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REVIEW ARTICLE

Cone beam computed tomography in dentomaxillofacial radiology: a two-decade overview

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Objectives: The aim of this study was to evaluate and summarise features of currently and formerly available cone beam CT (CBCT) devices from 1996 to 2019. Additionally, a recommendation for standardised reporting of CBCT characteristics was provided.
Methods and materials: Information about the features of all available CBCT devices was obtained from the manufacturers' available data. Moreover, site visits to newly developed CBCT machines' manufacturers were performed in order to obtain relevant information.
Results: A total of 279 CBCT models from 47 manufacturers located in 12 countries (Brazil, China, Denmark, Finland, France, Germany, Italy, Japan, Republic of Korea, Slovakia, Thailand, and USA) could be listed. Overall, wide variations in CBCT features and technical specifications were identified.
Conclusions: CBCT in dentomaxillofacial radiology is a generic term applicable to a broad range of CBCT machines and features. Experimental outcomes and literature statements regarding radiation doses, imaging performance and diagnostic applicability of dental CBCT cannot be simply transferred from one CBCT model to another considering a wide variation in technical characteristics and clinical diagnostic performance. The information tabulated in the present study will be later provided on the International Association of DentoMaxilloFacial Radiology website (www.iadmfr.one).
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Keywords: radiology; three-dimensional imaging; cone-beam computed tomography; tomography scanners

Introduction

Dentistry has witnessed tremendous advances over the past decade, with a shift towards digital dentistry, not only for diagnostics but also for surgical planning and treatment. In dentomaxillofacial diagnostics, traditional radiologic examinations are usually limited to two-dimensional (2D) views such as intraoral and panoramic radiographies.[1,2] For routine diagnostics, these imaging modalities may often suffice. However, the evolution of diagnostics and treatment in different dental disciplines has raised the need for three-dimensional (3D) imaging to overcome anatomical overlap and distortions inherent to 2D radiology.[1,3,4]

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Technological advances in radiological imaging have led to the introduction of new 3D imaging methods in many fields of radiology, including dentomaxillofacial radiology.[5] CT was the first technology to allow visualisation of both hard and soft tissues of the facial bones through the ability to acquire multiple consecutive cross-sectional images.[5] Since its introduction, CT imaging of the orofacial region has been of interest as a clinical tool. Since the late 1980s, CT was used for surgical planning in oral and maxillofacial surgery and early endosseous implant placement.[6–8] Considering high radiation dose, costs, and space requirements for CT, dedicated devices for 3D imaging in oral healthcare were developed in the 1990s: dental cone beam CT (CBCT),[5,9,10] which was available on the market in the late 1990s.[1,4,11] This modality may sometimes be denoted as digital volume tomography (DVT), particularly in German-speaking regions.[12] Prior to dental CBCT, this imaging modality was applied in medical radiology for angiography, and it is currently used for different other applications such as otorhinolaryngologic (ears, nose and throat—ENT), interventional and intraoperative imaging, cardiac imaging, radiotherapy, musculoskeletal (incl. extremities and spine), breast and peripheral bone imaging.[1,3,12–16]

Since its introduction in dentomaxillofacial radiology, CBCT has become a widely accepted radiographic tool for diagnosis and treatment planning in oral healthcare.[2] During the past two decades, the number of CBCT models has increased markedly, with new models being developed and released continuously.[1,17] In 2008, 23 different CBCT devices were reported,[18] which increased to 43 devices in 2013.[1] Meanwhile, the number of devices increased dramatically along with its increased application in all dental specialties. CBCT is now widespread used and surely not only in relation to diagnosis, yet also in relation to presurgical planning, dental treatment and post-surgical follow-up (such as with grafting procedures).

Dental CBCT devices exhibit wide variability in terms of physical dimensions, features, imaging modalities available, and essential parameters such as X-ray source specifications and exposure parameters, field of view (FOV), and imaging geometry.[19] At this moment, there is no recent overview available of all available systems. Therefore, the aim of the present study is to evaluate and summarise currently available CBCT devices and their features. Additionally, a recommendation for standardised reporting of CBCT characteristics was provided

Methods and materials

Medical and grey literature about CBCT devices were reviewed. First, previously published reviews were analysed to assemble CBCT devices used for dentomaxillofacial applications reported in medical literature.[1,5,18,20–22] Afterwards, information of CBCT devices that were not found in medical literature was gathered using a search engine. All CBCT devices on the market between 1996 and 2019 were included in this study.

Information about the features of each device was obtained from published articles, available data from manufacturers' websites, manuals, and brochures. Most of the missing or incomplete data were completed and verified at the International Dental Show in Cologne, Germany, in 2017 and 2019 and at the European Congress of Radiology in Vienna, Austria, in 2018 and 2019, as well as at the European Congress of DentoMaxilloFacial Radiology in Luzern, Switzerland, in 2018.

Features collected about all these devices were:

- Manufacturer.
- Country of manufacturing.
- CBCT Series.
- CBCT Model (machines with the optional cephalometric attachment were considered as different models, as well those with different optional fields of view).
- Availability on the market.
- Imaging modalities available: CBCT only, 2-in-1 (CBCT and panoramic radiography), 3-in-1 (CBCT, panoramic and cephalometric radiography).
- Dimensions of width, depth, and height, in meters.
- Weight in kilograms.
- Patient position condition: standing, sitting (*i.e.* built-in chair) or supine.
- Software available with the CBCT unit.
- Kilovoltage range (kV).
- Milliamperage range (mA).
- Focal spot size in millimetres.
- Detector type.
- Greyscale/contrast resolution in bits.
- FOV size, divided in three categories (small, medium and large) according to Bornstein et al.[23] To define the categories, FOV height was multiplied by FOV diameter, representing the FOV surface in cm^2. A small FOV was considered when the calculated surface was ≤ 40 cm^2; a medium FOV was considered if the surface was > 40 cm^2 and ≤ 100 cm^2; and a large FOV if it was > 100 cm^2.
- Use of stitching to acquire extended FOV.
- Voxel size in millimetres.
- Scan time (*i.e.* time between first and last projection) in seconds.
- Reconstruction time in seconds.
- Beam: pulsed or not pulsed (continuous).

Results

From the 143 CBCT series gathered in the present overview, a total of 279 CBCT models were examined, 203 of which available on the market at the time of writing. They are/were produced by 47 manufacturers from 12 countries (Brazil, China, Denmark, Finland, France,

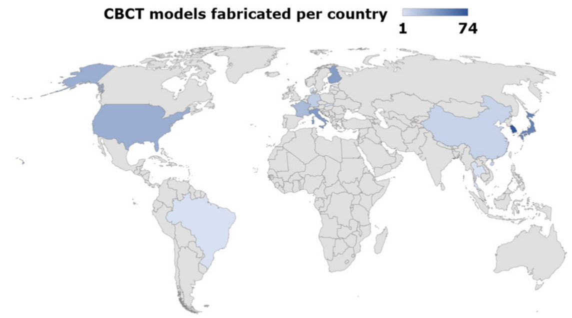

Figure 1 Representative world map highlighting the number of CBCT models produced by each county. CBCT, cone beam CT.

Germany, Italy, Japan, Republic of Korea, Slovakia, Thailand, and USA). Republic of Korea had the highest number of CBCT models (n = 72), followed by Japan, Finland, Italy, USA, and France. Brazil, Denmark, and Thailand had a single CBCT series, Eagle 3D, X1, and DentiiScan 2.0 respectively (Figure 1). Vatech (Republic of Korea), which produces 28 models (23 still available on the market) and Planmeca (Finland), which produces 18 models, showed the most variety of CBCT types by individual companies. KaVo, being the owner of different imaging companies (*i.e.* Gendex, Imaging Science International, Instrumentarium and Soredex) has 32 different CBCT models under its umbrella.

Most of the CBCT models were 2-in-1 models (n = 111), followed by 3-in-1 models (n = 106) while only 62 were CBCT-only models (Figure 2). Two models (RayScan *m* + SC and DR, Ray Medical Co., Republic of Korea) are 2-in-1 CBCT devices but instead of CBCT and panoramic radiography, they are equipped with CBCT and cephalometric radiography, as they are dedicated to otorhinolaryngology. The machines dimensions vary from 0.8 to 2.5 m in width, 0.8 to 3 m in depth and 1.5 to 2.5 m in height. The main difference in machines size are for 3-in-1 models, which present mean width of 1.9 m. The weight of CBCT devices ranged between 66 and 950 kg and referred only to the devices themselves, without separate workstations (Table 1). In 80% of the CBCT devices, patients are standing while the image

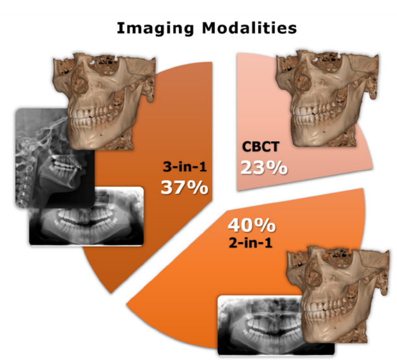

Figure 2 Graph showing the relative frequency of imaging modalities (CBCT-only, 2-in-1, or 3-in1, respectively) among the CBCT devices. CBCT, cone beam CT.

is acquired (mostly with wheelchair accessibility), and only 3% of the devices had the patients in supine position (Figure 3).

Regarding exposure parameters, kV and mA values were observed as constant or adjustable; most of the devices had adjustable kV and mA options (Table 2). Machines that used the lowest kV in the found range (as low as 40 kV) are not available on the market anymore. Few devices have fixed kV, while the overall kV range for devices currently on the market is from 50 to 120. It is crucial to note that these kV range do not always specifically refer to the actual selectable range in 'CBCT mode'; in many cases, especially for 2-in-1 and 3-in-1 units, the low end of the kV range may only apply to the panoramic, cephalometric and/or service mode. Also, for tube current, a vast diversity of ranges is encountered among the CBCT devices, with the overall range being from 1 to 32 mA, which is the case of NewTom VGi EVO (Quantitative Radiology/Cefla Dental Group, Italy). CBCT devices operate with 0.15, 0.2, 0.3, 0.4 0.5, 0.6, and 0.7 mm focal spot size, with the majority being 0.5 mm. NewTom 9000 Maxiscan (the first commercial CBCT machine for dental application) had a focal spot of 1.2 × 0.8 mm.

All CBCT systems use 2D-array detectors to generate and record projection images. Older technology devices have an image intensifier (II) along with a charge coupled device (CCD) that results in a spherical FOV and is larger and bulkier. Nowadays, the majority CBCT devices use flat panel detectors (FPD). II detectors were used in 3% of the units (only one unit is still available on the market), while 13% of the CBCT machines did not have information regarding the detector type available (Table 2). Nearly one-third (30%) of the manufactures did not report the bit depth of the detectors. From the reported CBCT devices, the bit depth ranged between 8 and 16 bits, with 14 bits being the most commonly used bit depth in all devices (Table 2).

Distribution of FOV options among the CBCT devices is displayed in Figure 4. Of all the CBCT devices examined, the smallest FOV was 20 × 20 mm (X1, 3Shape, Denmark). The device with the largest FOV was Viso (Planmeca, Finland), in which it is possible to achieve a 300 × 300 mm FOV via vertical stitching. A minority of the CBCT devices were equipped with Small/Large (n = 6), Small only (n = 14), Medium only (n = 16) and Medium/Large (n = 16) FOV options. A selection of FOVs comprising all three categories were found for 102 devices, and Small/Medium FOVs for 79 devices. The use of stitching method to extend FOV was clearly reported by the manufactures in 48 CBCT models.

Voxel sizes varied between 0.05 mm (Smart Dental, LargeV, China) and 0.6 mm (Planmeca devices). All the machines presented isotropic voxels, except for one outdated machine (CB Throne, Hitachi, Japan) with a reported anisotropic voxel size of 0.1 × 2 mm or 0.2 × 4 mm.[24] Scanning time of devices ranged between 1 and

Table 1 General features of CBCT devices

Manufacturer	*Model*	*Availability on the market*	*Imaging modalities*			*Maximum dimensions (width x depth x height) in meters*	*Maximum weight in kilograms*	*Patient position*	*Software*
			CBCT	*PANO*	*CEPH*				
3M IMTEC (USA)	ILUMA SFOV	No	x			2 × 1.1 x 2.2	350	Sitting	IlumaVision
	ILUMA LFOV	No	x			2 × 1.1 x 2.2	350	Sitting	IlumaVision
3Shape (Denmark)	3Shape X1	Yes	x	x	x	1.3 × 1.6 x 2.3	230	Standing	3D Shape viewer
Acteon (France)	X-Mind Trium	Yes	x	x		1.1 × 1.3 x 2.4	185	Standing	Acteon Imaging Suite 3D
	X-Mind Trium (Ceph)	Yes	x	x	x	1.7 × 1.3 x 2.4	215	Standing	Acteon Imaging Suite 3D
	X-Mind Trium “True low dose”	Yes	x	x	x	1.7 × 1.3 x 2.4	215	Standing	Acteon Imaging Suite 3D
	X-Mind Prime 3D	Yes	x	x		1 × 1.1 x 2.2	67	Standing	Acteon Imaging Suite 3D
	WhiteFox	Yes	x			1.6 × 1.9 x 2.5	275	Standing	WhiteFox Imaging
Air Techniques (USA)	ProVecta 3D Prime	Yes	x	x		1.2 × 1.5 x 2.2	180	Standing	VisionX
Asahi Roentgen (Japan)	Alphard 2520	No	x			2 × 1.7 x 2	480	Sitting	Neo 3D
	Alphard 3030 VEGA	No	x			2 × 1.7 x 2	480	Sitting	Neo 3D
	Alioth	No	x	x		1.2 × 1.4 x 2.3	280	Standing	ADR Plus
	Alioth CM	No	x	x	x	1.9 × 1.4 x 2.3	314	Standing	ADR Plus
	Auge Zio	No	x	x		1 × 1.3 x 2.3	298	Standing	ADR Plus
	Auge Zio CM	No	x	x	x	1.9 × 1.3 x 2.3	338	Standing	ADR Plus
	Auge Zio CM Maxim	No	x	x	x	1.9 × 1.3 x 2.3	348	Standing	ADR Plus
	Auge X Zio	No	x	x		1 × 1.3 x 2.3	298	Standing	ADR Plus
	Auge X Zio CM	No	x	x	x	1.9 × 1.3 x 2.3	338	Standing	ADR Plus
	Auge X Zio CM Maxim	No	x	x	x	1.9 × 1.3 x 2.3	348	Standing	ADR Plus
	Auge Solio Z	Yes	x	x		1.2 × 1.4 x 2.3	200	Standing	NEOSMART
	Auge Solio Z CM	Yes	x	x	x	1.9 × 1.4 x 2.3	220	Standing	NEOSMART
	Solio X	Yes	x	x		1 × 1.3 x 2.3	177	Standing	?
	Solio X Z Maxim	Yes	x	x	x	1.9 × 1.2 x 2.3	197	Standing	?
	PSR 9000N	No	x			?	?	Sitting	?
Biolase (USA)	DaVinci Imaging D3D	No	x			1.5 × 2.4 x 1.7	360	Supine	?
Carestream (France)	CS 8100 3D	Yes	x	x		1.2 × 1.4 x 2.4	127	Standing	Carestream Dental Imaging Software
	CS 8100SC 3D	Yes	x	x	x	2 × 1.4 x 2.4	127	Standing	Carestream Dental Imaging Software
	CS 9000 3D / Kodak 9000 3D	No	x	x		1.2 × 1.6 x 2.4	160	Standing	?
	CS 9000C 3D / Kodak 9000C 3D	No	x	x	x	2.2 × 1.6 x 2.4	199	Standing	?
	CS 9300	Yes	x	x		1.2 × 1.6 x 2.4	160	Standing	Carestream Dental Imaging Software
	CS 9300C	Yes	x	x	x	2.1 × 1.6 x 2.4	199	Standing	Carestream Dental Imaging Software
	CS 9300 Select	Yes	x	x		1.2 × 1.6 x 2.4	199	Standing	Carestream Dental Imaging Software
	CS 9300C Select	Yes	x	x	x	2.1 × 1.6 x 2.4	199	Standing	Carestream Dental Imaging Software
	CS 9300 ENT	Yes	x			1.2 × 1.6 x 2.4	160	Standing	Carestream Dental Imaging Software
	Kodak 9500 MFOV	No	x			1.7 × 1.7 x 2.3	176	Standing	Kodak Dental Imaging
	Kodak 9500 LFOV	No	x			1.7 × 1.7 x 2.3	176	Standing	Kodak Dental Imaging
	CS 9600 12 × 10	Yes	x	x		1.3 × 1.7 x 2.5	210	Standing	CS Imaging
	CS 9600 16 × 10	Yes	x	x		1.3 × 1.7 x 2.5	210	Standing	CS Imaging
	CS 9600 16 × 17	Yes	x	x		1.3 × 1.7 x 2.5	210	Standing	CS Imaging
Castellini (Italy)	X Radius Compact 3D	No	x	x		0.9 × 1.1 x 2.3	90	Standing	iRYS
	X Radius Trio SFOV	No	x	x		1.3 × 1.5 x 2.5	170	Standing	iRYS
	X Radius Trio SFOV (Ceph)	No	x	x	x	1.8 × 1.5 x 2.5	190	Standing	iRYS
	X Radius Trio LFOV	No	x	x		1.3 × 1.5 x 2.5	170	Standing	iRYS
	X Radius Trio LFOV (Ceph)	No	x	x	x	1.8 × 1.5 x 2.5	190	Standing	iRYS

(Continued)

Table 1 (Continued)

Manufacturer	*Model*	*Availability on the market*	*Imaging modalities*			*Maximum dimensions (width x depth x height) in meters*	*Maximum weight in kilograms*	*Patient position*	*Software*
			CBCT	*PANO*	*CEPH*				
Dürr (Germany)	VistaVOX S	Yes	x	x		1 × 1.3 x 2.5	180	Standing	VistaSoft
	VistaVOX S (Ceph)	Yes	x	x	x	1.5 × 1.2 x 2.2	202	Standing	VistaSoft
Dabi Atlante (Brazil)	Eagle 3D	Yes	x	x		1.9 × 1.8 x 2.5	115	Standing	OnDemand 3D Dental
	Eagle 3D (Ceph)	Yes	x	x	x	2.5 × 1.8 x 2.5	152	Standing	OnDemand 3D Dental
Dentium (Republic of Korea)	Rainbow CT	Yes	x			1.9 × 1.5 x 2.3	150	Standing	DaVinci
Denstply Sirona (Germany)	Orthophos S 3D	No	x	x		1.3 × 1.4 x 2.3	110	Standing	Sidexis 4
	Orthophos S 3D (Ceph)	No	x	x	x	2.2 × 1.4 x 2.3	132	Standing	Sidexis 4
	Orthophos SL 3D	Yes	x	x		1.3 × 1.4 x 2.3	110	Standing	Sidexis 4
	Orthophos SL 3D (Ceph)	Yes	x	x	x	2.2 × 1.4 x 2.3	132	Standing	Sidexis 4
	Orthophos XG 3D	Yes	x	x		1.3 × 1.4 x 2.3	110	Standing	Sidexis 4
	Orthophos XG 3D (Ceph)	Yes	x	x	x	2.2 × 1.4 x 2.3	132	Standing	Sidexis 4
	GALILEOS Compact	No	x			1.6 × 1.6 x 2.3	140	Standing	Sidexis 4
	GALILEOS Comfort	No	x			1.6 × 1.6 x 2.3	140	Standing	Sidexis 4
	GALILEOS Comfort Plus	Yes	x			1.6 × 1.6 x 2.3	140	Standing	Sidexis 4
Fussen (China)	Dentrix 20	Yes	x	x	x	1.7 × 1.1 x 2.3	160	Standing	Fussen DenView
FONA Dental (Slovakia)	Stellaris 3D	Yes	x	x		1.4 × 1.1 x 2.3	109	Standing	Stellaris PRO
	Stellaris 3D (Ceph)	Yes	x	x	x	2.4 × 1.1 x 2.3	137	Standing	Stellaris PRO
	FONA X PAN 3D	Yes	x	x		?	98	Standing	FONA OrisWin
	FONA X PAN 3D Plus	Yes	x	x	x	?	125	Standing	FONA OrisWin
Genoray (Republic of Korea)	Volux 6	No	x			1.2 × 1.3 x 2	220	Sitting	?
	Volux 9 (Dental/ENT)	No	x			1.5 × 1.4 x 1.9	220	Sitting	?
	Volux 21	No	x	x		0.9 × 1.5 x 2.4	250	Standing	TRIANA
	Volux 21C	No	x	x	x	2.1 × 1.5 x 2.3	300	Standing	TRIANA
	Papaya 3D	Yes	x	x		1.2 × 1.1 x 2.4	?	Standing	TRIANA
	Papaya 3D Plus	Yes	x	x	x	1.9 × 1.1 x 2.4	?	Standing	TRIANA
	Papaya 3D Premium NV	Yes	x	x		1.3 × 1.4 x 2.4	?	Standing	TRIANA
	Papaya 3D Premium NV (Ceph)	Yes	x	x	x	2 × 1.4 x 2.4	?	Standing	TRIANA
	Papaya 3D Premium LV	Yes	x	x		1.3 × 1.4 x 2.4	?	Standing	TRIANA
	Papaya 3D Premium LV (Ceph)	Yes	x	x	x	2 × 1.4 x 2.4	?	Standing	TRIANA
	Papaya 3D Premium ENT	Yes	x			1.2 × 1.1 x 2.4	?	Standing	TRIANA
HDX Will (Republic of Korea)	Dentri α Classic	Yes	x	x		1.2 × 1.4 x 2.5	233	Standing	OnDemand 3D
	Dentri α Extended	Yes	x	x		1.2 × 1.4 x 2.5	243	Standing	OnDemand 3D
	Dentri Cα Classic	Yes	x	x	x	2 × 1.4 x 2.5	243	Standing	OnDemand 3D
	Dentri Cα Extended	Yes	x	x	x	2 × 1.4 x 2.5	260	Standing	OnDemand 3D
	Dentri Sα Classic	Yes	x	x	x	1.9 × 1.4 x 2.5	260	Standing	OnDemand 3D
	Dentri Sα Extended	Yes	x	x	x	1.9 × 1.4 x 2.5	270	Standing	OnDemand 3D
	Dinnova 3 2520D/3030D	Yes	x	x	x	1.5 × 1.7 x 1.9	480	Sitting	OnDemand 3D
	Q-Face (non-stitch)	Yes	x	x		1.7 × 1.7 x 2.4	285	Standing	?
	Q-Face (one stitch)	Yes	x	x		1.7 × 1.7 x 2.4	305	Standing	?
	Q-Face (two stitch)	Yes	x	x		1.7 × 1.7 x 2.5	305	Standing	?
	Q-Face-S (non-stitch)	Yes	x	x	x	1.9 × 1.7 x 2.4	310	Standing	?
	Q-Face-S (one stitch)	Yes	x	x	x	1.9 × 1.7 x 2.4	330	Standing	?
	Q-Face-S (two stitch)	Yes	x	x	x	1.9 × 1.7 x 2.5	330	Standing	?
Hitachi (Japan)	CB Mercuray	No	x			1.8 × 1.9 x 2.3	950	Sitting	CB Works
	CB Throne	No	x			1.8 × 1.8 x ?	?	Sitting	CB Works
ImageWork (USA)	Panoura 18S	Yes	x	x		1 × 1.1 x 2.3	165	Standing	OnDemand 3D
	Panoura 18S (Ceph)	Yes	x	x	x	1.9 × 1.1 x 2.3	205	Standing	OnDemand 3D

(Continued)

Table 1 (Continued)

Manufacturer	Model	Availability on the market	Imaging modalities			Maximum dimensions (width x depth x height) in meters	Maximum weight in kilograms	Patient position	Software
			CBCT	PANO	CEPH				
J Morita (Japan)	3D Accuitomo	No	x			1.6 × 1.2 x 2.1	400	Sitting	i-Dixel
	3D Accuitomo FPD	No	x			1.6 × 1.2 x 2.1	400	Sitting	i-Dixel
	3D Accuitomo FPD 80	No	x			1.6 × 1.2 x 2.1	400	Sitting	i-Dixel
	3D Accuitomo 170	Yes	x			1.6 × 1.2 x 2.1	400	Sitting	i-Dixel
	Veraview X800 F40P	Yes	x	x		1.4 × 1.2 x 2.3	185	Standing	i-Dixel
	Veraview X800 F40CP	Yes	x	x	x	2.0 × 1.2 x 2.3	220	Standing	i-Dixel
	Veraview X800 R100P	Yes	x	x		1.4 × 1.2 x 2.3	185	Standing	i-Dixel
	Veraview X800 R100CP	Yes	x	x	x	2.0 × 1.2 x 2.3	220	Standing	i-Dixel
	Veraview X800 F150P	Yes	x	x		1.4 × 1.2 x 2.3	185	Standing	i-Dixel
	Veraview X800 F150CP	Yes	x	x	x	2.0 × 1.2 x 2.3	220	Standing	i-Dixel
	Veraviewepocs 3D F40	No	x	x		1 × 1.3 x 2.4	190	Standing	i-Dixel
	Veraviewepocs 3D F40CP	No	x	x	x	2 × 1.3 x 2.4	260	Standing	i-Dixel
	Veraviewepocs 3D R100	Yes	x	x		1 × 1.3 x 2.4	190	Standing	i-Dixel
	Veraviewpocs 3D R100CP	Yes	x	x	x	2 × 1.3 x 2.4	260	Standing	i-Dixel
KaVo Kerr (USA/ Finland)	KaVo 3D eXam	No	x			1.2 × 0.8 x 1.8	?	Sitting	DTX Studio
	KaVo OP 3D	Yes	x	x		0.8 × 1.1 x 2.5	120	Standing	DTX Studio
	KaVo OP 3D (Ceph)	Yes	x	x	x	1.5 × 1.7 x 2.5	155	Standing	DTX Studio
	KaVo OP 3D Pro Small Panel	Yes	x	x		1 × 1.4 x 2.4	200	Standing	DTX Studio
	KaVo OP 3D Pro Small Panel (Ceph)	Yes	x	x	x	2 × 1.4 x 2.4	250	Standing	DTX Studio
	KaVo OP 3D Pro Large Panel	Yes	x	x		1 × 1.4 x 2.4	200	Standing	DTX Studio
	KaVo OP 3D Pro Large Panel (Ceph)	Yes	x	x	x	2 × 1.4 x 2.4	250	Standing	DTX Studio
	KaVo OP 3D Vision (V8)	Yes	x			1.2 × 1.3 x 1.8	230	Sitting	DTX Studio
	KaVo OP 3D Vision (V10)	Yes	x			1.2 × 1.3 x 1.8	230	Sitting	DTX Studio
	KaVo OP 3D Vision (V17)	Yes	x			1.2 × 1.3 x 1.8	230	Sitting	DTX Studio
KaVo (Gendex - USA)	GXDP-800	No	x	x		1.1 × 1.4 x 2.4	200	Standing	?
	GXDP-800 (Ceph)	No	x	x	x	2 × 1.4 x 2.4	250	Standing	?
	GXDP-700-S	Yes	x	x		1.1 × 1.4 x 2.5	200	Standing	InVivo 5
	GXDP-700-SC	Yes	x	x	x	2 × 1.4 x 2.5	250	Standing	InVivo 5
	GXCB-500	Yes	x			1.2 × 1.3 x 1.8	230	Standing	InVivo5
KaVo (Imaging Science International - USA)	i-CAT Classic	No	x			1.1 × 1.3 x 1.8	192	Sitting	i-CAT Vision
	i-CAT Precise	No	x			1.2 × 1.3 x 1.8	231	Sitting	i-CAT Vision
	i-CAT Next Generation	No	x			1.2 × 0.9 x 1.8	231	Sitting	i-CAT Vision
	i-CAT FLX MV	No	x			1.2 × 0.9 x 1.8	230	Sitting	i-CAT Vision
	i-CAT FLX V8	Yes	x			1.2 × 1.3 x 1.8	230	Sitting	DTX Studio
	i-CAT FLX V10	Yes	x			1.2 × 1.3 x 1.8	230	Sitting	DTX Studio
	i-CAT FLX V17	Yes	x			1.2 × 1.3 x 1.8	230	Sitting	DTX Studio
KaVo (Instrumentarium – Finland)	OP200 D	No	x	x		2 × 1.3 x 2.3	175	Standing	?
	OC 200 D	No	x	x	x	2 × 1.3 x 2.3	210	Standing	?
	OP300	Yes	x	x	x	2 × 1.4 x 2.5	250	Standing	OnDemand 3D
	OP300 Maxio	Yes	x	x	x	2 × 1.4 x 2.5	250	Standing	OnDemand 3D
KaVo (Soredex – Finland)	SCANORA 3D	No	x	x		1.6 × 1.4 x 2	310	Sitting	OnDemand 3D
	SCANORA 3DX	No	x	x		1.6 × 1.4 x 2	310	Sitting	OnDemand 3D
	CRANEX 3D	No	x	x		1 × 1.4 x 2.4	200	Standing	OnDemand 3D
	CRANEX 3D (Ceph)	No	x	x	x	2 × 1.4 x 2.4	250	Standing	OnDemand 3D
	CRANEX 3DX	No	x	x		1 × 1.4 x 2.4	200	Standing	OnDemand 3D
	CRANEX 3DX (Ceph)	No	x	x	x	2 × 1.4 x 2.4	250	Standing	OnDemand 3D
LargeV (China)	HiRes 3D Dental	Yes	x			1.1 × 1.6 x 2.1	340	Sitting	SmartV
	HiRes 3D MAX	Yes	x			1.1 × 1.6 x 2.1	340	Sitting	SmartV
	Smart Dental	Yes	x	x		1.1 × 1.5 x 2.4	285	Standing	SmartV
	Smart Dental (Ceph)	Yes	x	x	x	2 × 1.5 x 2.4	335	Standing	SmartV

(Continued)

Table 1 (Continued)

Manufacturer	*Model*	*Availability on the market*	*Imaging modalities*			*Maximum dimensions (width x depth x height) in meters*	*Maximum weight in kilograms*	*Patient position*	*Software*
			CBCT	*PANO*	*CEPH*				
MyRay (Italy)	SkyView	No	x			1.5 × 2.5 x 1.8	360	Supine	SkyView
	Hyperion X5 3D/2D	Yes	x	x		0.9 × 1.1 x 2.3	90	Standing	iRYS
	Hyperion X5 3D/2D CEPH	Yes	x	x	x	1.8 × 1.1 x 2.3	115	Standing	iRYS
	Hyperion X9 Full FOV	Yes	x	x		1.3 × 1.5 x 2.5	170	Standing	iRYS
	Hyperion X9 Full FOV CEPH	Yes	x	x	x	1.8 × 1.5 x 2.5	190	Standing	iRYS
	Hyperion X9 Extended FOV	Yes	x	x		1.3 × 1.5 x 2.5	170	Standing	iRYS
	Hyperion X9 Extended FOV CEPH	Yes	x	x	x	1.8 × 1.5 x 2.5	190	Standing	iRYS
	Hyperion X9 Pro 10 × 8 version	Yes	x	x		1.3 × 1.5 x 2.5	155	Standing	iRYS
	Hyperion X9 Pro CEPH 10 × 8 version	Yes	x	x	x	1.8 × 1.5 x 2.5	175	Standing	iRYS
	Hyperion X9 Pro 13 × 16 version	Yes	x	x		1.3 × 1.5 x 2.5	155	Standing	iRYS
	Hyperion X9 Pro CEPH 13 × 16 version	Yes	x	x	x	1.8 × 1.5 x 2.5	175	Standing	iRYS
Meyer (China)	SS-91010D Pro-3D	Yes	x	x		1.1 × 1.4 x 2.5	?	Standing	DCTViewer
	SS-91010D Pro-3De	Yes	x	x	x	1.9 × 1.4 x 2.5	?	Standing	DCTViewer
	X12008D Pro-3D	Yes	x			1.5 × 1.7 x 2	350	Sitting	DCTViewer
PiXAMED (Thailand)	DentiiScan 2.0	Yes	x			1 × 1.3 x 2.4	190	Standing	In house software
Owandy (France)	I-MAX 3D	Yes	x	x		1 × 1.1 x 2.2	66	Standing	QuickVision
	I-MAX 3D Touch	Yes	x	x		1.2 × 1.3 x 2.5	161	Standing	QuickVision
	I-MAX 3D Touch CEPH	Yes	x	x	x	2 × 1.3 x 2.5	186	Standing	QuickVision
Osstem (Republic of Korea)	Osstem Implant CBCT T1	Yes	x	x	x	1.9 × 1.2 x 2.3	210	Standing	Oneclinic
Planmeca (Finland)	ProMax 3D Classic	Yes	x	x		1.2 × 1.3 x 2.4	113	Standing	Romexis
	ProMax 3D Classic (Ceph)	Yes	x	x	x	2 × 1.3 x 2.4	128	Standing	Romexis
	ProMax 3D S	Yes	x	x		1.2 × 1.3 x 2.4	113	Standing	Romexis
	ProMax 3D S (Ceph)	Yes	x	x	x	2 × 1.3 x 2.4	128	Standing	Romexis
	ProMax 3D Plus	Yes	x	x		1.2 × 1.4 x 2.4	131	Standing	Romexis
	ProMax 3D Plus (Ceph)	Yes	x	x	x	2.1 × 1.4 x 2.4	146	Standing	Romexis
	ProMax 3D Plus ENT	Yes	x	x		1.2 × 1.4 x 2.4	131	Standing	Romexis
	ProMax 3D Plus ENT (Ceph)	Yes	x	x	x	2.1 × 1.4 x 2.4	146	Standing	Romexis
	ProMax 3D Mid	Yes	x	x		1.2 × 1.4 x 2.4	131	Standing	Romexis
	ProMax 3D Mid (Ceph)	Yes	x	x	x	2.1 × 1.4 x 2.4	146	Standing	Romexis
	ProMax 3D Mid ENT	Yes	x	x		1.2 × 1.4 x 2.4	131	Standing	Romexis
	ProMax 3D Mid ENT (Ceph)	Yes	x	x	x	2.1 × 1.4 x 2.4	146	Standing	Romexis
	ProMax 3D Max	Yes	x	x		1.2 × 1.4 x 2.4	131	Standing	Romexis
	ProMax 3D Max ENT	Yes	x	x		1.2 × 1.4 x 2.4	131	Standing	Romexis
	Viso	Yes	x	x		1.3 × 1.5 x 2.3	165	Standing	Romexis
	Viso (Ceph)	Yes	x	x	x	2.1 × 1.5 x 2.4	180	Standing	Romexis
	Viso (Vertical stitching)	Yes	x	x		1.3 × 1.5 x 2.3	165	Standing	Romexis
	Viso (Vertical stitching) (Ceph)	Yes	x	x	x	2.1 × 1.5 x 2.4	180	Standing	Romexis
Pointnix (Republic of Korea)	Point I3D	Yes	x			1.2 × 1.1 x 1.8		Sitting	RealScan
	Point 3D Combi 500	Yes	x	x		1.1 × 1.3 x 2.3	150	Standing	Romexis
	Point 3D Combi 500c	Yes	x	x	x	2.1 × 1.3 x 2.3	190	Standing	Romexis
	Point 3D Combi 500 s	Yes	x	x	x	2.1 × 1.3 x 2.3	185	Standing	Romexis
	Point 800 HD Plus	Yes	x	x		1.1 × 1.3 x 2.3	150	Standing	Romexis
	Point 800c HD Plus	Yes	x	x	x	2.1 × 1.3 x 2.3	190	Standing	Romexis
	Point 800 s HD Plus	Yes	x	x	x	2.1 × 1.3 x 2.3	185	Standing	Romexis

(Continued)

Table 1 (Continued)

Manufacturer	*Model*	*Availability on the market*	*Imaging modalities*			*Maximum dimensions (width x depth x height) in meters*	*Maximum weight in kilograms*	*Patient position*	*Software*
			CBCT	*PANO*	*CEPH*				
PreXion (Japan)	PreXion 3D	No	x			1.2 × 1.6 x 2	400	Sitting	Prexion3D Viewer
	PreXion 3D Elite	Yes	x	x		1.2 × 1.6 x 2	390	Sitting	Prexion3D Viewer
	PreXion 3D Elite Element	Yes	x	x		1.2 × 1.6 x 2	390	Sitting	Prexion3D Viewer
	PreXion 3D Eclipse	Yes	x	x		1.2 × 1.3 x 2	260	Sitting	Prexion3D Viewer
	PreXion 3D Eclipse (Ceph)	Yes	x	x	x	1.8 × 1.3 x 2	300	Sitting	Prexion3D Viewer
	PreXion 3D Excelsior Ex	Yes	x	x		1 × 1.2 x 2.2	165	Standing	Prexion3D Viewer
	PreXion 3D Excelsior Ex (Ceph)	Yes	x	x	x	1.8 × 1.2 x 2.2	200	Standing	Prexion3D Viewer
	PreXion 3D Excelsior Plus	Yes	x	x		1 × 1.2 x 2.2	165	Standing	Prexion3D Viewer
	PreXion 3D Excelsior Plus (Ceph)	Yes	x	x	x	1.8 × 1.2 x 2.2	200	Standing	Prexion3D Viewer
	PreXion 3D Excelsior Pro	Yes	x	x		1 × 1.2 x 2.2	165	Standing	Prexion3D Viewer
	PreXion 3D Excelsior Pro (Ceph)	Yes	x	x	x	1.8 × 1.2 x 2.2	200	Standing	Prexion3D Viewer
	PreXion 3D Explorer	Yes	x	x	x	1.1 × 1.6 x 2.3	185	Standing	Prexion3D Viewer
Quantitative Radiology / Cefla Dental Group (Italy)	GiANO HR Prime	Yes	x	x		1.2 × 1.4 x 2.5	155	Standing	NNT
	GiANO HR Prime (Ceph)	Yes	x	x	x	1.8 × 1.2 x 2.5	175	Standing	NNT
	GiANO HR Advanced	Yes	x	x		1.2 × 1.4 x 2.5	155	Standing	NNT
	GiANO HR Advanced (Ceph)	Yes	x	x	x	1.8 × 1.2 x 2.5	175	Standing	NNT
	GiANO HR Professional	Yes	x	x		1.2 × 1.4 x 2.5	155	Standing	NNT
	GiANO HR Professional (Ceph)	Yes	x	x	x	1.8 × 1.2 x 2.5	175	Standing	NNT
	GiANO/NewTom VG3	Yes	x	x		1.4 × 1.4 x 2.4	170	Standing	NNT
	GiANO/NewTom VG3 (Ceph)	Yes	x	x	x	1.9 × 1.4 x 2.4	190	Standing	NNT
	Go 2D/3D Imaging	Yes	x	x		0.9 × 1.1 x 2.3	90	Standing	NNT
	NewTom 9000 Maxiscan	No	x			2.5 × 3 x 2.4	320	Supine	
	NewTom VG	No	x			1.1 × 1.5 x 2.3	272	Standing	NNT
	NewTom VG Flex	No	x			1.2 × 1.5 x 2	272	Sitting	NNT
	NewTom VGi	No	x			1.2 × 1.5 x 2.3	272	Standing	NNT
	NewTom VGi Flex	No	x			1.2 × 1.5 x 2	272	Standing	NNT
	NewTom VGi evo	Yes	x	x	x	1.3 × 1.6 x 2.3	337	Standing	NNT
	NewTom 3G	No	x			2 × 2.5 x 2	480	Supine	NewTom 3G Expert
	NewTom 5G	No	x			1.8 × 2.3 x 1.8	530	Supine	NNT
	NewTom 5G XL	Yes	x			1.8 × 3.6 x 1.8	660	Supine	NNT
Ritter Imaging (Germany)	Orion	No	x			?	?	Sitting	?
Ray Medical (Republic of Korea)	RAYSCAN Symphony BC	No	x			1.2 × 1.6 x 2	355	Sitting	?
	RAYSCAN Symphony V	No	x			1.4 × 1.7 x 2	355	Sitting	?
	RAYSCAN α−3D	Yes	x	x		1.5 × 1.7 x 2.3	150	Standing	?
	RAYSCAN α−3D (SC, OCS, OCL)	Yes	x	x	x	2.1 × 1.7 x 2.3	177.5	Standing	?
	RAYSCAN α + 130	Yes	x	x		1.5 × 1.5 x 2.3	148	Standing	?
	RAYSCAN α + 130 (SC, OCS, OCL)	Yes	x	x	x	2 × 1.5 x 2.3	164	Standing	?
	RAYSCAN α + 160	Yes	x	x		1.5 × 1.5 x 2.3	148	Standing	?
	RAYSCAN α + 160 (SC, OCS, OCL)	Yes	x	x	x	2 × 1.5 x 2.3	164	Standing	?
	RAYSCAN m+	Yes	x			1.5 × 1.5 x 2.3	?	Standing	?
	RAYSCAN *m* + SC	Yes	x		x	1.9 × 1.5 x 2.3	?	Standing	?
	RAYSCAN *m* + DR (with chest X-ray)	Yes	x		x	1.9 × 1.5 x 2.3	?	Standing	?
Ray Medical (Republic of Korea) / Apteryx (USA)	RAYSCAN α-Edge	Yes	x	x		1.5 × 1.7 x 2.3	150	Standing	?
	RAYSCAN α-SM Edge	Yes	x	x	x	2.1 × 1.7 x 2.3	177.5	Standing	?
Streamhealth Dental (USA)	Trophypan Smart 3D	Yes	x	x		1.2 × 1.4 x 2.4	92	Standing	?

(Continued)

Table 1 (Continued)

Manufacturer	*Model*	*Availability on the market*	*Imaging modalities*			*Maximum dimensions (width x depth x height) in meters*	*Maximum weight in kilograms*	*Patient position*	*Software*
			CBCT	*PANO*	*CEPH*				
Suni Medical Imaging (USA)	Suni3D	No	x	x		1 × 1.2 x 2.3	?	Standing	?
	Suni3D (Ceph)	No	x	x	x	1.9 × 1.2 x 2.3	?	Standing	?
	Suni Q3D	No	x	x		1.2 × 1.2 x 2.4	145	Standing	Q3D
	Suni Q3D (Ceph)	No	x	x	x	1.9 × 1.2 x 2.4	160	Standing	Q3D
Trident (Italy)	X-View Cone Beam	Yes	x	x		0.9 × 1.1 x 2.2	95	Standing	Deep View/Xelis
	X-View Cone Beam (Ceph)	Yes	x	x	x	1.7 × 1.1 x 2.2	125	Standing	Deep View/Xelis
Vatech (Republic of Korea)	PaX-i3D	Yes	x	x		1.1 × 1.4 x 2.4	120	Standing	Ez3D plus
	PaX-i3D (SC or OP)	Yes	x	x	x	1.9 × 1.3 x 2.4	150	Standing	Ez3D plus
	PaX-i3D Smart / i3D Smart 8 × 8	Yes	x	x		1.3 × 1.4 x 2.4	137	Standing	Ez3D plus
	PaX-i3D Smart (Ceph)/ i3D Smart 8 × 8 SC	Yes	x	x	x	1.9 × 1.4 x 2.4	162	Standing	Ez3D plus
	PaX-i3D Smart 2/Green Smart / Smart Plus / i3D Smart	Yes	x	x		1.1 × 1.4 x 2.4	137	Standing	Ez3D plus
	PaX-i3D Smart 2 (Ceph) / Green Smart SC / Smart Plus RC / i3D Smart RC	Yes	x	x	x	1.9 × 1.3 x 2.4	162	Standing	Ez3D plus
	PaX-i3D Green / Green CT	Yes	x	x		1.2 × 1.4 x 2.4	137	Standing	Ez3D plus
	PaX-i3DGreen SC or OP / Green CT SC or OP	Yes	x	x	x	2 × 1.4 x 2.4	162	Standing	Ez3D plus
	PaX-i3D 2/Green CT 2/ Green 16	Yes	x	x		1.1 × 1.5 x 2.4	187	Standing	Ez3D plus
	PaX-i3D 2 (Ceph) / Green CT 2 (Ceph) / Green 16 (Ceph)	Yes	x	x	x	1.9 × 1.5 x 2.4	212	Standing	Ez3D plus
	Green 18	Yes	x	x		1.1 × 1.5 x 2.4	187	Standing	Ez3D plus
	Green 18 (Ceph)	Yes	x	x	x	1.9 × 1.5 x 2.4	212	Standing	Ez3D plus
	Green 21/i3D Premium (AutoCeph)	Yes	x	x		1.5 × 1.6 x 2.2	321	Sitting	Ez3D plus
	PaX-Flex3D P	Yes	x	x		1 × 1.5 x 2.3	185	Standing	Ez3D plus
	PaX-Flex3D PC	Yes	x	x	x	2 × 1.5 x 2.3	225	Standing	Ez3D plus
	PaX-Uni3D P	Yes	x	x		1 × 1.5 x 2.3	185	Standing	Ez3D plus
	PaX-Uni3D PC	Yes	x	x	x	2 × 1.5 x 2.3	225	Standing	Ez3D plus
	PaX-Duo3D	Yes	x	x		1.1 × 1.6 x 2.3	220	Standing	Ez3D plus
	PaX-Zenith3D	Yes	x	x		1.8 × 2 x 1.9	493	Sitting	Ez3D plus
	PaX-Reve3D	Yes	x	x		1.4 × 1.6 x 2.3	210	Standing	Ez3D plus
	PaX-Reve3D OS	Yes	x	x	x	2.1 × 1.6 x 2.3	250	Standing	Ez3D plus
	Picasso Trio	Yes	x	x		1 × 1.5 x 2.3	185	Standing	Ez3D plus
	Picasso Trio (Ceph)	Yes	x	x	x	2 × 1.5 x 2.3	225	Standing	Ez3D plus
	Picasso Duo	No	x	x		0.9 × 1.5 x 2.4	?	Standing	Ez3D
	Picasso Master 3D	No	x			1.5 × 1.9 x 2.3	?	Sitting	Ex3D
	Picasso Pro 3D	No	x			1.4 × 1.6 x 1.8	?	Sitting	Ez3D
	PaX 500 ECT	No	x	x		1 × 1.3 x 2.3	?	Standing	ECT Viewer
	PaX 500 ECT (Ceph)	No	x	x	x	1.9 × 1.3 x 2.3	?	Standing	ECT Viewer
Villa Sistemi Medicalli (Italy)	Rotograph Evo 3D	Yes	x	x		1.1 × 1.3 x 2.5	191	Standing	Dental Studio
	Rotograph Evo 3D (Ceph)	Yes	x	x	x	2 × 1.3 x 2.5	216	Standing	Dental Studio
	Rotograph Prime 3D	Yes	x	x		1 × 1.1 x 2.2	67	Standing	Quick Vision / Villa 3D
UEG Medical (China)	Spectral	Yes	x			1.2 × 0.8 x 2	320	Sitting	UEG RealView
Xoran Technologies (USA)	Minicat	No	x			0.9 × 1 x 1.7	204	Sitting	Minicat Viewing Solutions
	Minicat IQ (ENT)	Yes	x			0.9 × 1 x 1.7	204	Sitting	Minicat Viewing Solutions
	Minicat 2020	Yes	x			?	?	Sitting	?
	XCat (Portable)	Yes	x			0.8 × 1.2 x 1.5	235	Supine	?

(Continued)

Table 1 (Continued)

Manufacturer	Model	Availability on the market	Imaging modalities			Maximum dimensions (width x depth x height) in meters	Maximum weight in kilograms	Patient position	Software
			CBCT	PANO	CEPH				
Yoshida (Japan)	Finecube	No	x			1.9 × 1.2 x 1.6	390	Sitting	PreXion 3D Viewer
	X-era Smart F+	Yes	x	x		0.9 × 1.1 x 2.2	170	Standing	?
	X-era Smart F+ (Ceph)	Yes	x	x	x	1.9 × 1.1 x 2.2	210	Standing	?
Yoshida (Japan) / ImageWorks (USA)	X-era NF / Panoura X-era NF	Yes	x	x		1.1 × 1.4 x 2.4	?	Standing	OneSystem
	X-era NF (Ceph) / Panoura X-era NF (Ceph)	Yes	x	x	x	1.9 × 1.4 x 2.3	?	Standing	OneSystem
	X-era MF / Panoura X-era MF	Yes	x	x		1.1 × 1.4 x 2.3	?	Standing	OneSystem
	X-era MF (Ceph) / X-era MF (Ceph)	Yes	x	x	x	1.9 × 1.4 x 2.3	?	Standing	OneSystem

CBCT: cone-beam computed tomography; PANO: panoramic radiography; CEPH: cephalometric radiography.

55 s, although some of the reported scanning times are more likely to be related to the exposure time, especially for those presenting pulsed beam. Devices with the smallest scan times are Orthophos SL 3D, Orthophos S 3D, Orthophos XG 3D and Galileos Comfort Plus with a range of 2–5 s according to the manufacturer. Reconstruction time may vary depending on the workstation, but it is reported to be between 10 and 390 s (Table 2).

Information regarding the X-rays beam operation (*i.e.* pulsed or continuous) was not found for 32% of the devices. Of the remaining devices, the X-rays beam generation is pulsed in 78% of the machines, and 19% devices used continuous exposure. Five CBCT models (CS9300 Series, Carestream, France) reported both pulsed and not pulsed X-rays beam generation depending on the scanning mode (Table 2).

Considering the wide variation in reported technical characteristics and clinical performance of the available dentomaxillofacial CBCT devices, it is advised to aim for structured feature reporting, thus allowing identification of the proper devices fitting the clinical needs and encompassing the research questions. The suggested standardisation is shown in Table 3.

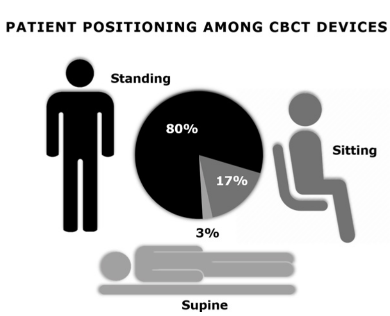

Figure 3 Representative scheme of patient positioning (standing, sitting, and supine) for scan among the CBCT devices. CBCT, cone beam CT.

Discussion

Dental X-ray examination and diagnosis have made great progress over the last 30 years. The number of manufacturers and devices using CBCT technology is growing rapidly. The first CBCT device (NewTom 9000 Maxiscan; Quantitative Radiology/Cefla Dental Group, Italy) was described in 1998 by Mozzo et al.[9] Since then, there has been an increasing and continuous development of CBCT machines incorporating new technologies. In the present study, 279 CBCT models (143 CBCT series) from 47 manufacturers were catalogued. Only a few studies explored the features of several CBCT devices, yet there are no recent studies comparing those features for all machines. De Vos et al,[20] Kau et al,[18] and Nemtoi et al[1] conducted similar reviews about the features of CBCT devices available before 2013.

An important development of second-generation CBCT devices was the detector type. Nowadays most of the devices use FPDs, which are distortion-free and show a wider dynamic range compared with the image intensifier detectors used in earlier CBCT models.[25] The bit depth of detectors in most current CBCT devices is between 14 and 16 bits and seems reasonable for dentomaxillofacial practice.

Crucial differences among the CBCT devices were found in terms of machine size and weight, available imaging modalities, exposure parameters (kV and mA) and exposure mode and time, FOV size, voxel size, and both scanning and reconstruction time. Machine size and weight is important considering the often-limited physical space available to install a CBCT. One may also consider the imaging modalities required for clinical practice, as most of the machines are either 2-in-1 or 3-in-1. This choice also has an impact in the required room space for installing a machine. From what was observed in the previous compilation of CBCT,[1] there has been an upward trend in developing hybrid devices, having the potential for both 2D and 3D extra oral imaging. Such devices are usually applying a smaller

Table 2 Cone beam computed tomography machines acquisition parameters

Manufacturer	*Model*	*kV*	*mA*	*Focal Spot (mm)*	*Detector Type*[a]	*Detector Gray Scale (bits)*	*FOV*[b]			*FOV Stitching*	*Voxel Size (min-max) (mm)*	*Scan Time (s)*[c]	*Reconstruction Time (s)*	*Pulsed Beam*
							Small	*Medium*	*Large*					
3M IMTEC (USA)	ILUMA SFOV	120	1–3.8	0.3	FPD (A-Si)	16			x	No	0.09–0.4	7.8–40	>120	No
	ILUMA LFOV	120	1–3.8	0.3	FPD (A-Si)	16			x	No	0.09–0.4	7.8–40	>120	No
3Shape (Denmark)	X1	60–90	4–12	0.5	FPD (CMOS)	16	x	x		No	0.1–0.4	12–14	300	Yes
Acteon (France)	X-Mind Trium	80–90	4–10	0.5	FPD (CMOS)	12	x	x		No	0.075–0.15	12–30	29	Yes
	X-Mind Trium (Ceph)	80–90	4–10	0.5	FPD (CMOS)	12	x	x		No	0.075–0.15	12–30	29	Yes
	X-Mind Trium "True low dose"	80–90	4–10	0.5	FPD (CMOS)	12	x			No	0.075	12–30	29	Yes
	X-Mind Prime 3D	60–86	2–12.5	0.5	FPD (CMOS)	16	x	x		No	0.08	7	?	?
	WhiteFox	105	6–10	0.5	FPD (A-Si)	16	x	x	x	No	0.1–0.3	18–27	30	Yes
Air Techniques (USA)	ProVecta 3D Prime	50–99	4–16	0.5	FPD (CMOS - CsI)	14	x	x	x	No	0.08–0.2	2–18	?	Yes
Asahi Roentgen (Japan)	Alphard 2520	60–110	2–15	0.6	FPD	?	x		x	No	0.1–0.39	?	?	?
	Alphard 3030 VEGA	60–110	2–15	0.6	FPD	?	x		x	No	0.1–0.39	?	?	?
	Alioth	60–100	1–12	0.5	FPD (CsI)	8–14	x	x		No	0.1–0.2	17	?	No
	Alioth CM	60–100	1–12	0.5	FPD (CsI)	8–14	x	x		No	0.1–0.2	17	?	No
	Auge Zio	60–95	2–12	0.5	FPD (CsI)	12	x	x		No	0.1–0.2	8.5–17	?	No
	Auge Zio CM	60–95	2–12	0.5	FPD (CsI)	12	x	x		No	0.1–0.2	8.5–17	?	No
	Auge Zio CM Maxim	60–95	2–12	0.5	FPD (CsI)	12	x	x		No	0.1–0.2	8.5–17	?	No
	Auge X Zio	60–95	2–12	0.5	FPD (CsI)	12	x	x		No	0.1–0.2	8.5–17	?	No
	Auge X Zio CM	60–95	2–12	0.5	FPD (CsI)	12	x	x		No	0.1–0.2	8.5–17	?	No
	Auge X Zio CM Maxim	60–95	2–12	0.5	FPD (CsI)	12	x	x		No	0.1–0.2	8.5–17	?	No
	Auge Solio Z	60–100	2–12	0.6	?	12	x	x	x	No	0.1–0.3	?	?	?
	Auge Solio Z CM	60–100	2–12	0.6	?	12	x	x	x	No	0.1–0.3	?	?	?
	Solio X	60–85	2–8	0.5	?	?	x	x		No	0.1–0.17	6–12	?	?
	Solio X Z Maxim	60–85	2–8	0.5	?	?	x	x		No	0.1–0.17	6–12	?	?
	PSR 9000N	?	?	?	?	?	?	?	?	?	0.1–0.15	17	?	?
Biolase (USA)	DaVinci Imaging D3D	90	10	0.5–0.6	II (CCD)	12		x	x	No	0.17–0.33	10–30	30–70	Yes
Carestream (France)	CS 8100 3D	60–90	2–15	0.6–0.7	FPD (CMOS)	14	x	x		No	0.075-?	7–15	>120	Yes
	CS 8100SC 3D	60–90	2–15	0.6–0.7	FPD (CMOS)	14	x	x		No	0.075-?	7–15	>120	Yes
	CS 9000 3D / Kodak 9000 3D	60–90	2–15	0.5	FPD (CMOS)	16	x	x		No	0.076-?	22	>120	Yes
	CS 9000C 3D / Kodak 9000C 3D	60–90	2–15	0.5	FPD (CMOS)	16	x	x		No	0.076-?	22	>120	Yes
	CS 9300	60–90	2–15	0.7	TFT	14	x	x	x	No	0.09–0.5	12–28	>120	Yes/No
	CS 9300C	60–90	2–15	0.7	TFT	14	x	x	x	No	0.09–0.5	12–28	>120	Yes/No
	CS 9300 Select	60–90	2–15	0.7	TFT	14	x	x		No	0.09–0.5	12–28	>120	Yes/No
	CS 9300C Select	60–90	2–15	0.7	TFT	14	x	x		No	0.09–0.5	12–28	>120	Yes/No
	CS 9300 ENT	60–90	2–15	0.7	TFT	14	x	x	x	No	0.09–0.5	12–28	>120	Yes/No
	Kodak 9500 MFOV	60–90	2–15	0.7	FPD (A-Si)	14			x	No	0.2–0.3	24	80–150	Yes
	Kodak 9500 LFOV	60–90	2–15	0.7	FPD (A-Si)	14			x	No	0.2–0.3	24	80–150	Yes
	CS 9600 12 × 10	60–120	2–15	0.3–0.7	FPD (CMOS)	14	x	x	x	No	0.075–0.4	5.5–40	?	Yes
	CS 9600 16 × 10	60–120	2–15	0.3–0.7	FPD (CMOS)	14	x	x	x	No	0.075–0.4	5.5–40	?	Yes
	CS 9600 16 × 17	60–120	2–15	0.3–0.7	FPD (CMOS)	14	x	x	x	No	0.075–0.4	5.5–40	?	Yes
Castellini (Italy)	X Radius Compact 3D	90	4–15	0.6	FPD (A-Si - CsI)	16	x	x		No	0.08–0.16	?	?	Yes
	X Radius Trio SFOV	60–90	1–10	0.5	FPD (A-Si - CsI)	16	x	x	x	Yes	0.075-?	>18	>15	Yes
	X Radius Trio SFOV (Ceph)	60–90	1–10	0.5	FPD (A-Si - CsI)	16	x	x	x	Yes	0.075-?	>18	>15	Yes
	X Radius Trio LFOV	60–90	1–10	0.5	FPD (A-Si - CsI)	16	x	x	x	Yes	0.075-?	>18	>15	Yes
	X Radius Trio LFOV (Ceph)	60–90	1–10	0.5	FPD (A-Si - CsI)	16	x	x	x	Yes	0.075-?	>18	>15	Yes
Dürr (Germany)	VistaVOX S	50–99	4–16	0.5	FPD (CMOS - CsI)	?	x	x	x	No	0.08–0.12	2–18	?	?
	VistaVOX S (Ceph)	50–99	4–16	0.5	FPD (CMOS - CsI)	?	x	x	x	No	0.08–0.12	2–18	?	?
Dabi Atlante (Brazil)	Eagle 3D	85	4–8	0.5	FPD (CMOS)	?	x	x	x	Yes	0.08–0.5	7–32	22–97	Yes
	Eagle 3D (Ceph)	85	4–8	0.5	FPD (CMOS)	?	x	x	x	Yes	0.08–0.5	7–32	22–97	Yes

(Continued)

Table 2 (Continued)

Manufacturer	Model	kV	mA	Focal Spot (mm)	Detector Type[a]	Detector Gray Scale (bits)	FOV[b] Small	FOV[b] Medium	FOV[b] Large	FOV Stitching	Voxel Size (min-max) (mm)	Scan Time (s)[c]	Reconstruction Time (s)	Pulsed Beam
Dentium (Republic of Korea)	Rainbow CT	60–100	4–12	0.5	FPD (CMOS)	?	x		x	Yes	0.2–0.3	19	>60	?
Denstply Sirona (Germany)	Orthophos S 3D	60–90	4–13	0.5	FPD (A-Si)	?	x	x	x	No	0.08–0.22	14	?	Yes
	Orthophos S 3D (Ceph)	60–90	4–13	0.5	FPD (A-Si)	?	x	x	x	No	0.08–0.22	14	?	Yes
	Orthophos SL 3D	60–90	4–13	0.5	FPD (A-Si)	?	x	x	x	No	0.08–0.22	14	?	Yes
	Orthophos SL 3D (Ceph)	60–90	4–13	0.5	FPD (A-Si)	?	x	x	x	No	0.08–0.22	14	?	Yes
	Orthophos XG 3D	60–90	4–13	0.5	FPD (A-Si)	?	x	x		No	0.1–0.16	14	?	Yes
	Orthophos XG 3D (Ceph)	60–90	4–13	0.5	FPD (A-Si)	?	x	x		No	0.1–0.16	14	90–390	Yes
	Galileos Compact	85	5–7	0.5	II	12			x	No	0.3	14	240–300	Yes
	Galileos Comfort	85	5–7	0.5	II	12			x	No	0.15–0.3	14	240–300	Yes
	Galileos Comfort Plus	98	3–6	0.5	II	12			x	No	0.125–0.25	14	?	?
Fussen (China)	Dentrix 20	60–90	4–10	0.5	FPD (CMOS)	16	x		x	No	0.075–0.25	15	>60	Yes
FONA Dental (Slovakia)	Stellaris 3D	60–86	2.5–10	0.5	FPD (CMOS)	14	x	x		No	0.08-?	13–16.9	?	Yes
	Stellaris 3D (Ceph)	60–86	2.5–10	0.5	FPD (CMOS)	14	x	x		No	0.08-?	13–16.9	?	Yes
	FONA X PAN 3D	61–85	4–10	0.5	FPD (CMOS)	14		x		No	0.16	12.3	>10	Yes
	FONA X PAN 3D Plus	61–85	4–10	0.5	FPD (CMOS)	14		x		No	0.16	12.3	>10	Yes
Genoray (Republic of Korea)	Volux 6	60–85	5–7	0.5	?	?	x	x		No	0.1–0.17	20	180	?
	Volux 9 (Dental/ENT)	85	7	0.5	?	?			x	No	?	8.5	120	?
	Volux 21	60–110	5–7	0.5	FPD (CMOS)	?			x	No	0.1–0.28	15.8	150	?
	Volux 21C	60–110	5–7	0.5	FPD (CMOS)	?			x	No	0.1–0.28	15.8	150	?
	Papaya 3D	60–90	4–12	0.5	?	?	x	x	x	Yes	0.075–0.4	7.7–14.5	?	?
	Papaya 3D Plus	60–90	4–12	0.5	?	?	x	x	x	Yes	0.075–0.4	7.7–14.5	?	?
	Papaya 3D Premium NV	60–90	4–12	0.5	?	?			x	Yes	0.075–0.4	>7.7	?	?
	Papaya 3D Premium NV (Ceph)	60–90	4–12	0.5	?	?			x	Yes	0.075–0.4	>7.7	?	?
	Papaya 3D Premium LV	60–90	4–12	0.5	?	?			x	Yes	0.075–0.4	>7.7	?	?
	Papaya 3D Premium LV (Ceph)	60–90	4–12	0.5	?	?			x	Yes	0.075–0.4	>7.7	?	?
	Papaya 3D Premium ENT	60–90	4–12	0.5	?	?			x	Yes	0.075–0.4	>7.7	?	?
HDX Will (Republic of Korea)	Dentri α Classic	60–110	5–10	0.5	FPD (CMOS)	14			x	No	0.1–0.3	16–36	8–40	Yes
	Dentri α Extended	60–110	5–10	0.5	FPD (CMOS)	14			x	Yes	0.1–0.3	8–24	8–40	Yes
	Dentri Cα Classic	60–110	5–10	0.5	FPD (CMOS)	14			x	No	0.1–0.3	16–36	8–40	Yes
	Dentri Cα Extended	60–110	5–10	0.5	FPD (CMOS)	14			x	Yes	0.1–0.3	8–24	8–40	Yes
	Dentri Sα Classic	60–110	5–10	0.5	FPD (CMOS)	14			x	No	0.1–0.3	16–36	8–40	Yes
	Dentri Sα Extended	60–110	5–10	0.5	FPD (CMOS)	14			x	Yes	0.1–0.3	8–24	8–40	Yes
	Dinnova 3 2520D/3030D	50–120	4–10	0.5	FPD (CMOS)	14			x	No	0.15–0.4	7–24	>120	Yes
	Q-Face (non-stitch)	60–90	4–10	0.5	FPD (CMOS)	14	x	x	x	No	0.1–0.3	8–24	>60	Yes
	Q-Face (one stitch)	60–90	4–10	0.5	FPD (CMOS)	14	x	x	x	Yes	0.1–0.3	8–24	>60	Yes
	Q-Face (two stitch)	60–90	4–10	0.5	FPD (CMOS)	14	x	x	x	Yes	0.1–0.3	8–24	>60	Yes
	Q-Face-S (non-stitch)	60–90	4–10	0.5	FPD (CMOS)	14	x	x	x	No	0.1–0.3	8–24	>60	Yes
	Q-Face-S (one stitch)	60–90	4–10	0.5	FPD (CMOS)	14	x	x	x	Yes	0.1–0.3	8–24	>60	Yes
	Q-Face-S (two stitch)	60–90	4–10	0.5	FPD (CMOS)	14	x	x	x	Yes	0.1–0.3	8–24	>60	Yes
Hitachi (Japan)	CB Mercuray	60–120	10–15	?	II (CCD)	12	x		x	No	0.1–0.37	9.6	360	?
	CB Throne	60–120	10–15	?	II (CCD)	12	x		x	No	0.1*2–0.2*4	9.6	?	?
ImageWork (USA)	Panoura 18S	58–82	2–10	0.5	?	16	x	x		No	0.08–0.1	11.5–23	?	?
	Panoura 18S (Ceph)	58–82	2–10	0.5	?	16	x	x		No	0.08–0.1	11.5–23	?	?
J Morita (Japan)	3D Accuitomo XYZ	60–80	1–10	0.5	II (CCD)	?	x			No	0.125	18	>300	No
	3D Accuitomo FPD 60	60–80	1–10	0.5	FPD (CMOS)	13	x			No	0.08–0.125	>18	>180	No
	3D Accuitomo FPD 80	60–80	1–10	0.5	FPD (CMOS)	13	x	x		No	0.08–0.16	>18	>180	No
	3D Accuitomo 170	60–90	1–10	0.5	FPD (A-Si)	14	x	x	x	No	0.08–0.25	5.4–30.8	>180	No
	Veraview X800 F40P	60–100	2–10	0.5	FPD	?	x	x		No	0.08–0.125	9.4	<60	No
	Veraview X800 F40PC	60–100	2–10	0.5	FPD	?	x	x		No	0.08–0.125	9.4	<60	No
	Veraview X800 R100P	60–100	2–10	0.5	FPD	?	x	x		No	0.08–0.125	9.4	<60	No
	Veraview X800 R100PC	60–100	2–10	0.5	FPD	?	x	x		No	0.08–0.125	9.4	<60	No
	Veraview X800 F150P	60–100	2–10	0.5	FPD	?	x	x	x	No	0.08–0.125	9.4	<60	No

(Continued)

Table 2 (Continued)

Manufacturer	*Model*	*kV*	*mA*	*Focal Spot (mm)*	*Detector Type*[a]	*Detector Gray Scale (bits)*	*FOV*[b]			*FOV Stitching*	*Voxel Size (min-max) (mm)*	*Scan Time (s)*[c]	*Reconstruction Time (s)*	*Pulsed Beam*
							Small	*Medium*	*Large*					
	Veraview X800 F150PC	60–100	2–10	0.5	FPD	?	x	x	x	No	0.08–0.125	9.4	<60	No
	Veraviewpocs 3D F40	60–90	2–10	0.5	FPD (CMOS)	13	x	x		No	0.125	9.4	<60	No
	Veraviewpocs 3D F40PC	60–90	2–10	0.5	FPD (CMOS)	13	x	x		No	0.125	9.4	<60	No
	Veraviewpocs 3D R100	60–90	2–10	0.5	FPD (CMOS)	13	x	x		No	0.125–0.16	9.4	<60	No
	Veraviewpocs 3D R100PC	60–90	2–10	0.5	FPD (CMOS)	13	x	x		No	0.125–0.16	9.4	<60	No
KaVo Kerr (USA/ Finland)	KaVo 3D eXam	120	3–7	0.5	FPD (A-Si)	14			x	No	0.2–0.4	9–27	>120	Yes
	KaVo OP 3D	95	2–12.5	0.5	FPD (CMOS)	?	x	x	x	No	0.08–0.4	10–20	?	?
	KaVo OP 3D (Ceph)	95	2–12.5	0.5	FPD (CMOS)	?	x	x	x	No	0.08–0.4	10–20	?	?
	KaVo OP 3D Pro Small Panel	57–90	3.2–16	0.5	FPD (CMOS)	?	x	x		No	0.085–0.3	11–21	?	?
	KaVo OP 3D Pro Small Panel (Ceph)	57–90	3.2–16	0.5	FPD (CMOS)	?	x	x		No	0.085–0.3	11–21	?	?
	KaVo OP 3D Pro Large Panel	57–90	3.2–16	0.5	FPD (CMOS)	?	x	x	x	Yes	0.085–0.4	11–42	?	?
	KaVo OP 3D Pro Large Panel (Ceph)	57–90	3.2–16	0.5	FPD (CMOS)	?	x	x	x	Yes	0.085–0.4	11–42	?	?
	KaVo 3D Vision (V8)	90–120	3–8	0.5	FPD (A-Si)	16	x	x		No	0.125–0.4	4.8–26.9	>30	Yes
	KaVo 3D Vision (V10)	90–120	3–8	0.5	FPD (A-Si)	16	x	x	x	No	0.125–0.4	4.8–26.9	>30	Yes
	KaVo 3D Vision (V17)	90–120	3–8	0.5	FPD (A-Si)	16	x	x	x	No	0.125–0.4	4.8–26.9	>30	Yes
KaVo (Gendex - USA)	GXDP-800	57–90	3.2–16	0.5	FPD (CMOS)	16	x	x	x	No	0.085–0.4	10–20	?	Yes
	GXDP-800 (Ceph)	57–90	3.2–16	0.5	FPD (CMOS)	16	x	x	x	No	0.085–0.4	10–20	?	Yes
	GXDP-700-S	57–90	3.2–16	0.5	FPD (CMOS)	16	x	x		No	0.085–0.3	11–17	?	Yes
	GXDP-700-SC	57–90	3.2–16	0.5	FPD (CMOS)	16	x	x		No	0.085–0.3	11–17	?	Yes
	GXCB-500	90–120	3–8	0.5	FPD (A-Si)	14		x	x	No	0.125–0.4	8.9–23	20–95	Yes
KaVo (Imaging Science - USA)	i-CAT Classic	120	3–7	0.5	FPD (A-Si)	14			x	No	0.2–0.4	10–40	>120	?
	i-CAT Precise	120	3–7	0.5	FPD (A-Si - CsI)	14	x	x	x	No	0.125–0.4	4–23	>95	?
	i-CAT Next Generation	120	3–7	0.5	FPD (A-Si)	14		x	x	No	0.125–0.4	5–27	>60	Yes
	i-CAT FLX MV	120	3–8	0.5	FPD (A-Si)	16	x	x	x	No	0.125–0.4	4.8–23	>30	Yes
	i-CAT FLX V8	120	3–8	0.5	FPD (A-Si)	16	x	x		No	0.125–0.4	4.8–26.9	>30	Yes
	i-CAT FLX V10	120	3–8	0.5	FPD (A-Si)	16	x	x	x	No	0.125–0.4	4.8–26.9	>30	Yes
	i-CAT FLX V17	120	3–8	0.5	FPD (A-Si)	16	x	x	x	No	0.125–0.4	4.8–26.9	>30	Yes
KaVo (Instrumentarium – Finland)	OP200 D	57–85	2–16	0.5	?	?	x			No	0.23	?	?	?
	OC 200 D	57–85	2–16	0.5	?	?	x			No	0.23	?	?	?
	OP300	57–90	4–16	0.5	FPD (CMOS)	14	x	x		No	0.085–0.3	11–21	>120	Yes
	OP300 Maxio	57–90	4–16	0.5	FPD (CMOS)	14	x	x	x	Yes	0.085–0.3	11–40	>120	Yes
KaVo (Soredex – Finland)	Scanora 3D	60–90	8–15	0.5	FPD (CMOS)	12	x	x	x	No	0.133–0.35	10–26	60–360	Yes
	Scanora 3DX	60–90	4–10	0.5	FPD (A-Si)	?	x	x	x	No	0.1–0.5	18–34	?	Yes
	Cranex 3D	57–90	4–16	0.5	FPD (CMOS)	16	x	x		No	0.085–0.3	10–20	?	Yes
	Cranex 3D (Ceph)	57–90	4–16	0.5	FPD (CMOS)	16	x	x		No	0.085–0.3	10–20	?	Yes
	Cranex 3DX	57–90	4–16	0.5	FPD (CMOS)	16	x	x	x	Yes	0.085–0.4	10–40	?	Yes
	Cranex 3DX (Ceph)	57–90	4–16	0.5	FPD (CMOS)	16	x	x	x	Yes	0.085–0.4	10–40	?	Yes
LargeV (China)	HiRes 3D Dental	60–100	2–10	0.5	FPD (CMOS)	?	x	x	x	Yes	0.075–0.25	15–21	>30	Yes
	HiRes 3D MAX	60–100	2–10	0.5	FPD (A-Si)	?		x	x	Yes	0.075–0.3	15	>40	Yes
	Smart Dental	60–100	2–10	0.4	FPD (CMOS)	?	x	x	x	No	0.05–0.25	13	20–40	?
	Smart Dental (Ceph)	60–100	2–10	0.4	FPD (CMOS)	?	x	x	x	No	0.05–0.25	13	20–40	?

(Continued)

Table 2 (Continued)

Manufacturer	*Model*	*kV*	*mA*	*Focal Spot (mm)*	*Detector Type*[a]	*Detector Gray Scale (bits)*	*FOV*[b] *Small*	*Medium*	*Large*	*FOV Stitching*	*Voxel Size (min-max) (mm)*	*Scan Time (s)*[c]	*Reconstruction Time (s)*	*Pulsed Beam*
MyRay (Italy)	SkyView	90	10 (max)	0.5–0.6	II	12		x	x	No	0.17–0.33	10–30	30–70	Yes
	Hyperion X5 3D/2D	90	4–15	0.6	FPD (A-Si)	16	x	x		No	0.08–0.16	6.4–16.8	>15	Yes
	Hyperion X5 3D/2D CEPH	90	4–15	0.6	FPD (A-Si)	16	x	x		No	0.08–0.16	6.4–16.8	>15	Yes
	Hyperion X9 Full FOV	60–90	1–10	0.5	FPD (A-Si)	16	x	x		No	0.075-?	18	>15	Yes
	Hyperion X9 Full FOV CEPH	60–90	1–10	0.5	FPD (A-Si)	16	x	x		No	0.075-?	18	>15	Yes
	Hyperion X9 Extended FOV	60–90	1–10	0.5	FPD (A-Si)	16	x	x	x	Yes	0.075-?	18	>15	Yes
	Hyperion X9 Extended FOV CEPH	60–90	1–10	0.5	FPD (A-Si)	16	x	x	x	Yes	0.075-?	18	>15	Yes
	Hyperion X9 Pro 10 × 8 version	90	2–16	0.5	FPD (A-Si)	16	x	x		No	0.075-?	18	>15	Yes
	Hyperion X9 Pro CEPH 10 × 8 version	90	2–16	0.5	FPD (A-Si)	16	x	x		No	0.075-?	18	>15	Yes
	Hyperion X9 Pro 13 × 16 version	90	2–16	0.5	FPD (A-Si)	16	x	x	x	No	0.075-?	18	>15	Yes
	Hyperion X9 Pro CEPH 13 × 16 version	90	2–16	0.5	FPD (A-Si)	16	x	x	x	No	0.075-?	18	>15	Yes
Meyer (China)	SS-91010D Pro-3D	50–90	2–10	0.5	FPD (CMOS)	?	?	?	?	?	?	11.7–20	?	?
	SS-91010D Pro-3De	50–90	2–10	0.5	FPD (CMOS)	?	?	?	?	?	?	11.7–20	?	?
	X12008D Pro-3D	60–120	2–8	?	?	?			x	?	0.24	20	60	?
PiXAMED (Thailand)	DentiiScan 2.0	90	6–9	0.5	FPD (A-Si)	16		x	x	No	0.2–0.4	18	8–18	Yes
Owandy (France)	I-MAX 3D	60–86	2–12.5	0.5	FPD (CMOS)	?	x	x	x	No	0.087–0.175	10.8–11.2	?	?
	I-MAX 3D Touch	60–86	6–10	0.5	FPD (A-Si)	?	x	x		No	0.092	20	>90	Yes
	I-MAX 3D Touch CEPH	60–86	6–10	0.5	FPD (A-Si)	?	x	x		No	0.092	20	>90	Yes
Osstem (Republic of Korea)	Osstem Implant CBCT T1	60–100	5–16	0.5	FPD	?		x	x	No	0.2	14–22	40	?
Planmeca (Finland)	Promax 3D Classic	54–90	1–14	0.5	FPD (CMOS)	12	x	x	x	Yes	0.075–0.4	9–37	2–25	Yes
	Promax 3D Classic (Ceph)	54–90	1–14	0.5	FPD (CMOS)	12	x	x	x	Yes	0.075–0.4	9–37	2–25	Yes
	Promax 3D S	54–90	1–14	0.5	FPD (CMOS)	15	x	x		Yes	0.075–0.4	7.5–27	2–25	Yes
	Promax 3D S (Ceph)	54–90	1–14	0.5	FPD (CMOS)	15	x	x		Yes	0.075–0.4	7.5–27	2–25	Yes
	Promax 3D Plus	60–120	1–14	0.5	FPD (CMOS)	15	x	x		No	0.075–0.6	9–33	2–30	Yes
	Promax 3D Plus (Ceph)	60–120	1–14	0.5	FPD (CMOS)	15	x	x		No	0.075–0.6	9–33	2–30	Yes
	Promax 3D Plus ENT	60–120	1–14	0.5	FPD (CMOS)	15	x	x	x	No	0.075–0.6	9–33	2–30	Yes
	Promax 3D Plus ENT (Ceph)	60–120	1–14	0.5	FPD (CMOS)	15	x	x	x	No	0.075–0.6	9–33	2–30	Yes
	Promax 3D Mid	54–90	1–14	0.5	FPD (CMOS)	15	x	x	x	Yes	0.075–0.6	9–33	2–55	Yes
	Promax 3D Mid (Ceph)	54–90	1–14	0.5	FPD (CMOS)	15	x	x	x	Yes	0.075–0.6	9–33	2–55	Yes
	Promax 3D Mid ENT	54–90	1–14	0.5	FPD (CMOS)	15	x	x	x	Yes	0.075–0.6	9–33	2–55	Yes
	Promax 3D Mid ENT (Ceph)	54–90	1–14	0.5	FPD (CMOS)	15	x	x	x	Yes	0.075–0.6	9–33	2–55	Yes
	Promax 3D Max	54–96	1–12.5	0.5–0.6	FPD (CMOS)	15	x	x	x	Yes	0.075–0.4	9–55	2–55	Yes
	Promax 3D Max ENT	54–96	1–12.5	0.5–0.6	FPD (CMOS)	15	x	x	x	Yes	0.075–0.6	9–55	2–55	Yes
	Viso	80–120	1–16	0.5	FPD	?	x	x	x	No	0.075–0.6	1–36	2–55	Yes
	Viso (Ceph)	80–120	1–16	0.5	FPD	?	x	x	x	No	0.075–0.6	1–36	2–55	Yes
	Viso (Vertical stitching)	80–120	1–16	0.5	FPD	?	x	x	x	Yes	0.075–0.6	1–36	2–55	Yes
	Viso (Vertical stitching) (Ceph)	80–120	1–16	0.5	FPD	?	x	x	x	Yes	0.075–0.6	1–36	2–55	Yes
Pointnix (Republic of Korea)	Point I3D	50–90	4–16	0.5	FPD (A-Si)	14		x	x	No	0.23–0.47	19	19–24	?
	Point 3D Combi 500	50–90	4–10	0.5	FPD (A-Si)	14		x	x	No	0.18–0.43	19	10–40	Yes
	Point 3D Combi 500c	50–90	4–10	0.5	FPD (A-Si)	14		x	x	No	0.18–0.43	19	10–40	Yes
	Point 3D Combi 500 s	50–90	4–10	0.5	FPD (CMOS - CsI)	14		x	x	No	0.18–0.43	19	10–40	Yes
	Point 800 HD Plus	50–90	4–10	0.5	FPD (A-Si)	14		x	x	No	0.18–0.43	19	10–40	?
	Point 800c HD Plus	50–90	4–10	0.5	FPD (A-Si)	14		x	x	No	0.18–0.43	19	10–40	?
	Point 800 s HD Plus	50–90	4–10	0.5	?	14		x	x	No	0.18–0.43	19	10–40	?
PreXion (Japan)	PreXion 3D	90	4	0.15	FPD (CsI)	16		x		No	0.1–0.15	19–37	>60	No
	PreXion 3D Elite	90	4	0.2	FPD (CsI)	14	x	x		No	0.1–0.16	8.6–33.5	30	No
	PreXion 3D Elite Element	90	4	0.2	FPD (CsI)	14		x		No	0.1–0.16	8.6–33.5	30	No

(Continued)

Table 2 (Continued)

Manufacturer	*Model*	*kV*	*mA*	*Focal Spot (mm)*	*Detector Type*[a]	*Detector Gray Scale (bits)*	*FOV*[b] *Small*	*Medium*	*Large*	*FOV Stitching*	*Voxel Size (min-max) (mm)*	*Scan Time (s)*[c]	*Reconstruction Time (s)*	*Pulsed Beam*
	PreXion 3D Eclipse	90	4	0.2	FPD (CsI)	14		x		No	0.15	8.7–17.4	>30	No
	PreXion 3D Eclipse (Ceph)	90	4	0.2	FPD (CsI)	14		x		No	0.15	8.7–17.4	>30	No
	PreXion 3D Excelsior Ex	60–110	1–6	0.3	FPD (CsI)	16	x	x		No	0.08–0.2	5.2–23	?	No
	PreXion 3D Excelsior Ex (Ceph)	60–110	1–6	0.3	FPD (CsI)	16	x	x		No	0.08–0.2	5.2–23	?	No
	PreXion 3D Excelsior Plus	60–110	1–6	0.3	FPD (CsI)	16	x	x		No	0.08–0.2	5.2–23	?	No
	PreXion 3D Excelsior Plus (Ceph)	60–110	1–6	0.3	FPD (CsI)	16	x	x		No	0.08–0.2	5.2–23	?	No
	PreXion 3D Excelsior Pro	60–110	1–6	0.3	FPD (CsI)	16	x	x	x	No	0.08–0.2	5.2–23	?	No
	PreXion 3D Excelsior Pro (Ceph)	60–110	1–6	0.3	FPD (CsI)	16	x	x	x	No	0.08–0.2	5.2–23	?	No
	PreXion 3D Explorer	90–110	1–5	0.3	FPD (A-Si TFT)	16	x	x	x	No	0.074–0.3	10–20	60	Yes
Quantitative Radiology / Cefla Dental Group (Italy)	Giano HR Prime	90	2–16	0.5	FPD (A-Si)	16	x	x		No	0.075–0.3	3.6–26.4	>15	Yes
	Giano HR Prime (Ceph)	90	2–16	0.5	FPD (A-Si)	16	x	x		No	0.075–0.3	3.6–26.4	>15	Yes
	Giano HR Advanced	90	2–16	0.5	FPD (A-Si)	16	x	x	x	No	0.068–0.3	6.4–33.6	>60	Yes
	Giano HR Advanced (Ceph)	90	2–16	0.5	FPD (A-Si)	16	x	x	x	No	0.068–0.3	6.4–33.6	>60	Yes
	Giano HR Professional	90	2–16	0.5	FPD (A-Si)	16	x	x	x	No	0.068–0.3	6.4–33.6	>60	Yes
	Giano HR Professional (Ceph)	90	2–16	0.5	FPD (A-Si)	16	x	x	x	No	0.068–0.3	6.4–33.6	>60	Yes
	Giano/NewTom VG3	60–90	1–10	0.5	FPD (A-Si)	16	x	x		No	0.075-?	18	>15	Yes
	Giano/NewTom VG3 (Ceph)	60–90	1–10	0.5	FPD (A-Si)	16	x	x		No	0.075-?	18	>15	Yes
	Go 2D/3D Imaging	90	4–15	0.6	FPD (A-Si)	16	x	x		No	0.08-?	6.4–16.8	>15	Yes
	NewTom 9000 Maxiscan	110	1–15	1.2 × 0.8	?	?			x	No	0.3–1.2	70	?	Yes
	NewTom VG	110	1–20	0.3	FPD (A-Si)	14			x	No	0.3	24	180	Yes
	NewTom VG Flex	110	1–20	0.3	FPD (A-Si)	14				No	0.3	24	180	Yes
	NewTom VGi	110	1–20	0.3	FPD (A-Si)	16	x	x	x	No	0.075–0.3	18–26	60	Yes
	NewTom VGi Flex	110	1–20	0.3	FPD (A-Si)	14	x	x	x	No	0.075–0.3	18–26	60	Yes
	NewTom VGi evo	75–110	1–32	0.3	FPD (A-Si)	16	x	x	x	No	0.1–0.3	15–25	60	Yes
	NewTom 3G	110	15	0.5	II (CCD)	12		x	x	No	0.3	36	300	Yes
	NewTom 5G	110	1–20	0.3	FPD (A-Si)	16	x	x	x	No	0.075–0.3	18–36	300	Yes
	NewTom 5G XL	110	1–20	0.3	FPD (A-Si)	16	x	x	x	No	0.075–0.3	18–36	300	Yes
Ritter Imaging (Germany)	Orion	?	?	?	?	?	?	?	?	?	0.1–0.167	?	?	?
Ray Medical (Republic of Korea)	RAYSCAN Symphony BC	60–90	4–10	0.5	FPD	16		x		No	0.14	20–40	?	?
	RAYSCAN Symphony V	60–90	4–10	0.5	FPD	16			x	No	0.19–0.38	20–40	?	?
	RAYSCAN α−3D	60–90	4–17	0.5	TFT	?		x		No	0.16–0.3	4.9–14	?	Yes
	RAYSCAN α−3D (SC, OCS, OCL)	60–90	4–17	0.5	TFT	?		x		No	0.16–0.3	4.9–14	?	Yes
	RAYSCAN α + 130	60–90	4–17	0.5	TFT	?	x	x	x	No	0.07–0.3	4.9–14	?	Yes
	RAYSCAN α + 130 (SC, OCS, OCL)	60–90	4–17	0.5	TFT	?	x	x	x	No	0.07–0.3	4.9–14	?	Yes
	RAYSCAN α + 160	60–90	4–17	0.5	TFT	?	x	x	x	No	0.07–0.3	4.9–14	?	Yes
	RAYSCAN α + 160 (SC, OCS, OCL)	60–90	4–17	0.5	TFT	?	x	x	x	No	0.07–0.3	4.9–14	?	Yes
	RAYSCAN m+	60–90	4–17	0.5	FPD (CMOS)	?	x	x	x	No	0.18–0.4	?	?	Yes
	RAYSCAN *m* + SC	60–90	4–17	0.5	FPD (CMOS)	?	x	x	x	No	0.18–0.4	?	?	Yes
	RAYSCAN *m* + DR (with chest X-ray)	60–90	4–17	0.5	FPD (CMOS)	?	x	x	x	No	0.18–0.4	?	?	Yes
Ray Medical (Republic of Korea) / Apteryx (USA)	RAYSCAN α-Edge	60–90	4–17	0.5	FPD (CMOS)	16		x		No	0.14–0.29	14	?	Yes
	RAYSCAN α-SM Edge	60–90	4–17	0.5	FPD (CMOS)	16		x		No	0.14–0.29	14	?	Yes
Streamhealth Dental (USA)	Trophypan Smart 3D	60–90	2–15	0.7	FPD (CMOS)	14	x	x		No	0.075–0.4	7–15	?	?

(Continued)

Table 2 (Continued)

Manufacturer	*Model*	*kV*	*mA*	*Focal Spot (mm)*	*Detector Type*[a]	*Detector Gray Scale (bits)*	*FOV*[b]			*FOV Stitching*	*Voxel Size (min-max) (mm)*	*Scan Time (s)*[c]	*Reconstruction Time (s)*	*Pulsed Beam*
							Small	*Medium*	*Large*					
Suni Medical Imaging (USA)	Suni3D	40–99	2–10	0.5	?	?	x			No	0.08–0.2	15–24	>60	Yes
	Suni3D (Ceph)	40–99	2–10	0.5	?	?	x			No	0.08–0.2	15–24	>60	Yes
	Suni Q3D	60–90	4–12	0.5	FPD (CMOS)	?	x	x	x	Yes	0.075–0.4	7.7–14.5	?	?
	Suni Q3D (Ceph)	60–90	4–12	0.5	FPD (CMOS)	?	x	x	x	Yes	0.075–0.4	7.7–14.5	?	?
Trident (Italy)	X-View Cone Beam	61–85	4–10	0.5	FPD (CMOS)	14		x		No	0.16	15	>10	Yes
	X-View Cone Beam (Ceph)	61–85	4–10	0.5	FPD (CMOS)	14		x		No	0.16	15	>10	Yes
Vatech (Republic of Korea)	PaX i3D	50–90	4–10	0.5	FPD (CMOS)	14	x	x		No	0.12–0.3	15–24	?	?
	PaX i3D (SC or OP)	50–90	4–10	0.5	FPD (CMOS)	14	x	x		No	0.12–0.3	15–24	?	?
	PaX i3D Smart / i3D Smart 8 × 8	60–99	4–16	0.5	?	14		x		No	0.2–0.3	13.5	95	?
	PaX i3D Smart (Ceph)/ i3D Smart 8 × 8 SC	60–99	4–16	0.5	?	14		x		No	0.2–0.3	13.5	95	?
	PaX i3D Smart 2/Green Smart / Smart Plus / i3D Smart	60–99	4–16	0.5	?	14	x	x	x	No	0.08–0.3	18	?	?
	PaX i3D Smart 2 (Ceph) / Green Smart SC / Smart Plus RC / i3D Smart RC	60–99	4–16	0.5	?	14	x	x	x	No	0.08–0.3	18	?	?
	PaX i3D Green / Green CT	50–100	4–16	0.5	?	14	x	x	x	No	0.08–0.3	9–15	?	?
	PaX i3D Green SC or OP / Green CT SC or OP	50–100	4–16	0.5	?	14	x	x	x	No	0.08–0.3	9–15	?	?
	PaX i3D 2/Green CT 2/ Green 16	60–99	4–16	0.5	FPD (CMOS)	14	x	x	x	No	0.08–0.3	4.9–9	?	?
	PaX i3D 2 (Ceph) / Green CT 2 (Ceph) / Green 16 (Ceph)	60–99	4–16	0.5	FPD (CMOS)	14	x	x	x	No	0.08–0.3	4.9–9	?	?
	Green 18	60–99	4–16	0.5	FPD (CMOS)	14	x	x	x	No	0.08–0.3	4.9–9	?	?
	Green 18 (Ceph)	60–99	4–16	0.5	FPD (CMOS)	14	x	x	x	No	0.08–0.3	4.9–9	?	?
	Green 21/i3D Premium (AutoCeph)	60–120	4–10	0.5	FPD (CMOS)	14		x	x	No	0.2–0.4	18	?	?
	PaX Flex 3D P	50–90	2–10	0.5	FPD (CMOS)	14	x	x	x	No	0.12–0.3	15–24	>90	Yes
	PaX Flex 3D PC	50–90	2–10	0.5	FPD (CMOS)	14	x	x	x	No	0.12–0.3	15–24	>90	Yes
	PaX Uni 3D P	50–90	4–10	0.5	FPD (CMOS)	?	x	x	x	No	0.12–0.3	15–24	>90	Yes
	PaX Uni 3D PC	50–90	4–10	0.5	FPD (CMOS)	?	x	x	x	No	0.12–0.3	15–24	>90	Yes
	PaX Duo 3D	50–90	2–10	0.5	FPD (CMOS)	?	x	x	x	No	0.12–0.3	15–24	>90	Yes
	PaX Zenith 3D	50–120	4–10	0.5	FPD (CMOS)	14	x	x	x	No	0.08–0.3	15–24	>220	Yes
	PaX Reve 3D	50–90	2–10	0.5	FPD (CMOS)	14	x	x	x	No	0.08–0.25	15–24	>120	?
	PaX Reve 3D OS	50–90	2–10	0.5	FPD (CMOS)	14	x	x	x	No	0.08–0.25	15–24	>120	?
	Picasso Trio	50–90	2–10	0.5	FPD (CMOS)	12	x	x	x	No	0.2	15–24	29	?
	Picasso Trio (Ceph)	50–90	2–10	0.5	FPD (CMOS)	12	x	x	x	No	0.2	15–24	29	?
	Picasso Duo 3D	60–90	2–10	0.5	FPD	16	x			No	?	18–24	20	?
	Picasso Master 3D	40–90	2–10	0.5	FPD	14			x	No	0.16–0.2	24	29	?
	Picasso Pro 3D	40–90	2–10	0.5	?	?		x		No	0.2–0.3	15	15	?
	PaX 500 ECT	40–90	2–10	0.5	FPD	14	x			No	0.2	8	90	?
	PaX 500 ECT (Ceph)	40–90	2–10	0.5	FPD	14	x			No	0.2	8	90	?
Villa Sistemi Medicalli (Italy)	Rotograph Evo 3D	60–86	6–10	0.5	FPD (A-Si)	14	x	x		No	0.16	18–20	18–40	?
	Rotograph Evo 3D (Ceph)	60–86	6–10	0.5	FPD (A-Si)	14	x	x		No	0.16	18–20	18–40	?
	Rotograph Prime 3D	60–86	2–12.5	0.5	FPD (CMOS)	16	x	x		No	0.087–0.17	6.2–9	?	?
UEG Medical (China)	Spectral	80–110	4–8	0.5	FPD (A-Si)	16			x	No	0.075–0.3	?	>5	Yes
Xoran Technologies (USA)	Minicat	120–125	7	0.3	?	8	?	?	x	?	0.2–0.44	10–30	?	?
	Minicat IQ (ENT)	120	7	?	?	?	?	?	?	?	?	10–30	?	?
	Minicat 2020	120	5.8	?	?	?			x	No	?	?	?	?
	XCat (Portable)	120	6	0.15	FPD (CsI)	8			x	No	0.4	20	30–120	?
Yoshida (Japan)	Finecube	90	4	0.15	FPD (CsI)	14	x	x		No	0.1–0.16	8.6–34	>60	No
	X-era Smart F+	60–82	2–10	?	FPD (CMOS)	16	x			No	0.08–0.1	11.5–23	?	?
	X-era Smart F+ (Ceph)	60–82	2–10	?	FPD (CMOS)	16	x			No	0.08–0.1	11.5–23	?	?

(Continued)

Table 2 (Continued)

Manufacturer	*Model*	*kV*	*mA*	*Focal Spot (mm)*	*Detector Type*[a]	*Detector Gray Scale (bits)*	*FOV*[b] *Small*	*Medium*	*Large*	*FOV Stitching*	*Voxel Size (min-max) (mm)*	*Scan Time (s)*[c]	*Reconstruction Time (s)*	*Pulsed Beam*
Yoshida (Japan) / ImageWorks (USA)	X-era NF / Panoura X-era NF	70–90	2–4	0.2	FPD (CMOS)	16	x	x		Yes	0.09–0.15	12–20	?	?
	X-era NF (Ceph) / Panoura X-era NF (Ceph)	70–90	2–4	0.2	FPD (CMOS)	16	x	x		Yes	0.09–0.15	12–20	?	?
	X-era MF / Panoura X-era MF	70–90	2–4	0.2	FPD (CMOS)	16	x	x		Yes	0.09–0.23	12–20	?	?
	X-era MF (Ceph) / X-era MF (Ceph)	70–90	2–4	0.2	FPD (CMOS)	16	x	x		Yes	0.09–0.23	12–20	?	?

CBCT, cone beam CT; 2D, two-dimensional; 3D, three-dimensional; FOV, field of view; kV: kilovoltage; mA: miliamperes (tube current).'CBCT mode', the lower end of the reported kV range may only apply to panoramic and cephalometric modes.
[a]Further information regarding detector components (*e.g.* scintillator) is shown in accordance with the terminology used by the manufacturer.
[b]The FOV was divided according to the irradiated surface considering FOV height multiplied by its diameter. A small FOV was considered when the surface was ≤40 cm²; a medium FOV was considered if the surface was >40 cm² and ≤100 cm²; and a large FOV if it was >100 cm².
[c]Scan time according to the values reported by the manufacture, although some of these values may actually refer to exposure time but no clear distinction could be made.

detector size, allowing a lower cost and a compact device, for upright patient imaging.

In contrast, the use of exclusive high-end CBCT devices is rapidly decreasing for the same reasons, which is unfortunate considering the often superior image quality of such dedicated devices.

X-ray beam quality and flux are determined by several parameters, such as tube voltage (kV) and tube current (mA).[12] These parameters may be fixed for a given CBCT unit, or they can vary between pre-set exposure programs (*e.g.* large/small, adult/paediatric pre-sets) or manually adjusted by the operator.[12,17] In the present overview, it was found that most of the current devices have adjustable kV and mA options. One must bear in mind that exposure parameters affect not only image quality, but also patient radiation dose, and therefore they should be adjusted to optimise the CBCT acquisition, maintaining image quality for diagnosis (as low as reasonably achievable – ALARA; and as low as diagnostically acceptable being indication-oriented and patient-specific– ALADAIP principles).[26–28]

Apart from exposure parameters, FOV selection also is crucial when acquiring a CBCT scan, as its size is related to the radiation dose.[3,11,17] Furthermore, X-ray

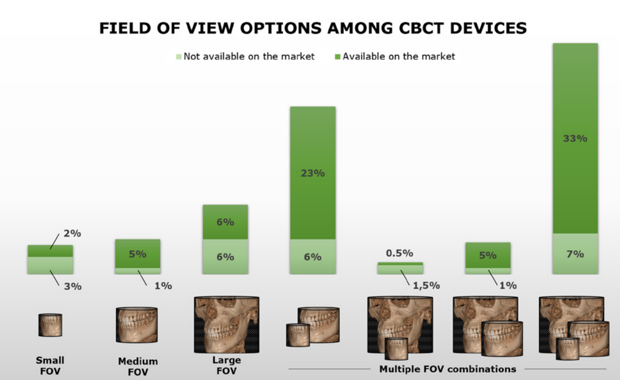

Figure 4 Relative frequency of different options of field of view (small, medium, large, and combinations) among the CBCT devices, considering the availability of the devices on the market. CBCT, cone beam CT; FOV, field of view.

scatter is notably increased for large FOVs, which can impair image quality.[29] It is also not practical to reconstruct larger FOVs at small voxel sizes due to excessive reconstruction time and file size; the use of a larger voxel size limits the spatial resolution,[30] as discussed further below. FOVs can be divided into three categories: small, medium and large,[25,31] with various combinations of diameter and height within these categories. FOVs may cover a few teeth, an entire jaw, or even the entire skull of the patient. It is advantageous to have devices with a selectable FOV so that the radiation dose given to the patient can be decreased depending on the indication of the examination (*e.g.* endodontic evaluation *vs* orthognathic surgery planning),[11,32] although small and medium FOVs may cover most dental applications.[25] To acquire bigger FOVs, CBCT device should have a large detector size, compatible to the FOV dimensions. However, a larger detector means more expensive machines. To overcome this additional expense in the manufacture, some devices employ automatic stitching of multiple scan volumes, either horizontal or vertical, to acquire larger FOVs.[12] In some of the machines, an option to extend the FOV is available as an upgradable feature. CBCT images acquired using FOV stitching imply the acquisition of two (or more) adjacent exams with common areas to allow the fusion of the volumes into one, and therefore double radiation exposure in the overlap region.[12] From a clinical point of view, it seems to interfere on image quality and artefacts expression, but this relation should be further investigated.

Usually, the FOV and voxel size are connected as for small FOV, smaller voxel sizes can be selected.[3] A wide range of voxel sizes was found in the present study, ranging from 0.05 to 0.6 mm, and they should be selected according to the diagnostic task.[3] Smaller voxel dimensions may be associated with better spatial resolution and may thus be necessary when a high level of detail is required. On the other hand, for a given FOV, a smaller voxel size is associated with a higher mAs, thus increasing the radiation dose to the patient. In addition, noise is increased.[3,12,32] Therefore, CBCT devices should offer a number of different voxel sizes, so that

Table 3 Recommended standardisation of CBCT machines features to be reported by the manufacturers

Features	***Specific features***	***Description**a*
General	Dimensions	Width x depth x (maximum) height in meters
	Weight	Total machine weight in kilograms, without workstation
	Patient positioning	Standing, sitting, supine. Wheelchair accessibility
	Software (acquisition)	Software used for image acquisition
	Software (DICOM viewer)	Software used as DICOM viewer Availability of DICOM structured report tools
X-rays	Tube voltage (kV)	Fixed (exact value) or variable (range)
	Tube current (mA)	Fixed (exact value) or variable (range)
	Focal spot size	Focal spot size in millimeters
	X-rays beam generation	Pulsed or continuous x-rays generation
Detector	Detector type	Type of the detector used for CBCT acquisitions (incl. scintillator and signal read-out system)
	Detector dimensions	Detector width x height in centimeters
	Detector resolution	Detector width x height in pixels Binning (if applicable)
	Detector bit depth	Signal range of the detector
Volume and resolution	Available FOV	All available possibilities of FOV in the machine, not just the smallest and the biggest
	Stitching for extended FOV	The use of stitching to achieve bigger volumes. Specify if it is horizontal or vertical (or both) stitching
	Voxel size	All available voxel sizes, not just the smallest and the biggest
	Rotation angle	Rotation arc of the gantry during acquisition
Times	Scan time	Time taken for the whole scan (mean and range)
	Exposure time	Time taken only when the X-rays generation is occurring (mean and range)
	Reconstruction time	Time taken for the volume reconstruction (mean and range)
Radiation dose	Dose index	Range of RDSR-compliant dose index values (preferably dose-area product, possibly dose-length product), considering low- and high-dose protocols
	Effective dose	Range of effective dose (in µSv) calculated in an appropriate phantom, considering low- and high-dose protocols

CBCT, cone beam CT; FOV: field of view; RDSR: radiation dose structured report; µSv: micro-sieverts;kV: kilovoltage; mA: miliamper.
[a]Importantly, for hybrid machines, the CBCT features should be reported separately from those of cephalometric and panoramic imaging.

the examinations allow the use of the largest voxel size (*i.e.* lowest radiation dose) while maintaining acceptable diagnostic accuracy.

The resolution of a CBCT image is also influenced by other parameters such as the focal spot size, number of projections (rotation angle & frame rate), reconstruction algorithm, scatter and patient motion.[3,32] Patient positioning during image acquisition may affect the probability of motion artefacts. Patients in a standing position, as in the great majority of the devices, can be more susceptible to motion, especially in cases with motion disabilities.[3] However, no studies have evaluated how the patient positioning can influence motion artefacts.[33] Additionally, the scan time may play a role. In the present study, the mean scan time was between 17.5 s, depending on the FOV and voxel size selection. Shortening the scan time could contribute to avoid (but not eliminate) motion artefacts considering that the patient could remain still during a fast scan.[33] However, if the patient moves during a shorter scan, the resulting motion artefact may be more pronounced than in a longer scan. Importantly, manufacturers should correctly report the scan time and the exposure time. The scan time correspond to the time between the first and last basis image acquisition while the exposure time is only related to those moments when the patient is exposed to radiation. In some machines very low scan time were reported (*e.g.* 1 s) and it is more likely to be the exposure time. The scanning time is only equal to the exposure time for CBCT devices that present a continuous beam operation mode (*i.e.* not pulsed). However, most of the CBCT devices presented a pulsed beam mode; therefore the scanning time is higher than the exposure time, but with the advantage of reducing radiation dose to the patient.[3]

Information on technical aspects of the machines are usually accessible on the company's official website and downloadable brochures and device manuals. However, on some websites this information is limited. Even in brochures and manuals, one may not find all the technical information about the CBCT device. This difficulty was previously reported,[1] thus some information could not be displayed in our current overview. This also applies to effective radiation dose range of the CBCT devices, which was probably the least reported feature (less than 40% of the machines). The lack of standardised data and the missing scientific reports comparatively assessing dose levels, prevented us from reporting tabulated comparative information on dosimetry. In a further report, an attempt will be made to compare the scientific output data for patient-specific and indication-oriented radiation dose levels. From the available evidence, we can summarise that differences in radiation dose levels are huge, both between and within specific CBCT devices. While some devices can provide 3D image data at the dose level of two to five panoramic images, such or other CBCT devices can also produces dose levels as high as medical CT when orienting towards another indication and parameter set-up. A 50-fold radiation dose difference can be easily seen when changing the settings in specific CBCT devices.[27,34] A standardisation of the technical aspects and features reported regarding the CBCT devices would benefit researchers and practitioners when considering acquiring a machine (see also Table 3).

Conclusion

In conclusion, 279 CBCT devices models were catalogued. Given the wide range of CBCT devices available on the market at the time of writing, dental CBCT should be considered as a generic name applicable to a group of heterogeneous devices. The variability of CBCT features makes it impossible to draw general comparisons between different models, especially in the research field, since CBCT devices may present more variables related to the final image then the tested parameter. Therefore, a systematic review should be carried out to compare published research evidence on indications, image quality and radiation dose levels of all CBCTs on the market. The information tabulated in the present study will be later provided on the International Association of DentoMaxilloFacial Radiology website (www.iadmfr.one). Considering ongoing developments and continued improvements, the present overview will need to be revised within 5 years.

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