Dental scan MDCT: comparison of dose levels and image quality assessment between three centres in two European countries

S. Puggina,
S. Galo, M. Calderone, L. Best, K. Katsari, R. Illing

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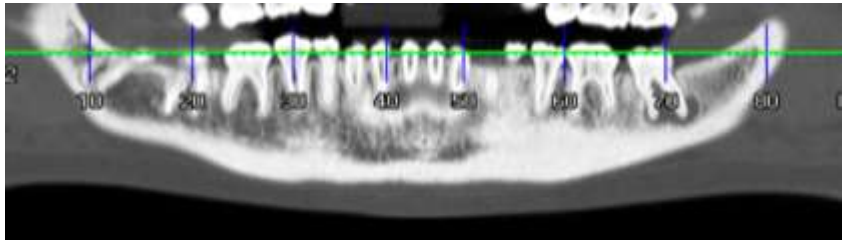
Aims and objectives

To analyse the relationship between **radiation exposure** and **diagnostic image quality** of **dental multidetector Computed Tomography (MDCT)** protocols, to determine best practice and compare to published dose data from cone beam CT (CBCT).

To determine the protocol with the lowest achievable CT dose for clinically appropriate image quality.



Why Dental MDCT?

- Common Examination!!
- Standard Protocol (mandible and/or maxilla)
- Interesting dose comparison with increasingly widespread CBCT

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Methods and materials

Study design and patient selection

Data from **90 patients** who underwent dental MDCT examination were collected from three European centers. The patients were categorized by center into three groups of 30, with the first and second groups from Italy and the third group from Portugal.

Inclusion and exclusion criteria

Only mandible Dental MDCT.
Clinical indication: tumors, cysts, inflamatory disease (endodontal and peryodontal), oroantral fistulas, dental implantology.
No TMJ evaluation.

Scanning Procedure and Protocols

Protocols from three MDCT scanner models were compared:

1. Discovery 750 HD 128 with ASiR (GEHC, Mil. USA)
2. LightSpeed VCT 64 with ASiR (GEHC, Mil. USA)
3. Somatom Sensation 64 with Care Dose option (Siemens Healthineers, Germany).

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Methods and materials

Data collection and analysis

The departments use GE HealthCare DoseWatch™ software to assist them in patient dose tracking and dose management. The **protocol parameters** and **Total DLP** values of each examination were exported from DoseWatch™.

Table I. Protocol parameters and dosimetric data

Protocol	Parameters	Slice Thickness (mm)	Spacing (mm)	Tube potential kV	AEC	Noise Index (NI)	Max Tube Current (mA)	Exposure time/ Rotation (ms)	Pitch	Dose Reduction %	Total DLP (mGy.cm)	Effective Dose (mSv)
1	MEAN	0,625	0,625	120	YES	12,00	150	1,00	0,53	50	285,64	0,60
	MEDIAN	0,625	0,625	120			150	1,00	0,53		287,37	0,60
	MIN	0,625	0,625	120			150	1,00	0,53		236,87	0,50
	MAX	0,625	0,625	120			150	1,00	0,53		344,90	0,72
2	MEAN	0,625	0,310	100	YES	9,10	300	0,50	0,52	30,00	131,17	0,28
	MEDIAN	0,625	0,310	100			300	0,50	0,52		124,71	0,26
	MIN	0,625	0,310	100			300	0,50	0,52		82,71	0,17
	MAX	0,625	0,310	100			300	0,50	0,52		201,63	0,42
3	MEAN	0,75	0,50	120	YES	NA	140	1,00	0,90	0,00	149,21	0,31
	MEDIAN	0,75	0,50	120			140	1,00	0,90		141,18	0,30
	MIN	0,75	0,50	120			140	1,00	0,90		113,69	0,24
	MAX	0,75	0,50	120			140	1,00	0,90		305,61	0,64

Methods and materials

Data collection and analysis

A set of images was set as **reference images**, selected from the local database that complied to best practice guidelines

All images (volume and MPR) were **anonymized** and **uploaded** on a viewing platform prepared by Biotronics 3Dnet

Three experienced radiologists independently reviewed the whole examinations for Image Quality Assessment.

Image Quality Assessment was performed in terms of **anatomy visualization** and **critical anatomical features** using a 5 level scale for subjective quality, based on the clinical indications modified European Guidelines on Quality criteria for computed tomography .
For the assessment of **pathology visualization**, a 3 level scale was used and scored.

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ANATOMY VISUALIZATION

Visualization of:

- *mandible*
- *mandibular canal*
- *mental foramen*
- *mandibular foramen*
- *teeth roots*

Definition of evaluation scales	
Clearly lower than the reference images	-2
Slightly lower than the reference images	-1
Equal to the reference images	0
Slightly better than the reference images	1
Clearly better than the reference images	2

CRITICAL ANATOMICAL FEATURES

Visually sharp reproduction of:

- *mandible (cortical and trabecular bone)*
- *mandible (width and height)*
- *mandibular canal*
- *teeth roots and mandibular canal relationship*
- *relationship between lesions (lytic or sclerotic) and the cortical margins and roots of the teeth*

Definition of evaluation scales	
Confident that the criterion is not fulfilled	-2
Somewhat confident that the criterion is not fulfilled	-1
Indecisive whether the criterion is fulfilled or not	0
Somewhat confident that the criterion is fulfilled	1
Confident that the criterion is fulfilled	2

PATHOLOGY VISUALIZATION

Presence of:

- *endodontal lesions*
- *peryodontal lesions*
- *bone lesion*

Definition of evaluation scales	
Not present	1
Present	2
Undecisive	3

ANATOMY VISUALIZATION

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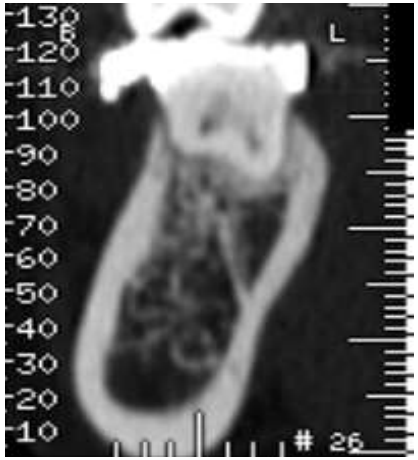

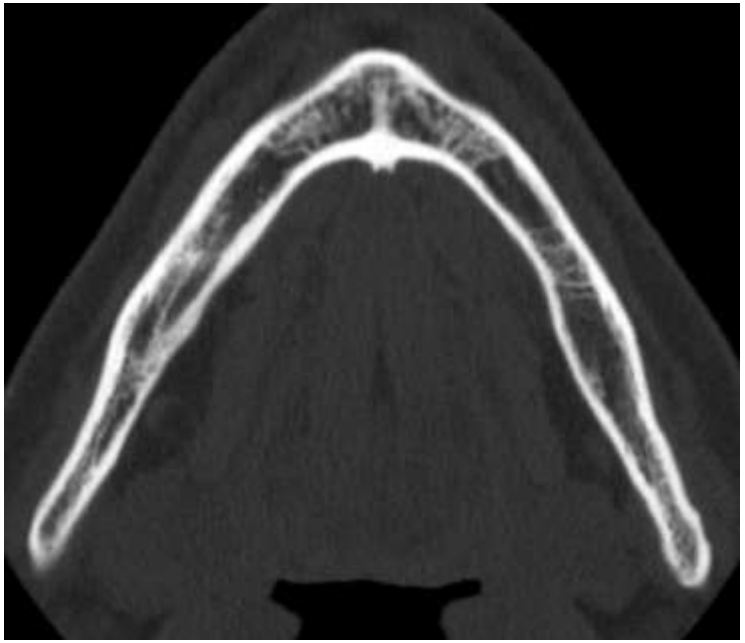

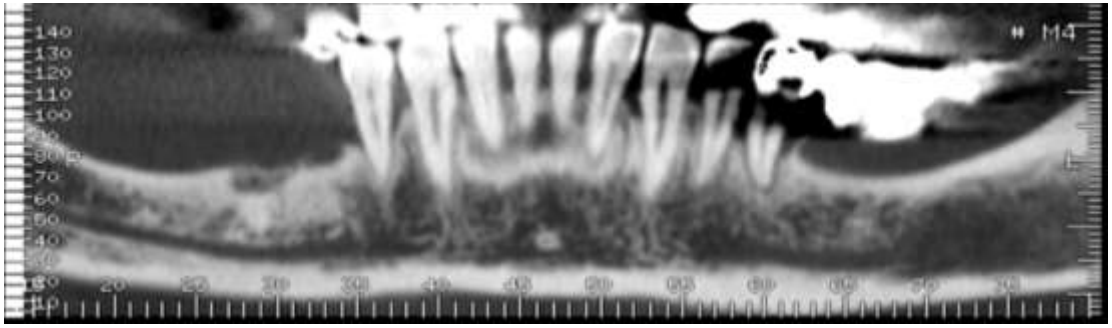

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Statistic analysis and Results

A **one way Anova** was performed to compare the **median** value of **DLP** and **effective dose** of the three Protocols

	Total DLP (mGy.cm)	Effective Dose (mSv)	
MEAN	285,64	0,60	PROTOCOL 1
MEDIAN	287,37	0,60	
MIN	236,87	0,50	
MAX	344,90	0,72	
	Total DLP (mGy.cm)	Effective Dose (mSv)	
MEAN	131,17	0,28	PROTOCOL 2
MEDIAN	124,71	0,26	
MIN	82,71	0,17	
MAX	201,63	0,42	
	DLP (mGy.cm)	Effective Dose (mSv)	
MEAN	149,21	0,31	PROTOCOL 3
MEDIAN	141,18	0,30	
MIN	113,69	0,24	
MAX	305,61	0,64	

Dosimetric parameters evaluation

- DLP varies significantly by protocol
- Effective dose varies significantly by protocol
- Protocol 1 has significantly higher DLP and effective dose than Protocol 2 and Protocol 3
- Non-significant statistical differences in DLP and effective dose variation in Protocol 2 and Protocol 3

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Statistic analysis and **Results**

Inter-rater reliability evaluation

The data from **Fleiss Kappa Comparison** suggests good inter-rater reliability across critical anatomical features visualization and pathology evaluation .
In regards to anatomy visualization Protocol 2 has significantly lower agreement than Protocol 1; no significant difference between the other protocols .
According to the **two tailed significant test of Pearson coefficient results**, there is no significant correlation between DLP and fleiss' kappa for visualization of anatomy (proxy for image quality).

Correlation between dose levels and image quality

DLP does not have a significant effect on visualisation scores.

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Statistic analysis and Results

Image quality evaluation

Two tailed t tests revealed significant differences in the visualization score between the protocols:

- Protocol 1 has a significantly lower score than Protocol 2
- Protocol 3 has significantly higher scores than Protocol 2; both offer diagnostically accurate images in visualization of expected and critical anatomical structures.

In particular, using a **two tailed t test with unequal variances with Bonferroni correction**:

Anatomy visualization comparison:

- *Protocols 2 and 3 have significantly higher scores than protocol 1*
- *Protocol 3 has significantly higher scores than protocol 2*

Critical anatomical features comparison:

- *Protocols* 2 and 3 have significantly higher scores than *protocol* 1
- *Protocol* 3 does not have significantly higher scores than *protocol* 2

Conclusions

The Protocol with the highest radiation dose, in this study, didn't result in the production of high quality images.

Dose Monitoring and comparison of different CT scanners permit real optimization of protocols in terms both of image quality and radiation exposure, as well as comparison between vendors and models.

The most appropriate scanning protocol selected, to standardize across the centers in this study, was the one that provided the lowest achievable radiation dose with diagnostically accurate image quality

Protocol 2 (Mean Effective Dose 0,28 mSv) compared with CBCT published dose data, has significantly higher level of **radiation dose.**

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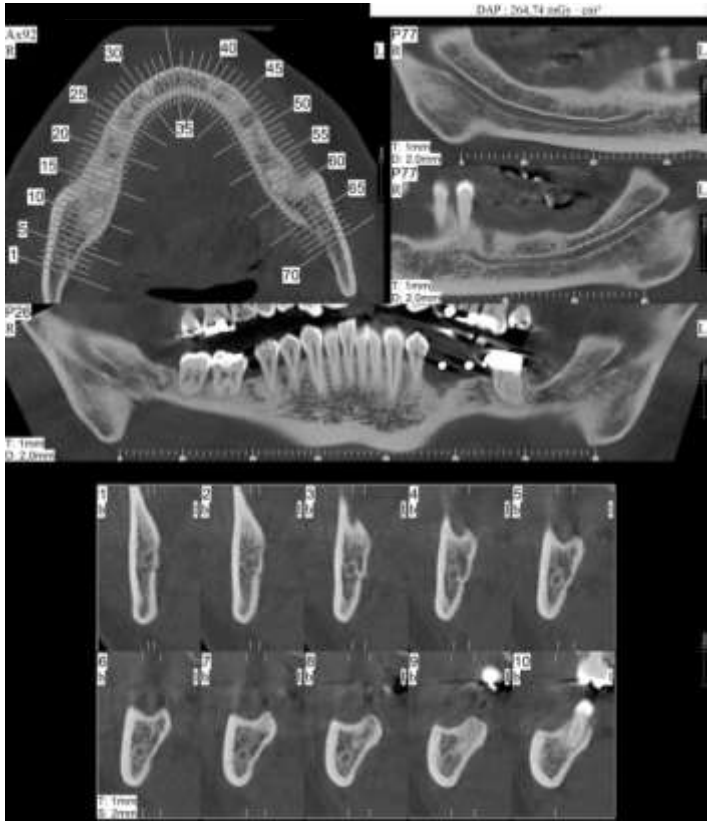

Dental CBCT

Effective dose (mSv): Mean/SD*

- CBCT (large FOV): 0.21 / 0.21

Data are from the following sources:

CBCT (large FOV): Ludlow JB, Timothy R, Walker C, Hunter R, Benavides E, Samuelson DB, et al. Effective dose of dental CBCT—a meta analysis of published data and additional data for nine CBCT units. Dentomaxillofac Radiol 2015; 44: 20140197.

CT (brain + PF): Conference of Radiation Control Program Directors. NEXT Tabulation and Graphical Summary of the 2005-06 survey of computed tomography. CRCPD publication E-15-3, 2015.

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Thanks for the Attention

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