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How CBCT Scanners are being used in practice

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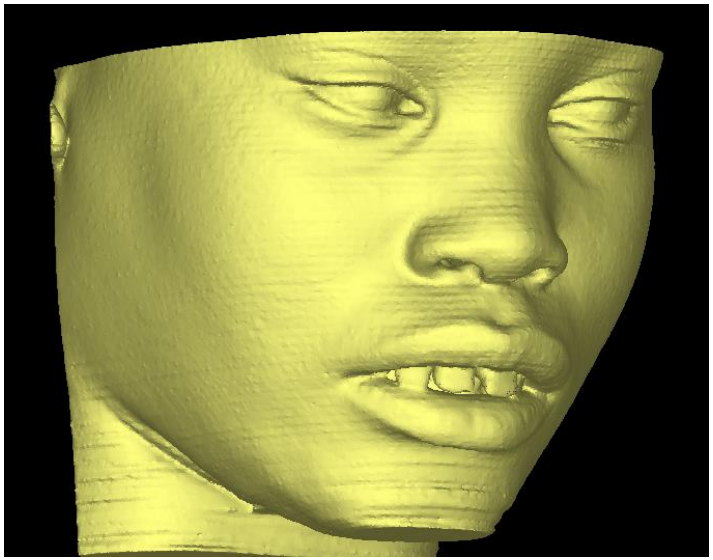
Who or what is IDT?

Image Diagnostic Technology Ltd aka "IDT Scans"



Specialises in:

- **arranging dental CT/CBCT scans**
- **3D processing**
- **radiology reports**
- **implant simulation**
- **3D models**
- **surgical drill guides**

25,000 scans processed since 1991

FOV, kVp, mAs, DAP, DLP, Effective Dose stored in database for last 5000 scans

Outline of Presentation

- **Introduction / Disclosure**
- **Analysis of Stored Data**
- **Interpretation of Results**
- **Why QA and Training are Important**

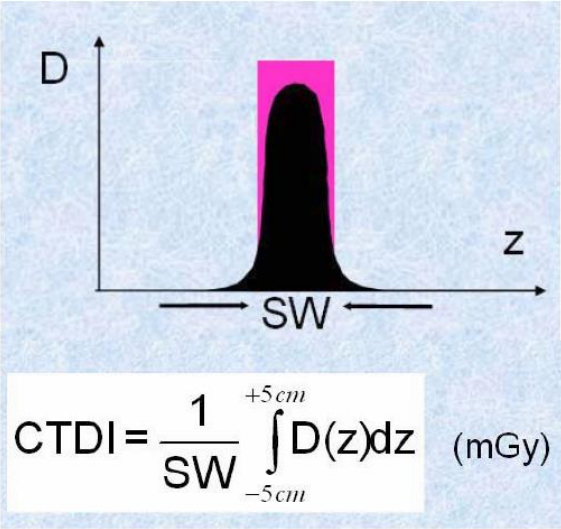
	Sirona XG3D	i-CAT 17-19	Gendex CB-500	Carestream 9000 3D	Vatech PaX-Flex3D	NewTom VG	J.Morita Accuitomo 170	Planmeca Promax 3D
Min DAP	157	212	111	117	149	209	125	270
Avg DAP	**304**	**346**	**358**	**361**	**410**	**536**	**663**	**752**
Max DAP	563	947	589	708	1032	830	2170	1430
n=	**34**	**217**	**548**	**63**	**105**	**31**	**497**	**26**

Table 1A. Average DAP (mGy.cm2) retrieved from DICOM headers

Dose Length Product (DLP)

DLP = $CTDI_{vol}$ x Irradiated Length

Effective Dose = DLP x F (where F is a conversion factor)



- **most CBCT manufacturers don't display $CTDI_{vol}$ (exception: J.Morita, NewTom)**
- **$CTDI_{vol}$ = <u>Effective Dose</u>**
  F x Irradiated Length
- **Can use $CTDI_{vol}$ to interpolate published data**

	Sirona XG3D	i-CAT 17-19	Gendex CB-500	Carestream 9000 3D	Vatech PaX-Flex3D	NewTom VG	J.Morita Accuitomo 170	Planmeca Promax 3D
Min E.D.	20	10	20	20	20	25	10	40
Avg E.D.	**46**	**48**	**64**	**43**	**52**	**60**	**63**	**88**
Max E.D.	95	145	120	115	105	100	195	165
n=	**34**	**217**	**548**	**63**	**105**	**31**	**497**	**26**

Table 1B. Effective Doses (μSv) interpolated from published data*

Ludlow JB et al. Effective dose of dental CBCT – a meta analysis of published data and additional data for nine CBCT units.** ***Dentomaxillofac Radiol **2015; 44; 20150197**

Interpretation

- **Users prefer the higher dose settings**
  - **Some machines deliver better low dose images than others**
  - **QA is vital to ensure optimal performance at low dose**
- **Operator Training is very important**
  - **Operators do not have a good understanding of practical ways to reduce the radiation dose.**

Principles of Radiation Protection

- **Justification** **(benefits must outweigh the risks)**
- **Optimisation** **(keep doses As Low As ~~Reasonably Achievable~~) Diagnostically Acceptable**
- **Dose Limits** **(1 mSv per year for members of the public)**
  (no dose limits for medical exposures)

Want to Optimise

$$\frac{\textbf{Benefit to Patient*}}{\textbf{Risk to Patient}}$$

*** not to the dentist!**

What is the Risk from a CBCT scan?

- **Assume adult patient, dento-alveolar scan, both jaws**
- **Effective Dose might be 100 microSieverts**
- **Risk that patient might develop fatal cancer in 20 years time**

  = 5% (1 in 20) per Sievert (from ICRP103)

  = 1 in 20 million for 1 microSv

  = 100 in 20 million for 100 microSv

  = 1 in 200,000 (roughly) for 100 microSv

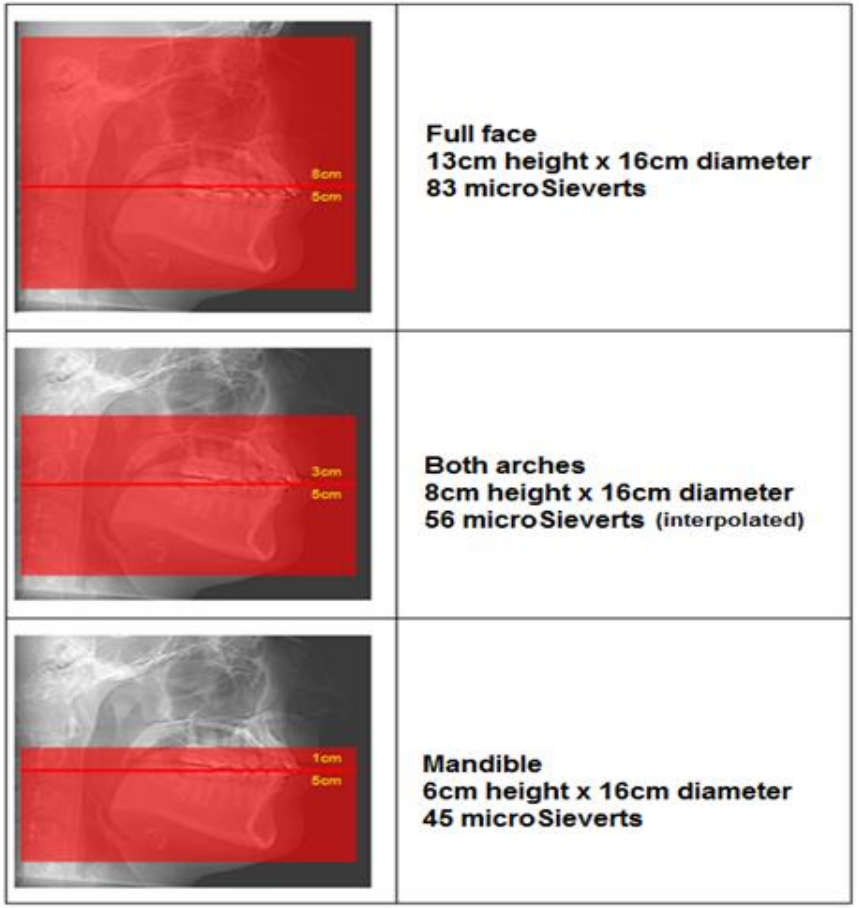
Health & Safety people would call this a "Minimal Risk"

*** If your patient is a child the risk is 3x more**

Practical ways to Reduce the ~~Risk~~ Dose

1. **Reduce the Height (vertical collimation)**

   Reduces the risk without loss of benefit in most cases.



Absorbed Dose outside primary beam is effectively zero

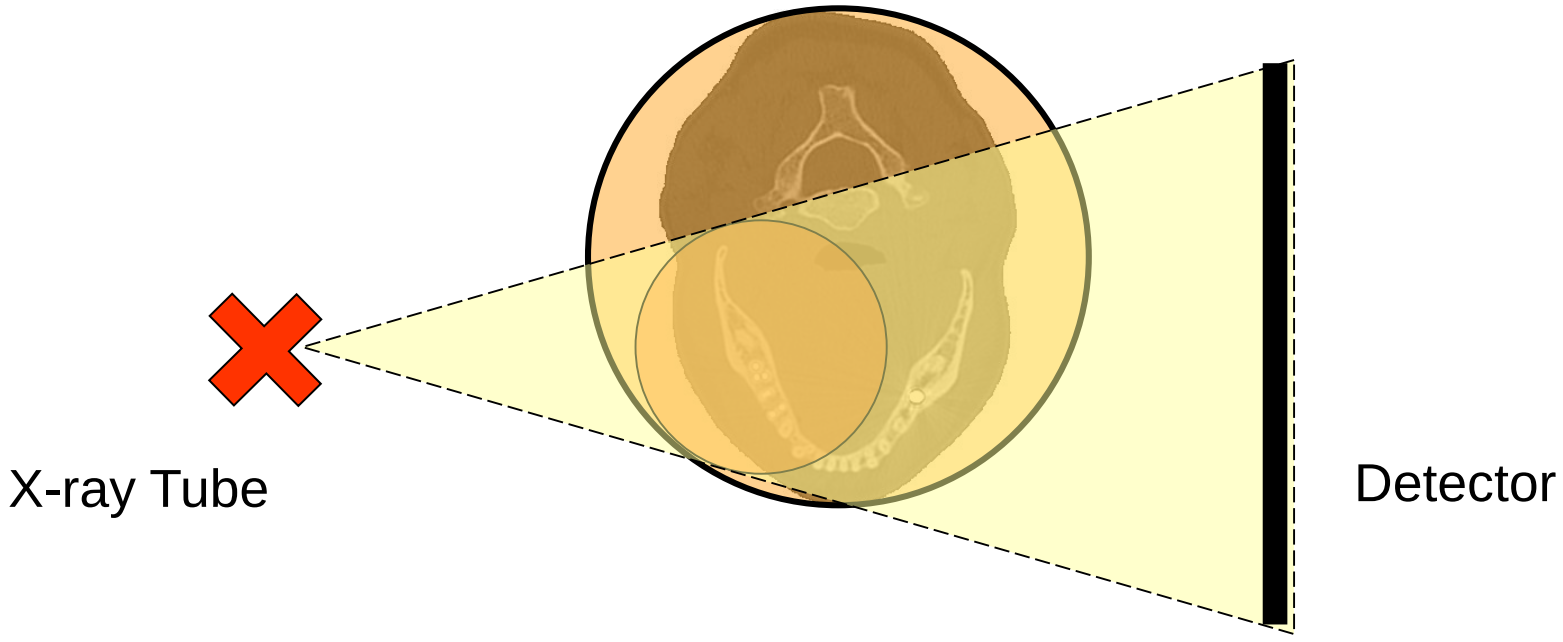
More ways to Reduce the Dose

2. **Reduce the mAs (tube current, scan time)**

- **Reducing the mAs may have a negative impact on image quality**

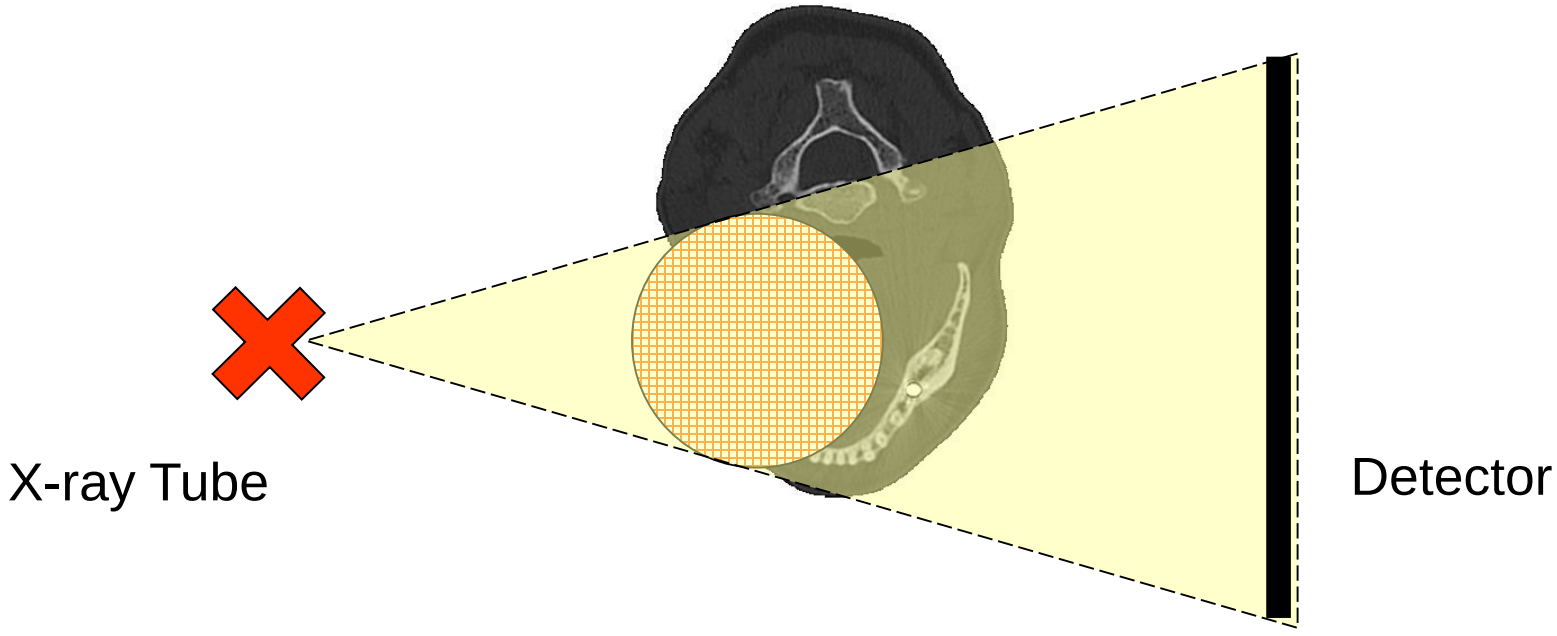
- **On some scanners, the voxel size is linked to the mAs**

3. Reduce the Width (horizontal collimation)



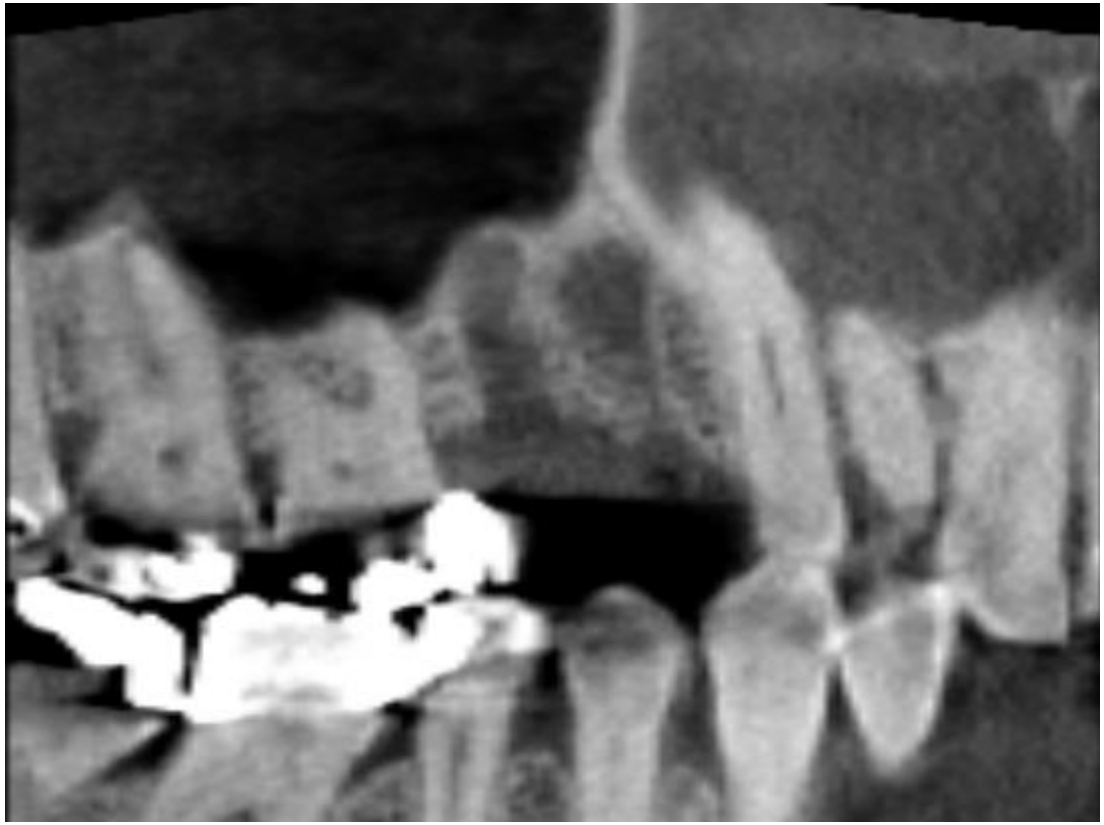
- **Absorbed Dose outside primary beam is not zero (about 50% from SEDENTEXCT measurements)**
- **There may be some loss of benefit**

Basic problem with Small Field Of View

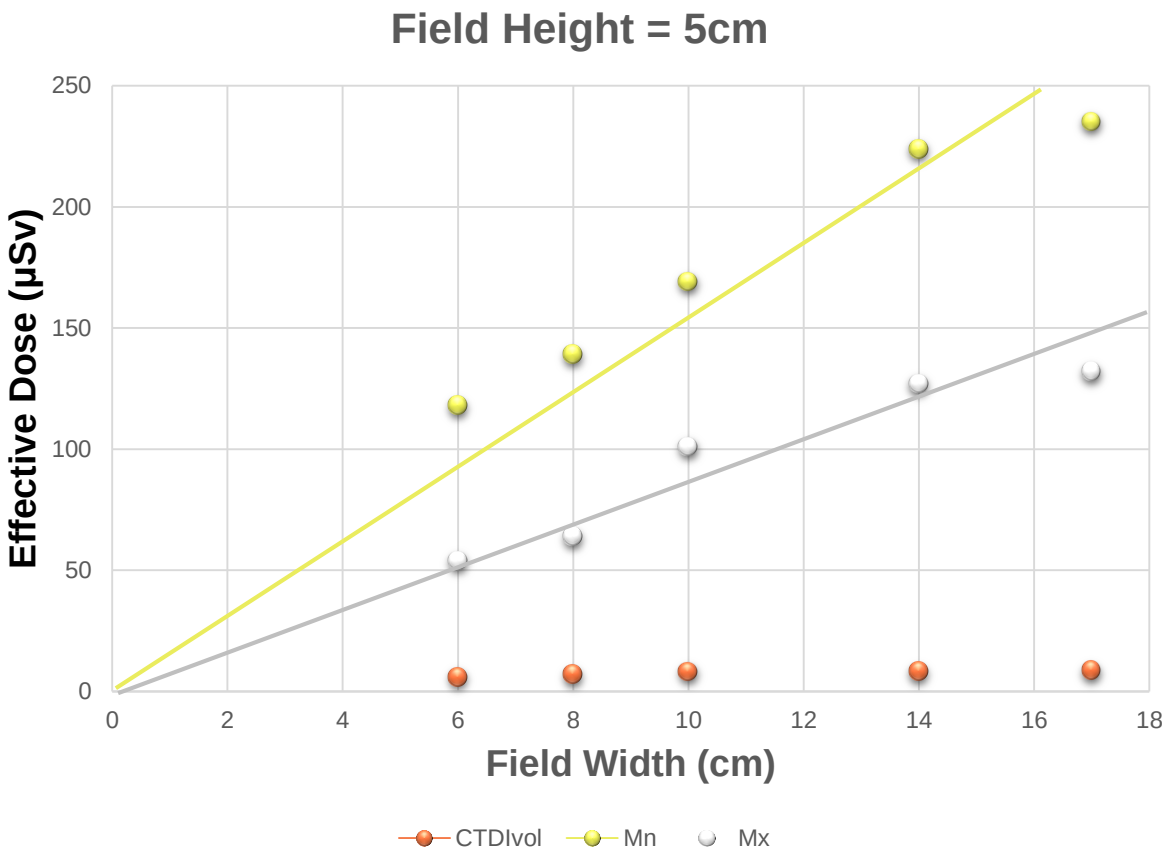


- **CBCT measures the density within the Field Of View only**
- **Material outside the Field Of View has an unpredictable effect**

Air should be black



J.Morita Accuitomo



Variation of Effective Dose* with Field Width

***data interpolated from: Ludlow JB et al. Effective dose of dental CBCT – a meta analysis of published data and additional data for nine CBCT units. *Dentomaxillofac Radiol* 2015; 44; 20150197**

Summary of ways to Reduce the Dose

1. **Reduce the Height**
   - **linear reduction in risk, no loss of benefit in most cases**

2. **Reduce the mAs**
   - **linear reduction in risk, some loss of benefit**

3. **Reduce the Width**
   - **less than linear reduction in risk, more loss of benefit**

CBCT State of the Art (circa 2005)

fixed mA
2 scan times
20s or 40s

pulsed
x-ray tube

low dose
typical Mx 30μSv
typical Mn 45μSv

adjustable
collimator
4 to 13 cm height
9.5 or 16 cm width

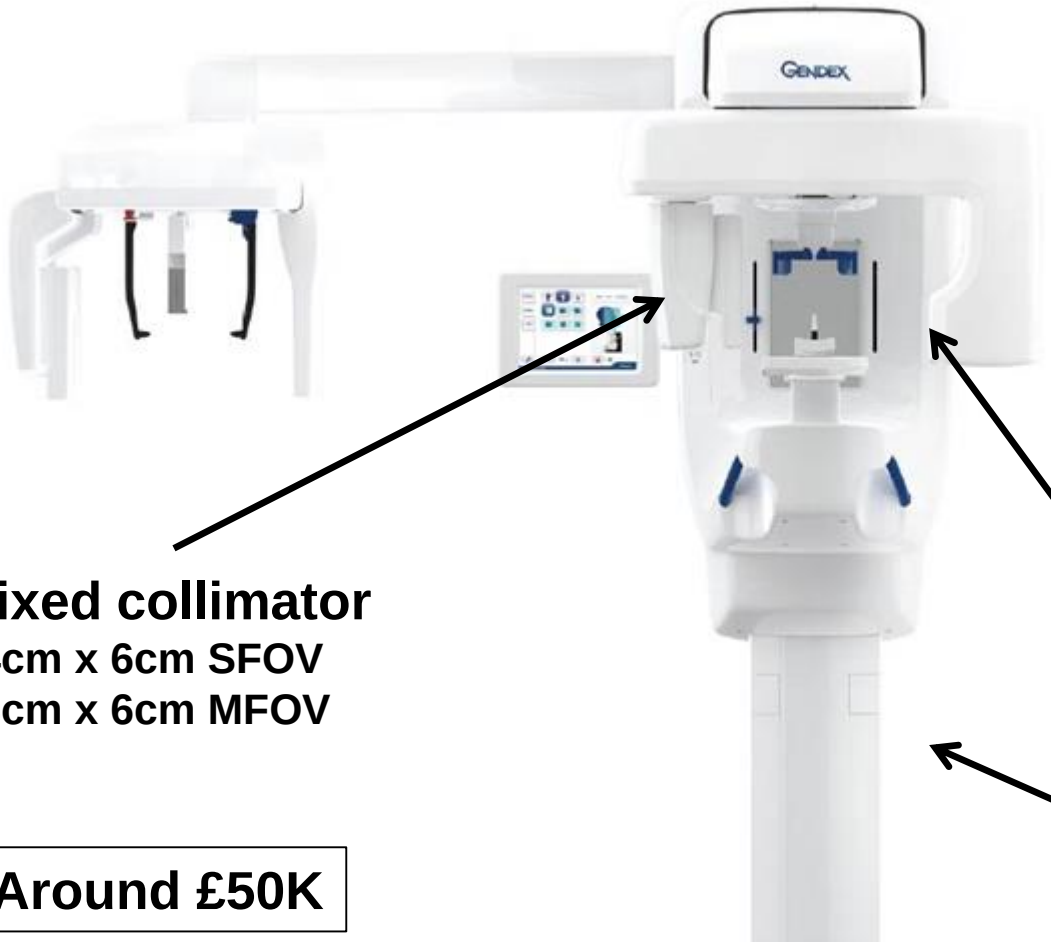
large
detector
18cm x 24cm

adjustable
chair

Around £150K

i-CAT™ is a trademark of Imaging Sciences International LLC of Hatfield, USA

CBCT State of the Art (circa 2015)



variable mA
fixed scan times
11s for SFOV
45s for MFOV

medium dose
typical Mx 60µSv
typical Mn 100µSv

fixed collimator
4cm x 6cm SFOV
8cm x 6cm MFOV

small detector

no chair

Around £50K

Gendex™ is a trademark of Gendex Dental Systems of Lake Zurich, USA

A Brief History of Dental CBCT

- **Technical aspects have not advanced significantly over the last 10 years**
- **We've lost the ability to collimate vertically**
- **Average doses have not decreased**
- **Machines have become much less expensive**

The Best CBCT Scanner on the Market

Toshiba Aquilion ONE medical CT Scanner

320 detector rows

operates in cone beam mode

0.5s scan time

volume capture
24cm x 16cm max

Effective doses
typical Mx 100μSv
typical Mn 150μSv

Around £1M

Dental Protocols on medical CT Scanners

- **Operator has more control over kVp, mAs, pitch than on a dental CBCT scanner.**
- **The dentoalveolar region has high natural contrast, so we can get away with a low radiation dose.**
- **Training is required to help operators choose a low dose protocol for dental CT scans.**

	Toshiba Aquilion ONE	Siemens Definition AS	GE LIghtSpeed VCT	Siemens Sensation 64	Philips Brilliance 64	Toshiba Aquilion 64	Siemens Emotion 6
Min DLP	42	47	72	88	83	53	95
Avg DLP	**60**	**112**	**123**	**123**	**138**	**147**	**155**
Max DLP	90	238	242	170	242	295	228
n=	**28**	**46**	**351**	**36**	**70**	**129**	**35**

Table 2A. Average DLP (mGy.cm) retrieved from DICOM headers

	Toshiba Aquilion ONE	Siemens Definition AS	GE LIghtSpeed VCT	Siemens Sensation 64	Philips Brilliance 64	Toshiba Aquilion 64	Siemens Emotion 6
Min E.D.	70	100	150	150	160	111	145
Avg E.D.	**124**	**276**	**370**	**310**	**346**	**416**	**343**
Max E.D.	200	550	750	475	630	880	650
n=	**28**	**46**	**351**	**36**	**70**	**129**	**35**

Table 2B. Effective Doses (µSv) estimated from DLP*

***conversion factorsfrom Shrimpton PC et al. Effective dose and dose-length product in CT.**
***Radiology* 2009; 250; 604-605.**

~~*Why Training is Important*~~
Some Popular Misconceptions:

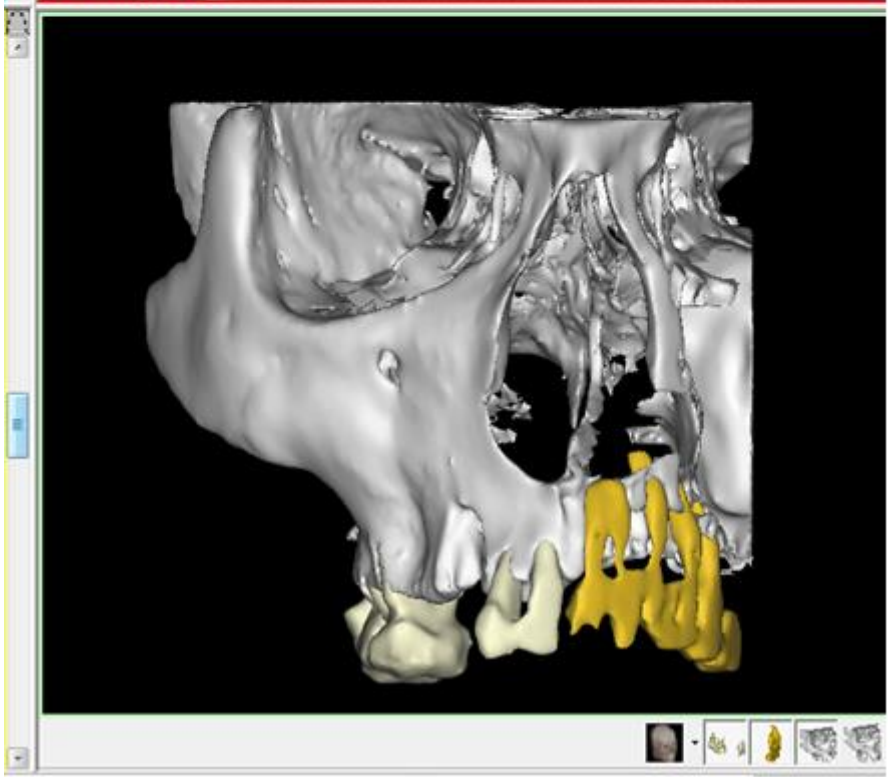
1. **If I can't see it in the images it didn't receive any dose**
   FALSE

2. **If the Field Of View is small then the dose must be low**
   Effective Dose on a 4cm x 6cm can be up to 150µSv

3. **Even if the Effective Dose is high, it's just a small region so the risk is low**
   FALSE

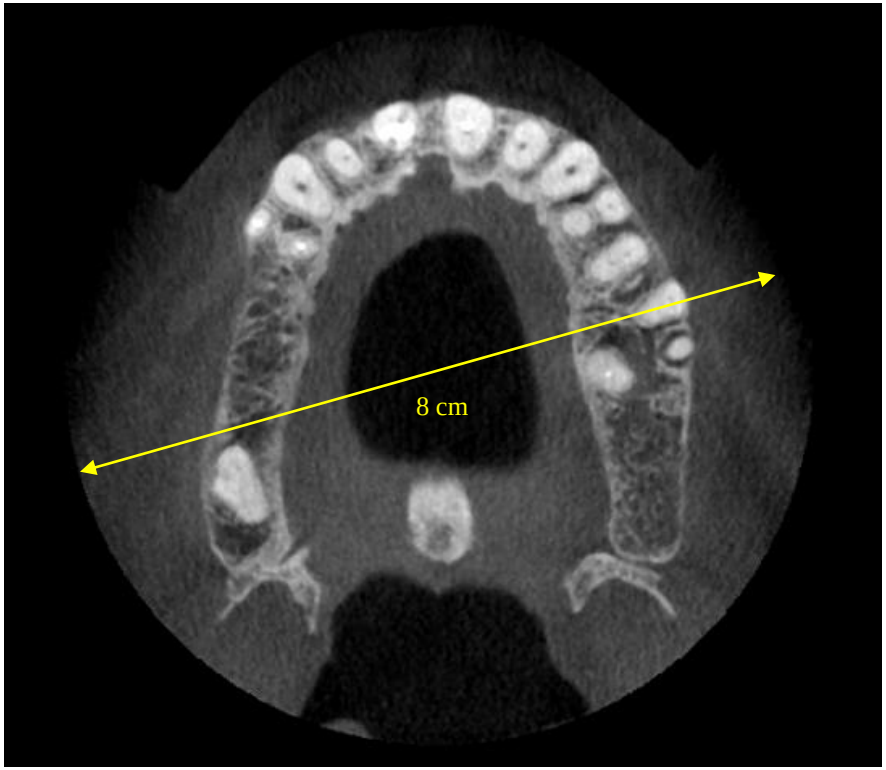
4. **If I can't see it in the images I don't have to report on it**
   TRUE

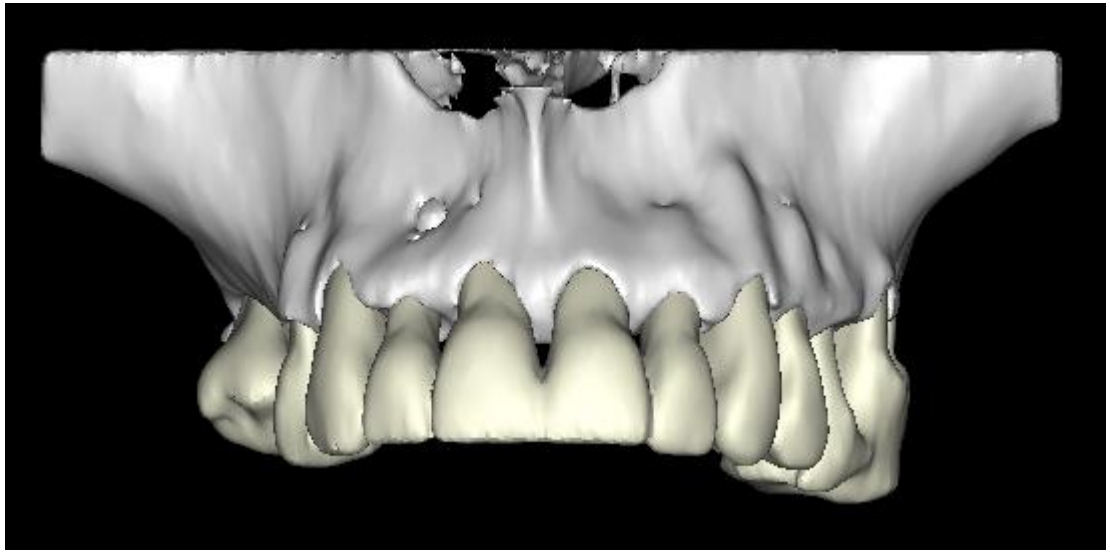
Rogues Gallery



Moving patient to the side (without reducing the Field Of View) –

does it reduce the dose?

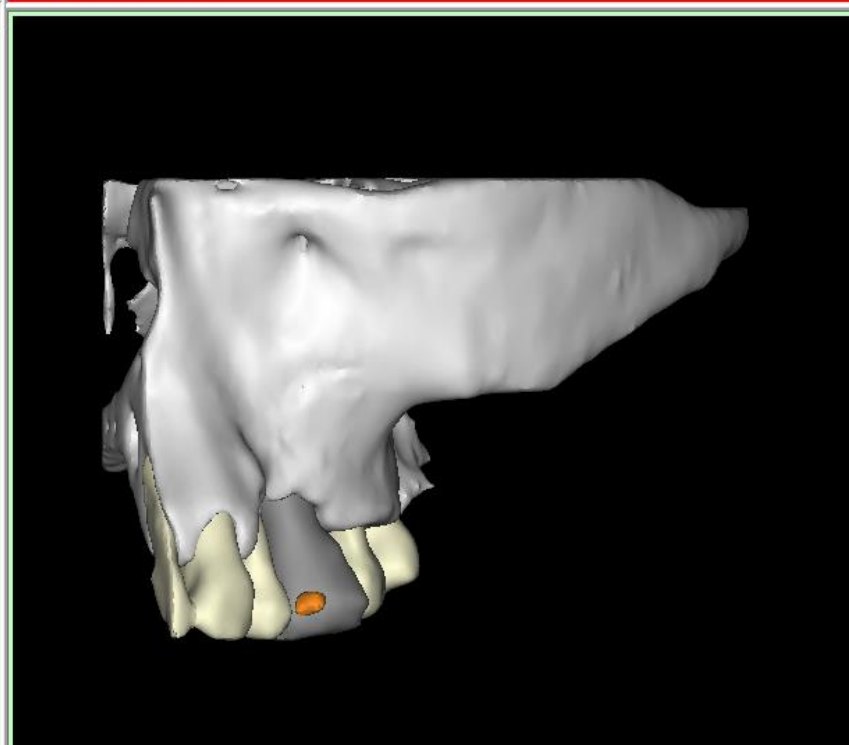

8 cm




B
L
31

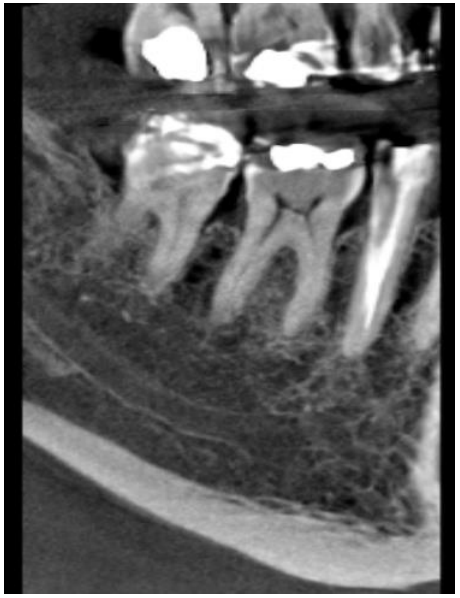

R
CT Axial: -27.38


R
L



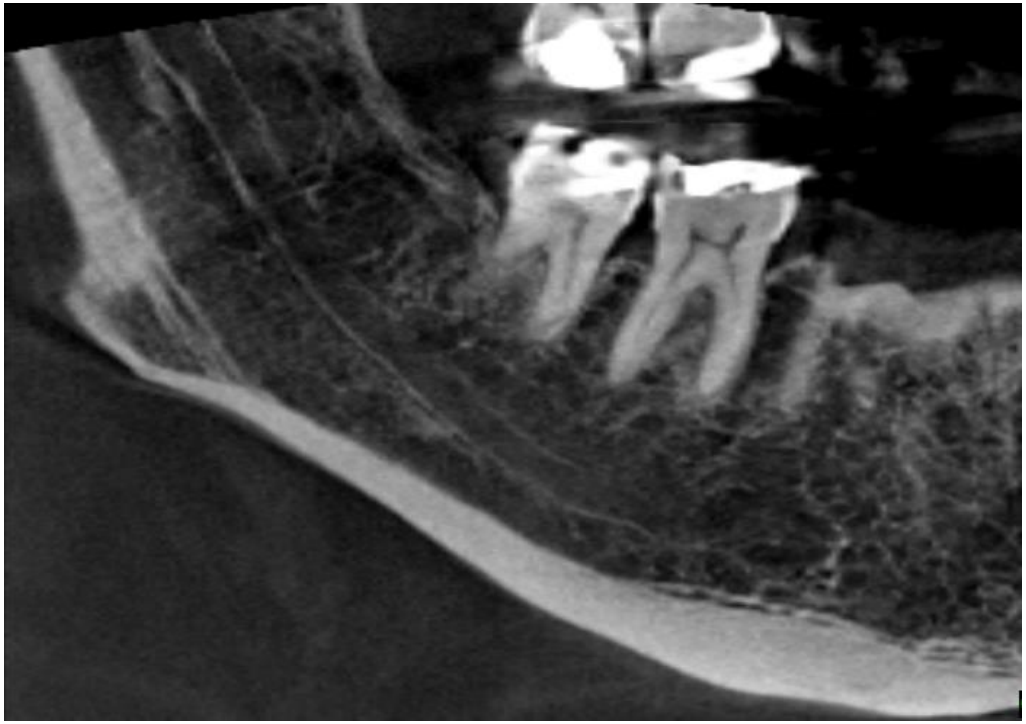
IDT27226

Accuitomo F170
14cm x 10cm
0.25mm voxels
DAP 2170 mGy.cm2
DLP 81.8 mGy.cm
Effective Dose
240µSv approx.

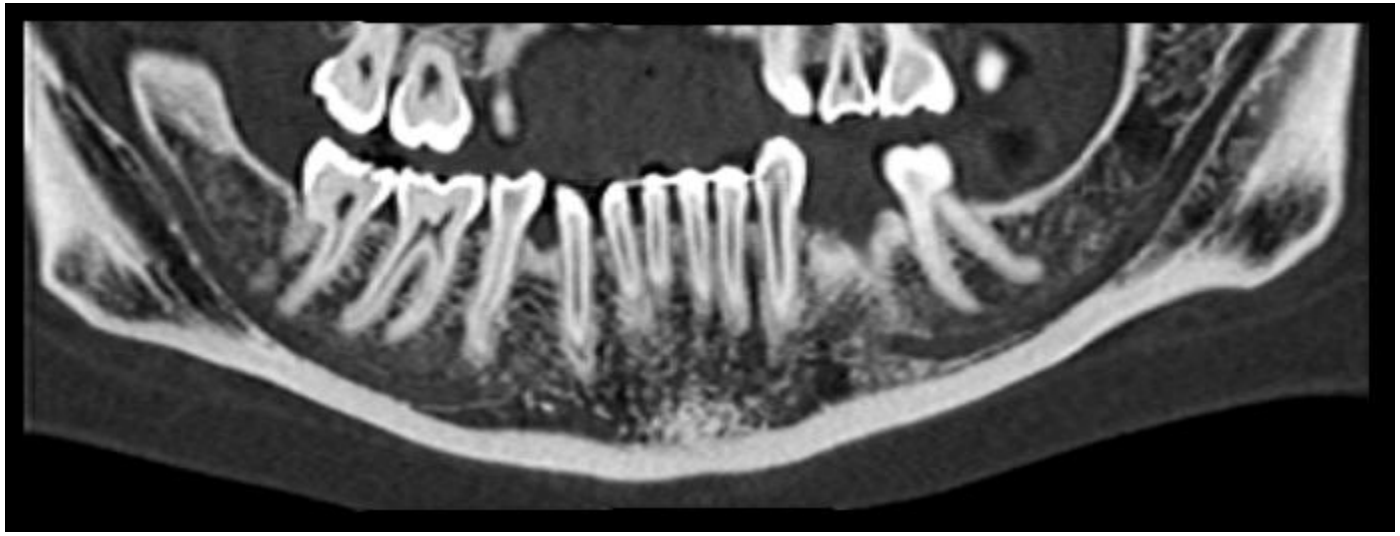


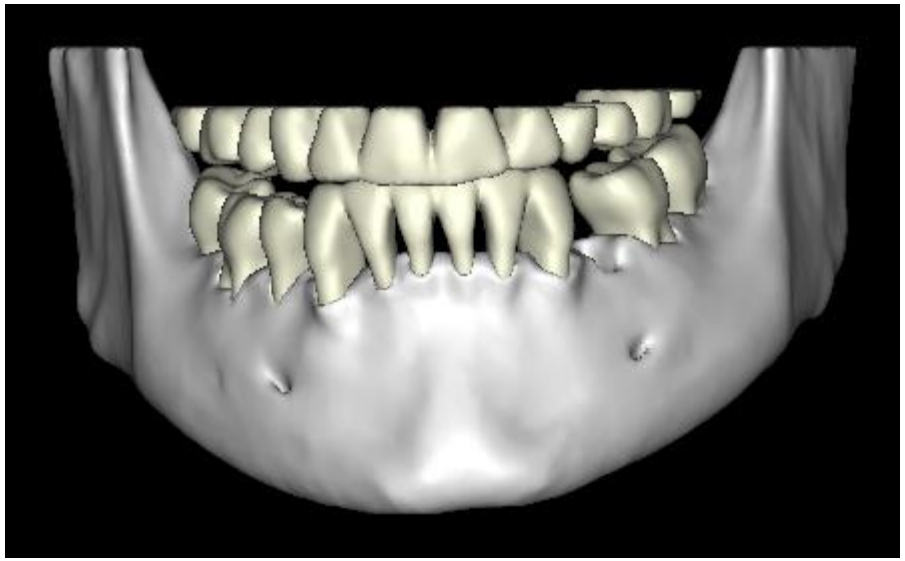
IDT29826

Gendex DP-700
4cm x 6cm
0.133mm voxels
79 mAs
DLP 35.9 mGy.cm
Effective Dose
150µSv approx.

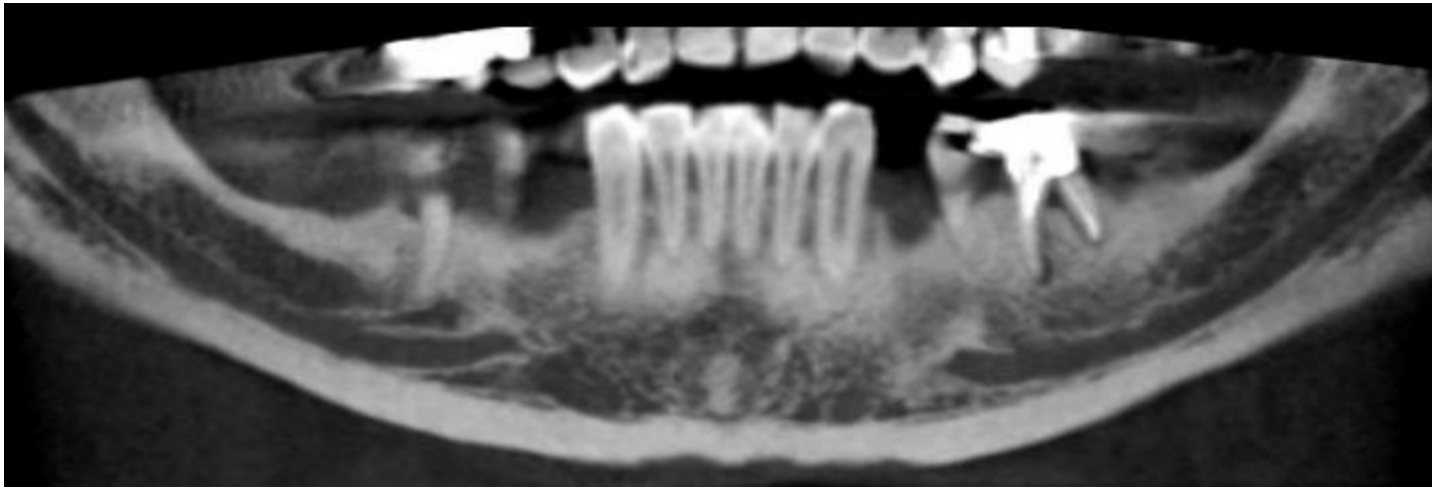


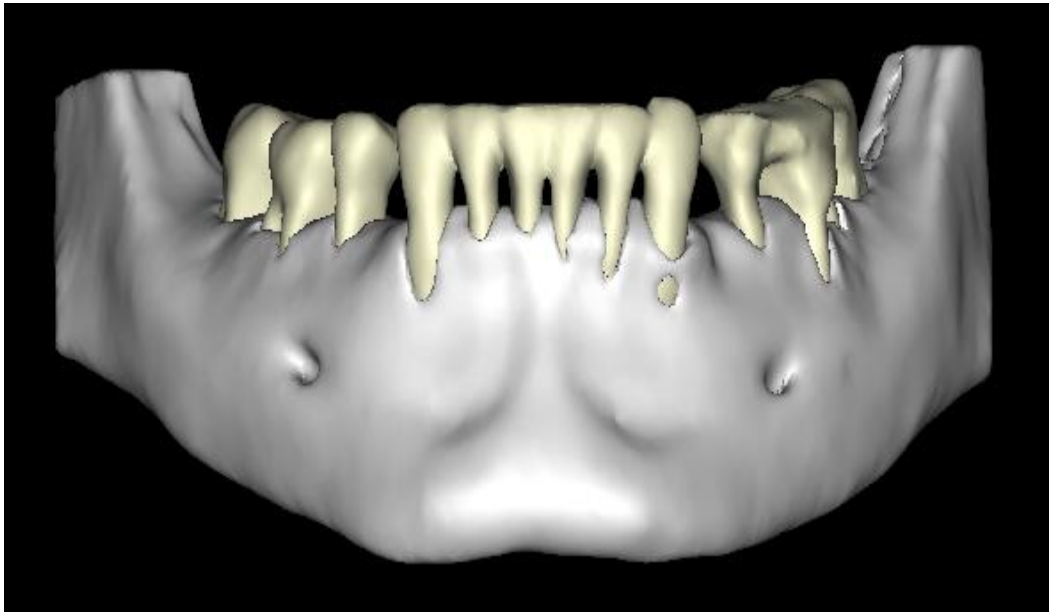
Gendex DP-700
8cm x 6cm
0.2mm voxels
132.5 mAs
DLP 58.5 mGy.cm
Effective Dose
230µSv approx.





Toshiba Aquilion ONE
12cm x 6cm
0.25mm voxels
DLP 54mGy.cm
Effective Dose 150µSv approx.





IDT27563
i-CAT Classic
9.5cm x 5.4cm
0.25mm voxels
DLP 13mGy.cm
Effective Dose 50µSv approx.

Conclusions

- **Effective Doses from Dental CBCT are not as low as they could be.**
- **QA is important to keep machines running optimally**
- **Training is important to give Operators a good understanding of how to monitor and reduce the dose.**