, which in most cases will be the mandible (lower jaw), maxilla (upper jaw), or both. Occasionally, the zygoma, orbits and eyes will need to be included, but this is the exception rather than the rule.

1.1 What are dental implants?

If a patient is missing some or all of their teeth and does not wish to have a removable denture, implants can be an alternative. Implants are, in effect, titanium roots that are screwed into the bone and on which new teeth can be made by a dental laboratory. An average sized implant will be about 3.5 mm in diameter and 12 mm in length and can only be placed in bone of adequate dimensions and quality. The images that IDT generates by **reformatting** or post-processing CT scans demonstrate this bone in slice by slice presentations, as well as in the form of 3D views. Using these images, the surgeon can determine the ideal implant position for long-term stability, function and success.

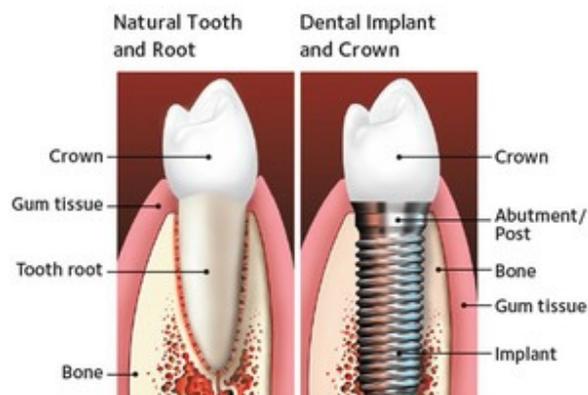


Figure 1. Natural Tooth compared with Dental Implant

1.2 What does IDT do with the CT scan?

The axial CT slices are post-processed using a number of software programmes including Simplant, Mimics, InVivo, Osirix and Blue Sky Plan. These convert the axials into 3D, Panoramic, and Cross-Sectional views. IDT sends all this information to the dentist or surgeon on a CD or via the internet (secure email or secure FTP). After loading the dataset onto his or her computer, the dentist or surgeon can interact with the images to evaluate different potential implant sites. 3D software such as Simplant also allows him/her to place exact replicas of implants in the bone, as he/she would during surgery. This gives an excellent overview and potential problems can readily be foreseen.

IDT can prepare datasets for a number of software packages including Simplant, Mimics, InVivo, Osirix, Blue Sky Plan, coDiagnostiX, Nobel Guide and iDent. We can also provide Radiology Reports and we have a Treatment Planning service and we can design 3D Models and Surgical Drill Guides.

As IDT uses its own reformatting software, **you do not need Dental Software on your CT scanner to scan patients for IDT.**

1.3 Working with IDT

There are three ways that your hospital or imaging centre can work with IDT:

- 1) Referring dentist books and pays for the scan plus any reformatting work online, and IDT in turn pays the imaging centre to perform the scan. This is the best scenario from IDT's point of view because we can make sure the entire process goes smoothly and maintain high standards throughout.
- 2) Referring dentist or patient pays the imaging centre for the scan plus any reformatting work and the imaging centre pays IDT for the reformatting (the exact opposite of 1). This provides "one stop shopping" for the patient but creates extra work and responsibilities for the imaging centre.
- 3) Referring dentist or patient pays the imaging centre for the scan only and pays IDT separately for the reformatting work only. This may seem like the easiest way of working, but it creates extra work for the referring dentist, as he/she must liaise and coordinate separately with both the imaging centre and with IDT. Also, it is very difficult to maintain high quality standards throughout two separate processes.

Under scenario 1, IDT can take on some of the imaging centre's administrative burden, as we have put streamlined procedures in place that ensure as little paperwork as possible for the radiographers to complete. Also, we work closely with IDT Scanning Site Partners to find ways of achieving the best possible image quality at the lowest practical radiation dose.

If a dentist books a scan directly with the imaging centre instead of through IDT (scenarios 2 or 3) we will assist as much as possible but we cannot take any responsibility for the quality of the scan or delays in receiving the data.

We encourage scanning sites to send the CT data to us electronically via a secure service such as Virtual Private Network (VPN) or bbRad. This enables us to provide a much faster turnaround to the referring dentist. Please include the following when you send the CT data to IDT:

1. All axial slices
2. All ScoutViews or alignment images
3. The Patient Protocol or Dose Report screen (showing the DLP).

Please do NOT include any reformatted images (Sagittal or Coronal or 3D views).

Please include the Dose Length Product (DLP) because we will use it to calculate the Effective Dose (in microSv) and report these numbers back to the referring dentist.

Please do NOT rotate or reformat the data using your own software. Datasets that have been rotated or reformatted cannot be processed by IDT. Please send us the axial slices exactly the way they were reconstructed by the scanner.

2. Before your First Scan

Please set the scanner according to a dental CT protocol that has been designed specifically for the make and model of your CT scanner. IDT can provide you with a suitable protocol. Our protocols have been chosen to obtain the maximum in image quality at an appropriate radiation dose. If you change scanners, please inform IDT so that we can send you the protocol for your new scanner.

2.1 Pre-scan Preparation

Carry out your normal pre-scan checks to identify the patient and ensure the patient is suitable for a procedure involving medical radiation.

On some scanners, it is possible for "left" and "right" to be transposed for post-acquisition display reasons. **Please ensure the laterality on the scanner is correct before proceeding** (the patient's "left" should be displayed on the observer's "right").

Ask the patient to remove any metal dentures (chrome-cobalt plates) or dentures with any metal parts (clasps). If the patient's dentures are metal-free, the patient should wear them, unless he or she was given a stent (scanning prosthesis) by the dentist to wear instead. Information regarding the stent should be on the dentist's Referral Letter. If the patient did not bring a stent but the Referral Letter indicates one should be worn, please contact the referring dentist or IDT before scanning the patient.

2.2 Instructions to the Patient

Please explain to the patient that they must stay entirely still during the scan. It is of utmost importance that the patient does not move. To prevent even the slightest movement, the mandible should be "locked" to the maxilla. If the patient has natural teeth, or a denture, or a stent, we recommend biting down on a wooden tongue depressor to keep the teeth slightly (1-2mm) apart while stabilising the mandible. The tongue depressor should be placed crossways at the back of the mouth so that the flat side touches the back (posterior) teeth on each side.

If the patient has natural teeth in both arches, placing a tongue depressor as described above is very helpful. By

having the bite open a few mm (but not too much!) it will be easier for IDT to divide the teeth to see which teeth belong to which arch. This will help derive the maximum benefit from the CT scan.

Never use a plastic syringe to separate the teeth as it opens the bite too much.

The patient must remain **completely motionless** during the entire scanning procedure (from the prescribing scout view right through to the final axial slice). Normal breathing will not adversely affect the study, however, any motion of the head - including swallowing - can diminish the image quality, possibly to the point where the images cannot be used. The desire to swallow during the scan can be reduced by placing the tongue on the roof of the mouth.

- **Tell the patient approximately how long the scan will take**
- **Stress the importance of keeping entirely still**
- **Keep in contact with the patient at all times**
- **Let them know when they must stay still and when they can relax.**

3. Positioning the Patient

Position the patient supine on the scanner bed to be moved into the gantry head first. Please make sure the patient is entirely straight and is not rotated laterally. Align the head to achieve the requested scanning plane (usually this requires getting the occlusal plane vertical).

As you can see from Figure 2, the region of interest is centred above the ears and focused on the centre of the mandible. This often requires setting the table at its lowest position. It is also important to **use the lowest head rest available** to get the patient's head back sufficiently so that the occlusal plane is vertical.

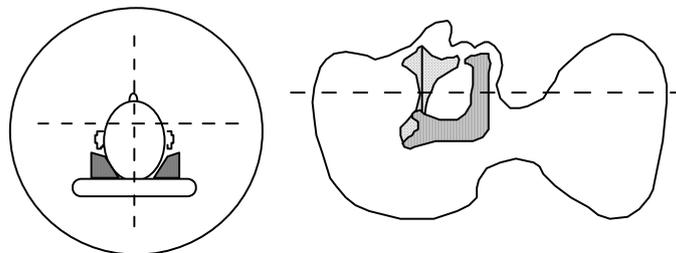


Figure 2. Patient Alignment

3.1 Patient Comfort, Support and Restraint

A relaxed and comfortable patient is less likely to move. Make the patient as comfortable as possible, using pillows to elevate the knees and resting the arms at the side. Support the head and neck evenly with sponges or padding for comfort and stabilisation. Secure the patient with two Velcro straps – the first strap across and below the chin and the second strap across the forehead. Please be prepared to re-position the patient if necessary to correct the alignment.

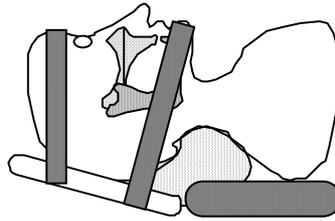


Figure 3. Patient with neck supports and Velcro restraint straps

3.2 Scanner Table Height

Set the table height so that the patient's required scan region (mandible, maxilla or both) is as close as possible to the centre of the scan field or wherever the best image quality can be achieved. It may be necessary to use "target" reconstruction to centre the maxilla or mandible in the display field. You might consider taking a single low dose reference slice to make sure that the patient is positioned straight and centred correctly.

4. Scanning Parallel to the Requested Plane

The dentist's Referral Letter may ask you to scan parallel to one of these three planes: the occlusal plane, the hard palate of the maxilla, or the lower border of the mandible. In some cases, the dentist might draw a line on a patient's stent to show which plane should be used. As you cannot tilt the gantry, you must tilt the patient's head until the requested plane is parallel to the gantry. Unless the referring dentist specifies otherwise, **tilt the head so that slices are acquired parallel to the occlusal plane (Figure 4):**

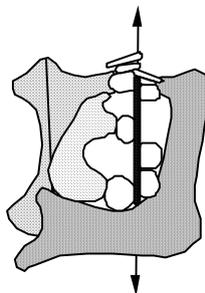


Figure 4: Scanning parallel to the occlusal plane

4.1 Parallel to the occlusal plane

Indication: Maxilla, Mandible, or both together.

UNLESS A DIFFERENT PLANE IS SPECIFIED, THIS IS THE PLANE TO USE. The occlusal surface of a tooth is the biting surface, and the occlusal plane is the plane passing through the area where the maxillary and mandibular teeth come into contact when the mouth is closed. On an alignment image or scout view, this will show up as a line

running from the tips of the anterior (front) teeth to the occlusal surfaces of the posterior (back) teeth.

If you are scanning both jaws, always try to scan them in the same series whenever possible. If you scan the patient with the mouth open, there will be different "occlusal planes" for the maxilla and the mandible and therefore the patient will need to be repositioned between maxilla and mandible scans. For this reason we recommend scanning the patient with the mouth closed (biting on a wooden tongue depressor) so you don't have to stop to reposition the patient. **Never use a plastic syringe to open the bite.**

The occlusal plane may actually be curved (curves of Monson and Spee) so you may have to imagine "straightening out" this curve and scanning parallel to the resulting imaginary plane. **If the patient is biting on a wooden tongue depressor, you can use this to indicate the occlusal plane (Figure 5):**

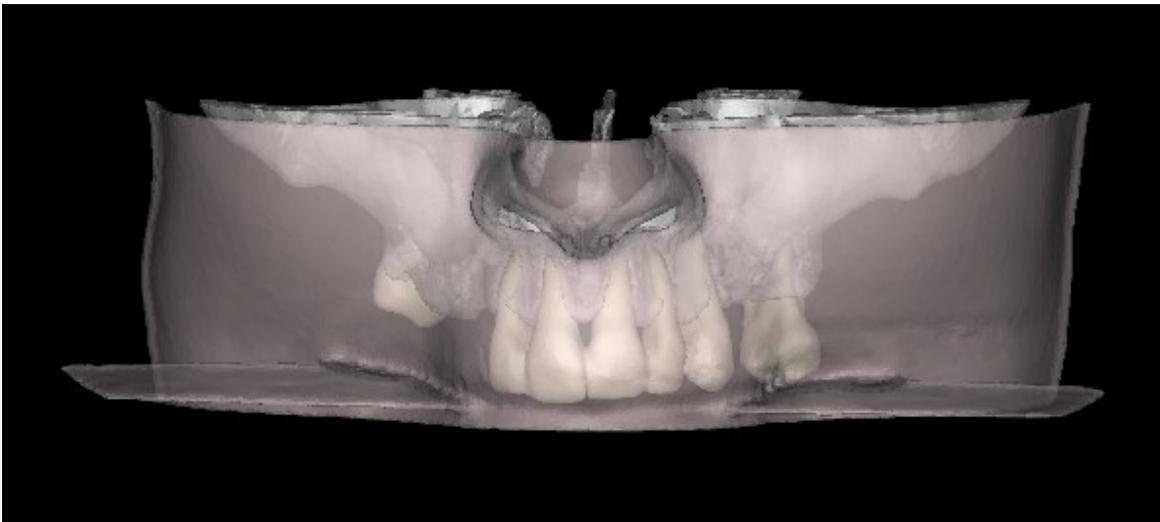


Figure 5: Patient biting on wooden tongue depressor (3D view)

Often the anterior mandibular teeth are much "higher" than the posterior teeth. This may happen because the front teeth over-erupted when there were no teeth in the opposing arch. In such cases, please ignore the anterior teeth and find the plane by only using the posterior teeth.

If in doubt, **it is always better to have the chin up a bit extra, rather than down.** This will ensure that the entire jaw is scanned, without taking unnecessary slices.

4.2 Parallel to the lower border of the mandible

Indication: Mandible only

ONLY USE THIS PLANE IF EXPLICITLY REQUESTED. The lower border is the lower jaw line. If it cannot be clearly seen, it can usually be assessed by placing your thumbs along the jaw line on each side of the chin. In addition to getting the jaw line parallel to the gantry, please ensure that the patient's head is straight. In other words, one side of the mandible should not be significantly lower than the other.

This plane should be verified on the lateral scout view. Care should be taken to have both sides of the mandible at the same height, the centre of the mandible in the centre and the jaw line parallel to the gantry. If repositioning is

needed or if the patient moved, please take a new scout view.

Under no circumstances should a maxilla be scanned parallel to the lower border of the mandible, even if this appears to be what the dentist has requested.

4.3 Parallel to the hard palate

Indication: Maxilla only

ONLY USE THIS PLANE IF EXPLICITLY REQUESTED. The hard palate is the roof of the mouth. The best way to assess this position is to check the lateral scout view. Please ensure that the patient's head is straight and centred. If repositioning is needed or if the patient moved, please take a new scout view.

NEVER USE GANTRY TILT OR POST-PROCESSING SOFTWARE TO CORRECT ALIGNMENT. If no plane was indicated on the Referral Letter or if the information isn't clear, use the occlusal plane.

4.4 Limiting the effects of artefact caused by metallic restorations

Metal restorations, such as amalgam fillings or gold crowns, will create artefact or streaks that blacken out or obscure details of bone in the scan. Patient positioning can allow artefact to be directed away from the region of interest (so it will affect the bone less than the teeth). Please use your judgement and reposition the patient if you know it will result in a better scan. Below is an illustration which you may find useful when assessing each patient and the potential for reducing artefact by repositioning.

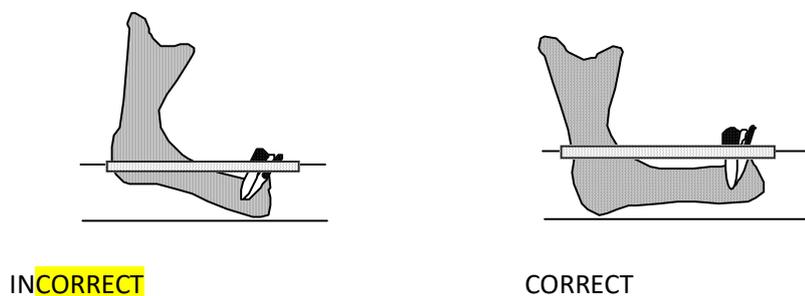


Figure 6: Adjusting the scanning plane to reduce the effects of artefact

The rectangular area in the figure above is the region that would be affected by artefact from metallic restorations in the teeth. By angling the jaw, this artefact can be directed away from the region of interest (the bone, especially the potential implant sites). For the mandible the rule of **chin up a bit extra** usually results in a better scan.

Where artefact is present, **scanning parallel to the metal** will generally result in the minimum number of slices being affected. **Always scan the entire anatomical region requested, even if artefact will be included.** Some artefact can be removed later when IDT post-processes the images.

Many CT scanners now have “Metal Artefact Reduction” software such as “MARS” or “SEMAR” that can go a long way to reducing the effects of artefact. If your scanner has this software, please send us 2 datasets – before and after applying the Metal Artefact Reduction algorithm – so we can decide which works best for our application.

4.5 Checking the lateral Scout View

The lateral scout view is the key to ensuring correct positioning. If the patient is seen to be incorrectly aligned after the scout view is taken, he or she must be repositioned and **another lateral scout view must be taken** to confirm the new position. IDT incorporates the scout view into the patient's dataset and therefore a correct scout view must be included in the study. Wrong scout views can be deleted as they are of no use.

5. How Many Transaxial Slices to Acquire?

The number of slices taken should be the minimum needed to include the whole region of interest, with one or two slices either side for completeness.

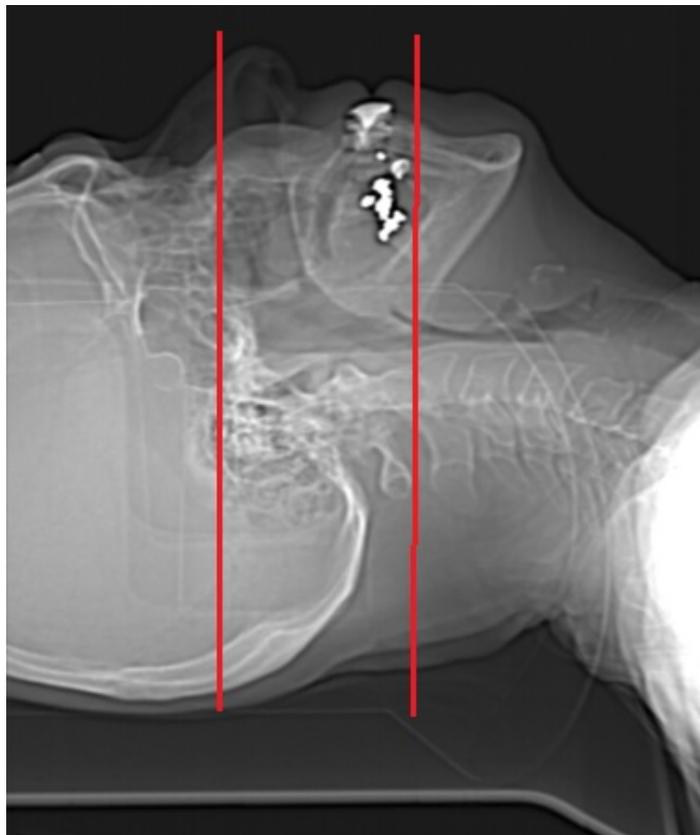


Figure 7: Dental CT Scan of the Maxilla

A Dental CT Scan of the Maxilla should include:

- about 10mm of the mandibular teeth, to indicate the occlusal relationship
- all of the bone that forms the Maxilla
- the full length of all the maxillary teeth
- the full extent of any radio-opaque markers or teeth in a stent
- at least 25 mm of sinuses above the hard palate
- all bone grafts and bone graft pins

- the full extent of all sinus grafts
- the full extent of polyps or other abnormalities
- additional regions if requested by the dentist.

It is best to start above the hard palate and scan downwards towards the teeth. This reduces the possibility of inadvertently scanning too many slices, resulting in excess radiation dose to the orbits. In the absence of explicit instructions from the dentist, set the **first slice about 25 mm above the hard palate**. Set the **last slice below the mandibular teeth**, or in an edentulous (no teeth) case, **below any stent or markers**. An average sized maxilla study will cover 40 to 50 mm, e.g. 160 to 200 slices spaced at 0.25 mm intervals.

Check the referral form for special instructions. In special cases, the referring dentist might ask for the zygomatic arch or lower border of the orbits to be included in the study.

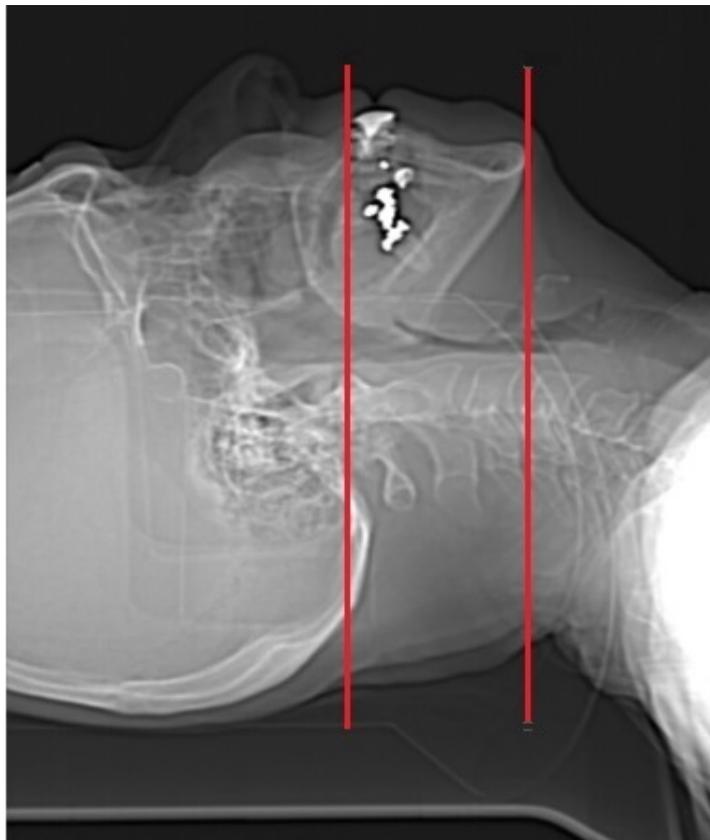


Figure 8: Dental CT Scan of the Mandible

A Dental CT Scan of the Mandible should include:

- about 10mm of the maxillary teeth, to indicate the occlusal relationship
- all the bone that forms the mandible
- half of the bone that forms the ramus of the mandible
- the full length of all mandibular teeth
- the full extent of any radio-opaque markers or teeth in a stent
- all bone grafts and bone graft pins
- full extent of any abnormalities

- additional regions if requested by the dentist.

It is best to scan towards the teeth and away from radiosensitive organs, in this case the thyroid. Set the **first slice below the inferior border of the mandible**. Set the **last slice above the maxillary teeth** and so that the posterior of the mandible (ramus) and any stent or markers is included. **IT IS NOT NECESSARY TO SCAN THE ENTIRE RAMUS UP TO THE TMJ (temporo-mandibular-joint) UNLESS EXPLICITLY REQUESTED.** An average size mandible will require 160 to 200 axial slices spaced at 0.25 mm intervals.

- **A reference slice will help you determine where to start.**
- **If you start or finish at the wrong place you cannot come back later and add extra slices to the start or the middle of a sequence – you must re-scan.**
- **All slices that are to be included in an IDT Dental CT Scan must be scanned in the same direction without changing the slice thickness, table increment, field of view, target centre or table height.**
- **Make sure the patient is positioned straight otherwise you might miss structures on one side.**

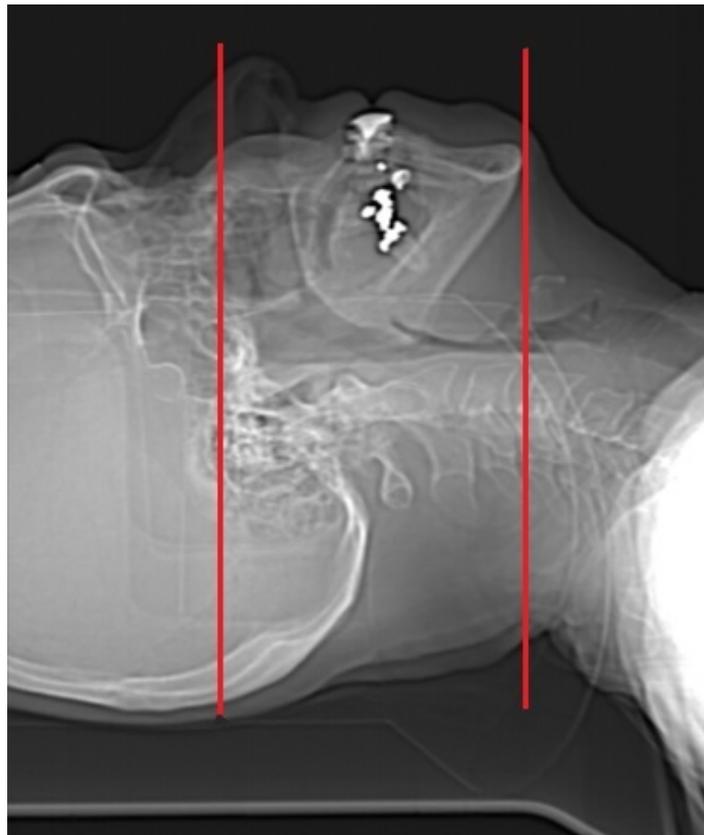


Figure 9: Dental CT Scan of Both Jaws

6. Before Letting the Patient Go

6.1 Check for Patient Motion

Keep the patient on the table until all the axial scans have been reconstructed and you have made a quick sagittal and/or coronal reconstruction if possible. This way you can verify whether or not the patient has remained motionless and the scan process has been completed properly. **If the patient has moved during the scan and you think they are capable of staying still next time, you should re-scan rather than having to call the patient back at a later date.** If in doubt, contact the referring dentist or IDT.

6.2 Keep the Raw Data

Please keep the raw data on the disk until you receive a feedback form from IDT indicating that the scan was satisfactory. If you have saved the raw data, you may be able to retrospectively reconstruct the transaxial slices again to correct any problems. For example if the wrong algorithm has been used or the target reconstruction has not been centred correctly.

7. Sending the CT Data to IDT

Please send us the entire study, including the axial slices, scout views and the Dose Report. **Do not send us the Raw Data or reformatted images (sagittals, coronals or 3Ds) that you make yourself.**

If your scanner reports (1) the scan duration in seconds, and (2) the dose-length product (DLP) in mGy.cm, please write these numbers down and include them on the paperwork or email them to IDT. Alternatively, please include the Dose Report or Patient Protocol screen with the images that you send to IDT. We will double-check these numbers and include them with the images sent to the referring dentist.

8. Keeping a Backup Copy

Please make a backup copy of the images using your local archival system (this may be your hard disk or PACS). The backup copy may be needed in case the original images get lost or corrupted. ***The back-up copy must be an exact FULL RESOLUTION copy of the images sent to IDT.***

9. The IDT Checklist

Please keep a copy of the following checklist nearby whenever doing a dental CT scan. It is a good "quick reference" and will ensure continued quality from your scanning site.

**THE IDT CHECKLIST
for
DENTAL CT SCANS**

- If there's no signed referral from the dentist – don't take the scan!
- Make sure the scanner does not transpose Left and Right on images
- Remove jewellery and metal dentures
- Make sure the patient is wearing the Stent if indicated on the Referral Letter
- Stabilize the jaws with a wooden tongue depressor to avoid movement
- Make sure the patient is straight and centred in the gantry
- Tilt the patient's head to the correct scanning plane
- Adjust the scanning plane to limit the effects of artefact
- Make sure the scanner settings are appropriate for a dental CT protocol
- Field of view approximately 15 cm, no gantry tilt
- Follow the dentist's instructions regarding the region to be scanned
- Do not scan more than has been indicated
- Make sure the ScoutView agrees with the axials (i.e. the patient didn't move)
- Don't add extra slices to the study or change the patient's position during the study
- Check for movement before the patient leaves
- Include Axials, ScoutViews and screen showing DLP in the images sent to IDT
- Make a backup copy on your hard disk or PACS.

10. Dental CT Feedback Form

You will be sent a Dental CT Scan Review with comments and suggestions following each Dental CT Scan performed for IDT. This indicates the most common and avoidable problems that can occur with dental CT Scans. Please keep in contact with the IDT office for information and guidance - there will always be someone who can answer your questions or provide advice on dental scanning procedures. Your feedback and comments to the referring dentist and to IDT will ensure the continued improvement of IDT Dental CT Scans.

DENTAL CT SCAN REVIEW

- | | | |
|-----|---|--|
| 1. | There was no lateral Scout View included with the data.
Please include a "Scout View" or "Localizer" with every dataset. | <input checked="" type="radio"/> N/A <input type="radio"/> Minor <input type="radio"/> Major |
| 2. | The axial slices do not correspond with the Scout View.
Please ensure the patient doesn't move after the Scout View is taken. | <input checked="" type="radio"/> N/A <input type="radio"/> Minor <input type="radio"/> Major |
| 3. | The patient was rotated / not straight with respect to the gantry.
Please position the patient as straight as possible. | <input checked="" type="radio"/> N/A <input type="radio"/> Minor <input type="radio"/> Major |
| 4. | An incorrect Slice Increment (interval) of mm was used.
Please use an increment of 0.3 or less for future scans. | <input checked="" type="radio"/> N/A <input type="radio"/> Minor <input type="radio"/> Major |
| 5. | An incorrect Slice Thickness of mm was used.
Please use a Slice Thickness of 0.75 for future scans. | <input checked="" type="radio"/> N/A <input type="radio"/> Minor <input type="radio"/> Major |
| 6. | An incorrect Gantry Tilt of degrees was used.
Please use a Gantry Tilt of 0 degrees for future scans. | <input checked="" type="radio"/> N/A <input type="radio"/> Minor <input type="radio"/> Major |
| 7. | An incorrect Field of View (FOV) of mm was used.
Please use an FOV of 150 mm for future scans. | <input checked="" type="radio"/> N/A <input type="radio"/> Minor <input type="radio"/> Major |
| 8. | An incorrect Reconstruction Kernel of was used.
Please use B for future scans. | <input checked="" type="radio"/> N/A <input type="radio"/> Minor <input type="radio"/> Major |
| 9. | An incorrect Scanning Plane was used.
Please scan parallel to the Occlusal Plane unless otherwise specified. | <input checked="" type="radio"/> N/A <input type="radio"/> Minor <input type="radio"/> Major |
| 10. | An excessive number of axial slices appears to have been acquired.
This makes the Effective Dose higher than necessary.
Please don't scan more than the Referrer has requested. | <input checked="" type="radio"/> N/A <input type="radio"/> Minor <input type="radio"/> Major |
| 11. | The region scanned did not include all of the bony anatomy or landmarks required. Please include the full height of teeth and markers. | <input checked="" type="radio"/> N/A <input type="radio"/> Minor <input type="radio"/> Major |
| 12. | The patient moved during the examination.
Please encourage the patient to stay entirely still. | <input checked="" type="radio"/> N/A <input type="radio"/> Minor <input type="radio"/> Major |

Remarks:

No Probs Minor Probs Major Probs Training Required Rescan Required

If you have any questions on the above - please phone IDT on +44 (0)20 8982 3588

Checked By: RAR

Date: 2009-12-14

IT IS NOW SAFE TO DELETE YOUR COPY OF THE PATIENT'S IMAGES