

CLINICAL RESEARCH

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How is the Use of Digital Dental Radiology in a Developing Country?
An Overview of Brazil

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¿Cómo es el uso de la radiología dental digital en un país en vías
de desarrollo? Una visión general de Brasil

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ABSTRACT: The aim of this study was to assess the use of digital dental radiology in Brazil, by focusing on the use of image receptors, imaging exams and digital image enhancement tools, also assessing the methods of professional image transfer. Questionnaires were distributed in person on dental meetings and digitally via messaging (WhatsApp®) and mailings list. The sample of this cross-sectional study consisted of 478 questionnaires. Most participants were woman (n=315, 65.9%), with average age of 33.8±9.2 years. Descriptive and frequency analysis was performed. Chi-square and Fisher's exact tests were used ($\alpha=0.05$). Most dentists worked at shared dental clinics (34.7%) and use digital image receptors (51.1%), but a representative percentage (48.9%) still exclusively use radiographic films. Photostimulable phosphor plate is the most used digital image receptor. Among extraoral exams, panoramic radiography (PAN) is the most used. Regarding dental specialties, oral radiologists and oral and maxillofacial surgeons mostly use cone-beam computed tomography ($p<0.001$). Most dentists who use digital systems make use of digital image enhancement tools (87.8%), mainly contrast, zoom, brightness and measurements. The most common method of professional image transfer (professional-professional and professional-patients) is by email, with few dentists using online app and social media (26%). Therefore,

while most Brazilian dentists use digital imaging systems, a significant percentage still exclusively use radiographic films. The most extraoral imaging exams used is PAN. Regarding image enhancement tools, brightness and contrast adjustments, zoom and measurements are the most applied. Finally, dentists generally use email for professional image transfer.

KEYWORDS: Dental digital radiography; Diagnostic imaging; Radiographic image enhancement; Radiography; Panoramic.

RESUMEN: El objetivo de este estudio fue evaluar uso de la radiología dental digital en Brasil, centrándose en uso de receptores de imagen, exámenes de imágenes y herramientas de mejora de imagen digital, evaluando también los métodos de transferencia de imagen profesional. Cuestionarios se distribuyeron de forma presencial en reuniones odontológicas y de forma digital a través de mensajería (WhatsApp®) y lista de correo. Muestra de este estudio transversal estuvo compuesta por 478 cuestionarios. Mayoría de los participantes eran mujeres (n=315, 65,9%), con edad promedio de 33,8±9,2 años. Se realizó un análisis descriptivo y de frecuencias. Se utilizaron las pruebas Chi-cuadrado y exacta de Fisher ($\alpha=0,05$). La mayoría de los odontólogos trabajaban en clínicas dentales compartidas (34,7%) y utilizan receptores de imágenes digitales (51,1%), pero un porcentaje representativo (48,9%) todavía utiliza exclusivamente películas radiográficas. Placa de fósforo fotoestimulable es el receptor de imagen digital más utilizado. Entre los exámenes extraorales, la radiografía panorámica (PAN) es la más utilizada. En cuanto a las especialidades odontológicas, los radiólogos orales y los cirujanos orales y maxilofaciales utilizan mayoritariamente la tomografía computarizada de haz cónico ($p<0,001$). Mayoría de los odontólogos que utilizan sistemas digitales utilizan herramientas de mejora de imagen digital (87,8%), principalmente contraste, zoom, brillo y medidas. Método más común de transferencia de imágenes profesionales (profesional-profesional y profesional-pacientes) es por correo electrónico, con pocos dentistas que utilizan aplicaciones en línea y redes sociales (26%). Por lo tanto, mientras que la mayoría de dentistas brasileños utilizan sistemas de imágenes digitales, un porcentaje significativo aún utiliza exclusivamente películas radiográficas. Examen de imagen extraoral más utilizado es el PAN. En cuanto a las herramientas de mejora de imagen, los ajustes de brillo y contraste, el zoom y las medidas son las más aplicadas. Finalmente, los dentistas generalmente usan el correo electrónico para la transferencia de imágenes profesionales.

PALABRAS CLAVE: Radiografía digital dental; Diagnóstico por imagen; Mejora de la imagen radiográfica; Radiografía; Panorámica.

INTRODUCTION

Advancements in technology and its advantages have increased the use of digital systems in dentistry (1,2). Improvements in digital imaging systems and software have expanded the possibility of image enhancement and diagnostic task specific post-processing adjustments (3). Digital imaging systems also enable a long-term online imaging storage and simplify communication with professionals and patients (4). The lower radiation dose required by digital image receptor is another advantage of digital imaging systems compared with conventional radiographic films (1), which minimize the radiation-related risks and optimizing the outcomes for both professionals and patients (5). Moreover, it presents a lower risk of environmental contamination due to the non-use of chemical solutions used in conventional radiographic processing, as well as a decrease in imaging exams repetition due to errors in this processing (1).

In the United States and in many European countries, digital radiology is a reality (5). In Belgium, for example, 90% of dentists use digital imaging systems (4). Such a reality, however, may be different in developing countries like Brazil, country of huge dimensions and regions with different socioeconomic conditions. It is important to verify the realities of access to digital systems to establish guidelines for digital radiology, communication and radiological protection adequate for each region. The main objective of the present study was, therefore, to analyze the use of digital imaging systems by dentists, assessing the types of image receptors, imaging exams and digital imaging enhancement tools used in Brazilian dental offices. In addition, the methods of sharing the imaging exams with colleagues and patients was

assessed to achieve an overview of the current use of dental radiographic in Brazil.

MATERIAL AND METHODS

This questionnaire-based cross-sectional study was approved without restrictions by the Institutional Ethics Committee (protocol: #23706819.7.0000.5418), and written informed consent was obtained from volunteers. Participation was confidential, and the questionnaires were evaluated anonymously.

Based on the questionnaire proposed by Snell *et al.* (2018) (4), multiple-choice questions were divided into: demographic data (gender, age, professional experience), professional status (dental specialty and type of clinic where dentist works), radiographic system used (conventional and/or digital; if digital, photostimulable phosphor plate (PSP) and/or solid sensor; and intra and/or extra-oral exams), and dental image communication (printout, email, cloud storage, portable storage, social media, online applications (app) or website).

Two oral radiologists adjusted the questionnaire to address topics not covered in the original, as the use of digital image enhancement tools and the sharing of imaging exams on social media. Ten oral radiology professors with experience in digital and conventional imaging systems evaluated the questionnaire to confirm the appropriateness of each multiple-choice question.

Then, a pre-test was conducted with 10 dentists from different dental specialties to verify the participants' understanding of the questionnaire. Each dentist filled one questionnaire. Anyone have doubts nor made suggestions. The final

version of the questionnaire comprised 8 questions. Questions 1 and 2 were common to all dentists, while questions 3 to 8 were answered only by dentists who used digital radiography systems. Fully or almost fully completed questionnaires were considered valid.

This final version was applied to a convenience sample of dentists between September (2019) and June (2020). Manually, during dental meetings in Brazil, and digitally, by emailing and messaging (WhatsApp®) through an access link to the questionnaire on the Google Forms platform (Alphabet Co., Mountain View, California, USA). The questionnaire was completed in approximately five minutes. The final sample consisted of 478 valid questionnaires (372 paper-based and 126 online-based) (Figure 1). Most participants were woman (n=315, 65.9%), with average age of 33.8±9.2 years.

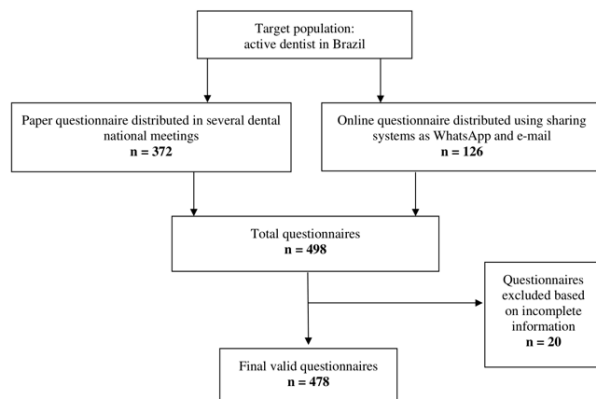


Figure 1. Flowchart showing the inclusion and exclusion criteria and study population (questionnaires considered for analysis) n=numbers.

Data were underwent descriptive and frequency analysis. Statistical significance was calculated by chi-square and Fisher's exact test, using SPSS software version 24.0 (IBM Corp., Armonk, NY) and significance level of 5%.

RESULTS

Table 1 shows the sample distribution according to sex, age group and workplace. Most dentists

are between 20 and 29 years old (43.7%, n=209) and work in shared dental clinics (34.7%, n=166).

Regarding the use of intraoral image receptor, 51% (n=244) of the dentists uses digital receptors (PSP and or solid sensor), while 68.4% (n=327) uses radiographic films. Some dentists use exclusively radiographic films (48.9%, n=234) and some others use exclusively digital receptors (31.6%, n=151). Among digital image receptors, PSP is more used than solid sensors (Table 2). Dentists between 20 and 29 years old use more radiographic films than other age groups (p=0.001). General practitioners, implantodontists and orthodontists use more radiographic films than other dental specialties (p<0.001), whereas oral radiologists use more digital image receptors (mainly PSP) than radiographic films (p<0.001) (Table 2).

As for extraoral imaging exams, dentists use more panoramic radiography (PAN) than skull radiographies (44%, n=245). Considering the age group and type of image receptor, dentists between 20 and 29 years old use more radiographic film than digital receptors for both PAN and skull radiography (p=0.004). This same age group uses less skull radiography and cone-beam computed tomography (CBCT) than the others (p=0.007). PAN is less used by edodontists and more used by oral radiologists (p<0.001). When compared to endodontists, general practitioners, periodontists and prosthodontists, oral radiologists perform digital skull radiography more often (p<0.001). CBCT is most often performed by oral radiologists and oral and maxillofacial surgeons (p<0.001) (Table 3).

Of those dentists who use digital receptors, most use digital image enhancement tools (87.8%, n=209 from 238). Contrast (89.5%, n=187), zoom (80.4%, n=168), brightness (74.2%, n=155) and measurements (57.9%, n=121) are the tools used most often. Dentists aged between 20 and 29

years use digital image enhancement tools the least ($p=0.020$). When comparing dental specialties, oral radiologists use digital image enhancement tools most often, mainly contrast, brightness, sharpness, zoom, and measurement tools ($p<0.05$) (Table 4).

Email is the method most commonly used to send digital imaging exams with colleagues (76.9%, $n=183$) and patients (67.6%, $n=161$). Cloud storage and app are also significant methods to transfer images. Of those who use digital imaging system, nearly half still print the imaging exams for send them to other dentists

or patients; the 20-29 age group prints imaging exams less often than the others ($p=0.003$). As for dental specialties, oral radiologists and endodontists print exams more and less often, respectively ($p<0.0001$). Regarding cloud storage, oral radiologists use it more often and general practitioners use it less often ($p<0.0001$) (Table 5).

While most dentists do not use app and social media to share imaging exams (74.1%, $n=177$) (Table 6), of those who do, most use it to share experiences ($n=42$) (Table 7). Age and specialty did not influence the sharing of imaging exams on app or social media ($p>0.05$).

Table 1. Sample distribution, according to sex, age group and workplace.

Sex	Age group	Workplace							Total	
		Shared DC	Shared DC + Personal DC	Shared DC + Dental school	Personal DC	ORC	ORC + Dental school	Public DC		Dental school
Female	Without answer	2	0	0	1	1	0	0	1	5
	20-29	65	19	7	16	11	1	13	23	155
	30-39	31	11	3	21	17	2	1	9	95
	40-49	13	3	1	10	5	0	2	2	36
	50-59	3	0	1	6	8	1	1	2	22
	60-69	0	1	0	1	0	0	0	0	2
	Total	114	34	12	55	42	4	17	37	315
Male	Without answer	1	0	0	1	2	1	0	0	5
	20-29	27	2	5	2	8	0	3	7	54
	30-39	12	5	5	7	14	1	0	3	47
	40-49	8	3	1	8	20	1	0	2	43
	50-59	3	0	0	5	2	0	0	2	12
	60-69	1	0	0	0	0	0	0	0	1
	70-80	0	1	0	0	0	0	0	0	1
	Total	52	11	11	23	46	3	3	14	163
Total	166	45	23	78	88	7	20	51	478	

Dental clinic (DC); Oral radiology clinic (ORC).

Table 2. Types of intraoral image receptors used, according to age group and dental specialty.

Age Group	Intraoral image receptors							Total
	Film	Film + PSP	Film + PSP + Solid sensor	Film + Solid sensor	PSP	Solid sensor	PSP + Solid sensor	
Without answer	2	0	1	2	3	2	0	10
20-29	123	5	2	31	27	17	4	209
30-39	67	13	0	17	36	4	5	142
40-49	28	0	3	12	23	8	5	79
50-59	11	1	2	4	11	4	1	34
60-69	3	0	0	0	0	0	0	3
70-80	0	0	0	0	0	1	0	1
Total	234	19	8	66	100	36	15	478
DENTAL SPECIALTY								
General practice	62	2	1	16	12	6	2	101
OMFS	5	1	1	2	2	0	0	11
Restorative dentistry	7	0	0	3	2	0	0	12
Endodontics	26	3	0	14	1	7	0	51
Implantodontist	25	0	0	4	2	2	0	33
Pediatric dentistry	11	1	0	4	0	2	0	18
Orthodontics	45	2	0	6	9	7	0	69
Periodontics	8	0	2	2	3	5	1	21
Prosthodontics	17	1	1	6	2	1	1	29
Oral Radiology	11	9	3	8	66	3	10	110
Others	17	0	0	1	1	3	1	23
Total	234	19	8	66	100	36	15	478

Photostimulable phosphor (PSP); Solid sensor (charge-coupled device (CCD) and Complementary metal oxide semiconductor (CMOS); Oral and maxillofacial surgery (OMFS). Bold number indicates statistically significant difference from the others within the same category ($p < 0.05$).

Table 3. Extraoral imaging exams used, according to age group and dental specialty.

Age Group	Imaging exam									
	Panoramic Radiography				Skull radiography				CBCT	
	No use	Digital	Conventional	Digital + Conventional	No use	Digital	Conventional	Digital + Conventional	No use	Use
Without answer	3	5	1	1	7	2	0	1	5	5
20-29	107	60	26	16	167	28	10	4	152	57
30-39	69	58	7	8	87	44	7	4	85	57
40-49	37	38	1	3	51	26	0	2	46	33
50-59	14	17	1	2	21	12	0	1	17	17
60-69	3	0	0	0	3	0	0	0	3	0
70-80	0	1	0	0	0	1	0	0	0	1
Total	233	179	36	30	336	113	17	12	308	170
DENTAL SPECIALTY										
General practice	62	24	11	4	88	7	6	0	80	21
OMFS	1	4	3	3	6	1	2	2	3	8
Restorative dentistry	9	3	0	0	12	0	0	0	10	2
Endodontics	40	5	6	0	51	0	0	0	40	11
Implantodontist	21	7	4	1	30	1	1	1	27	6
Pediatric dentistry	10	5	2	1	16	1	0	1	14	4
Orthodontics	40	20	4	5	49	12	6	2	56	13
Periodontics	15	3	0	3	21	0	0	0	17	6
Prosthodontics	14	7	2	6	27	1	0	1	20	1
Oral Radiology	10	95	0	5	17	87	2	4	22	7
Others	11	6	4	2	19	3	0	1	19	91
Total	233	179	36	30	336	113	17	12	308	170

Cone-beam computed tomography (CBCT); Oral and maxillofacial Surgery (OMFS).

Table 4. The use and type of digital image enhancement tools used, according to age group and dental specialty.

Age Group	Use of enhancement tools		Bright-ness	Contrast	Zoom	Measure-ment	Inversion	Relief	Sharp-ness
	No	Yes							
Without answer	0	6							
20-29	18	68	49	60	52	35	15	8	26
30-39	4	69	49	59	57	39	15	7	29
40-49	4	45	37	43	37	28	16	12	24
50-59	3	21	16	19	18	16	10	6	9
Total	29	209	155	187	168	121	57	36	91
DENTAL SPECIALTY									
General practice	10	29	18	25	21	13	6	5	11
OMFS	0	6	3	5	6	5	3	0	0
Restorative dentistry	2	3	2	2	1	1	2	1	1
Endodontics	5	20	13	17	15	14	11	4	7
Implantodontist	0	8	5	8	6	4	2	0	3
Pediatric dentistry	2	4	4	3	3	0	0	0	0
Orthodontics	3	21	10	17	17	8	3	0	9
Periodontics	1	11	8	11	11	7	3	0	3
Prosthodontics	3	8	6	7	7	6	4	1	4
Oral Radiology	3	93	82	86	77	59	22	24	51
Others	0	6	4	6	4	4	1	1	2
Total	29	209	155	187	168	121	57	36	91

Oral and maxillofacial Surgery (OMFS).

Table 5. Methods to send imaging exams among dentists and from dentist to patients.

Age Group	Dentist to dentist					Dentist to patient								
	Printing	Email	Cloud storage	Portable storage	Social media	App	Sites	Printing	Email	Cloud storage	Portable storage	Social media	App	Sites
Without answer	3	3	5	3	2	4	3	3	4	4	1	0	1	2
20-29	27	60	35	14	7	30	14	46	54	7	9	4	17	6
30-39	33	63	41	20	5	28	17	41	50	12	6	1	21	8
40-49	30	38	30	12	6	22	12	31	34	8	3	0	13	8
50-59	14	19	14	11	4	6	4	15	19	9	4	4	4	2
Total	107	183	125	60	24	90	50	136	161	40	23	9	56	26
DENTAL SPECIALTY														
General practice	12	24	11	7	5	19	2	21	21	3	4	1	11	2
OMFS	2	5	4	1	0	2	1	3	4	3	1	0	2	0
Restorative dentistry	1	5	2	0	0	0	0	3	3	1	0	0	1	0
Endodontics	4	18	7	6	2	12	2	7	17	3	1	0	9	0
Implantodontist	3	7	5	5	1	3	2	4	4	1	2	1	3	1
Pediatric dentistry	0	5	1	1	0	2	1	2	4	0	0	0	3	0
Orthodontics	7	20	11	6	2	8	5	9	19	2	2	2	7	2
Periodontics	2	12	8	2	0	5	1	2	4	2	2	0	1	1
Prosthodontics	5	8	6	1	1	6	0	5	12	3	1	0	5	0
Oral Radiology	70	76	66	29	12	30	34	5	7	3	1	1	6	0
Others	1	3	4	2	1	3	2	75	66	19	9	4	8	20
Total	107	183	125	60	24	90	50	136	161	40	23	9	56	26

Oral and maxillofacial Surgery (OMFS); Applications (App).

Table 6. Use of applications (app) and social media for sharing imaging exams.

Age Group	Sharing imaging exams on the internet		Ways of sharing imaging exams on internet	
	No	Yes	APP	SOCIAL MEDIA
No informed	3	3	1	2
20-29	66	20	7	12
30-39	55	19	2	15
40-49	38	11	2	6
50-59	14	9	5	3
70-80	1	0	0	0
Total	177	62	17	38
DENTAL SPECIALTY				
General practice	29	10	4	6
OMFS	4	2	0	1
Restorative dentistry	4	1	0	0
Endodontics	17	8	2	6
Implantodontist	5	3	1	1
Pediatric dentistry	6	0	0	0
Orthodontics	21	3	0	2
Periodontics	10	3	0	2
Prosthodontics	9	2	1	1
Oral Radiology	70	26	7	18
Others	2	4	2	1
Total	177	62	17	38

Oral and maxillofacial surgery (OMFS).

Table 7. Reasons for the sharing of imaging exams by dentists.

Age Group	Experience sharing	Doubts	Publicity	Academic
No informed	2	1	2	2
20-29	15	11	10	12
30-39	12	3	12	8
40-49	7	4	7	2
50-59	6	6	4	1
Total	42	25	35	25
DENTAL SPECIALTY				
General practice	5	7	3	7
OMFS	0	0	0	2
Restorative dentistry	0	0	1	0
Endodontics	7	3	5	3
Implantodontist	3	1	2	0
Pediatric dentistry	0	0	0	0
Orthodontics	2	0	3	1
Periodontics	1	1	2	1
Prosthodontics	2	2	1	1
Oral Radiology	18	9	15	8
Others	4	2	3	2
Total	42	25	35	25

Oral and maxillofacial surgery (OMFS).

DISCUSSION

IMAGE RECEPTORS AND IMAGING EXAMS

The present study found that most dentists in Brazil still use exclusively radiographic film (conventional system); while in many European countries and in the United States digital radiology is a reality (4,6,7). A study conducted in Brazil found no significant associations between age and the use of digital radiography (5). Contrary to expectations, the present study found that the 20-29 age group used more radiographic film than digital image receptor, compared to other age groups. Such finding may be explained by the fact that dentists in this age group are often working in facilities without access to digital systems (e.g., public dental clinics, postgraduate courses

in educational institutions and shared clinics with no digital system available). Another hypothesis is that most of them would lack sufficient economic power to invest in digital systems, since they are starting their careers.

When comparing dental specialties, this study found that oral radiologists use more digital image receptors than radiographic films. Oral radiologists usually work in oral radiology clinics, which invest in technology in an effort to improve the agility of services and the quality of radiographic images. Among the image receptors, it was found that PSP is more commonly used than solid sensor, what is in line with a Belgium study (4). General practitioners, implantodontist and orthodontists, in turn, use more radiographic film than digital image receptors and this finding may be explained

by the fact that, in Brazil, it is not common these dental specialties have digital imaging systems in their own dental clinics.

Among extraoral exams, PAN is most used in clinical practice, possibly due to its good overview of the patient's jaws, dentition and important neighboring anatomical structures, such as maxillary sinuses and mandibular canal, with low radiation dose (2). However, for endodontists, PAN has a low demand probably because they need detailed images of the root apex and adjacent alveolar bone, which is better provided by periapical radiography. Oral radiologists, on the other hand, work with PAN most often, most likely because this imaging exam is usually performed in oral radiology clinics. CBCT are also performed in oral radiology clinics, thus justifying the greater use of this exam among radiologists. Surgeons also frequently use CBCT due to the possible three-dimensional visualization of the maxillofacial structures, which is important for surgical planning in order to avoid damaging the anatomical structures (8).

DIGITAL IMAGE ENHANCEMENT TOOLS

In the present study most dentists using digital systems apply digital image enhancement tools, a result in line with Rovaris *et al.* (2016) (5). Studies evaluating dentists' perception of the quality of digital radiographs found that some dentists preferred the enhanced image to the original (1,9). Rovaris *et al.* (2016) (5) found that brightness and contrast adjustments and zoom were the digital tools most used by Brazilian dentists, as in the present study. Such a finding may be explained by the fact that brightness and contrast adjustments can be easily made in any imaging software and are usually applied according to personal visual preferences (3). A previous study showed the importance of brightness and contrast adjustments for specific diagnostic tasks, such as soft-tissue calcifications (2). Similarly, other previous studies (10,11) found a high preference

for the zoom tool due to its intuitiveness (12). On the other hand, inversion and relief were the digital tools least used by Brazilian dentists. Inversion tool has no relevance for improving the visibility of anatomical structures or diagnosing bone loss measurements (13,14). As expected, oral radiologist is the dental specialty that uses digital image enhancement tools (e.g., zoom, brightness, contrast, and measurement tools) most often.

Contrary to expectations, i.e., that younger professionals would use digital image enhancement tools more often due to their familiarity with technology, dentists between 20 and 29 years old use less them than the others age groups. The present authors hypothesized that such 20-29 age group may have less practice with those tools when compared to more experienced professionals, thus its low use. The lack of training may also result from the undergraduate course, since not all Brazilian universities offer access to digital radiology during practice (15), showing that the bureaucratic processes and the high costs of digital systems, compared to conventional ones, continue to be obstacles to increase the use of digital systems.

COMMUNICATION AND SOCIAL MEDIA

Email appears as the method most commonly used by Brazilian dentists to send imaging exams to colleagues and patients, which is in line with a previous Belgian study (4). Online transfer of digital files can be useful in healthcare because it is a fast and convenient process (16). Many radiographic image file formats can be easily used and transferred, such as tagged image file format (TIFF), bitmap file format (BMP), portable network graphics (PNG), joint photographic experts group (JPEG), and digital imaging and communications in medicine (DICOM). Previous studies showed that digital radiographic images can be stored in multiple file formats without affecting task-specific diagnosis (16,17).

How dentists send imaging exams varies according to age and dental specialty. The present study showed that younger dentists print exams less than other age groups. Although support campaigns have been held to reduce the printing of radiographic exams in an effort to preserve the environment and get all the benefits specific to digital imaging exams, a significant percentage of dentist still print exams obtained by digital systems, reinforcing the need for more campaigns in this regard.

As for the dental specialty, endodontic professionals generally use imaging exams during treatment for personal evaluation, which culminates in less printed exams. Oral radiologists, in turn, print more imaging exams to send to other professionals. This seems paradoxical for radiologists should understand the benefits of not printing digital images; since they provide a service to other specialties, however, radiologists have to follow the society's culture of having printed images. Moreover, oral radiologists more often use cloud storage and websites to send exams to other professionals or patients, since radiology clinics have their own websites and cloud storage generates greater security regarding backup and reduces physical storage space (e.g., computers and external storage devices).

Exchange of experiences and discussion of clinical cases appears as the primary reasons for dentists to share images via social media. It is interesting to note, however, that such images can only be used with the patient's consent (18).

CONCLUSION

While most Brazilian dentists use digital imaging systems, a significant part still use exclusively radiographic films, with younger dentists employing more radiographic films than other age groups. PAN is the extraoral modality most used

by dentists. Brightness and contrast adjustments, zoom and measurements are the digital enhancement tools most used. Regarding dental specialty, oral radiologists use digital image enhancement tools most often. Email is the main method used to send imaging exams to other professionals and patients. Finally, the main reason to share images on social media is to exchange experience in dentistry community.

CONFLICTS OF INTEREST

The authors declare no conflict of interest.

AUTHOR CONTRIBUTION STATEMENT

Conceptualization and design: L.M.S, E.D.C. and D.Q.F.

Literature review: L.M.S., L.O.R., F.N.R., E.D.C. and D.Q.F.

Methodology and validation: L.M.S, E.D.C and D.Q.F.
Formal analysis: D.Q.F.

Investigation and data collection: L.M.S., L.O.R. and F.N.R.

Resources: L.M.S., L.O.R., F.N.R., E.D.C. and D.Q.F.
Data analysis and interpretation: L.M.S., L.O.R., F.N.R., E.D.C. and D.Q.F.

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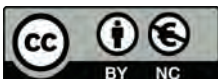
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REFERENCES

1. Wenzel A., Møystad A. Workflow with digital intraoral radiography: a systematic review. *Acta Odontol Scand* 2010; 68 (2): 106-14.
2. Moreira-Souza L., Michels M., Lagos de Melo L.P., Oliveira M.L., Asprino L., Freitas D.Q. Brightness and contrast adjustments influence the radiographic detection of soft tissue calcification. *Oral Dis* 2019; 00: 1-6.
3. Gaêta-Araujo H., Nascimento E.H.L., Brasil D.M., Gomes A.F., Freitas D.Q., De Oliveira-Santos C. Detection of Simulated Periapical Lesion in Intraoral Digital Radiography with Different Brightness and Contrast. *Eur Endod J* 2019; 4 (3): 133-8.
4. Snel R., Van De Maele E., Politis C., Jacobs R. Digital dental radiology in Belgium: A nationwide survey. *Dentomaxillofac Radiol* 2018; 47 (8): 20180045.
5. Rovaris K., Vasconcelos K. de F., do Nascimento E.H.L., Oliveira M.L., Freitas D.Q., Haiter-Neto F. Brazilian young dental practitioners' use and acceptance of digital radiographic examinations. *Imaging Sci Dent* 2016; 46: 239-44.
6. Berkhout W.E.R., Verheij J.G., Syriopoulos K., Li G., Sanderink G.C.H, van der Stelt P.F. Detection of proximal caries with high-resolution and standard resolution digital radiographic systems. *Dentomaxillofac Radiol* 2007; 36: 204-10.
7. Brian J.N., Williamson G.F. Digital radiography in dentistry: a survey of Indiana dentists. *Dentomaxillofac Radiol* 2007; 36: 18-23.
8. Costa E.D., Peyneau P.D., Ambrosano G.M.B., Oliveira M.L. Influence of cone beam CT volume orientation on alveolar bone measurements in patients with different facial profiles. *Dentomaxillofac Radiol* 2019; 48 (6): 20180330.
9. Kullendorff B., Nilsson M. Diagnostic accuracy of direct digital dental radiography for the detection of periapical bone lesions. II. Effects on diagnostic accuracy after application of image processing. *Oral Surg Oral Med Oral Pathol Oral Radiol Endod* 1996; 82 (5): 585-9.
10. Madarati A.A. Usage of image-enhancement tools when reading radiographs taken during root-canals treatments' procedures. *Eur Endod J* 2020; 5: 95-104.
11. Krupinski E. Technology and perception in the 21st century reading room. *J Am Coll Radiol* 2006; 3: 433-440.
12. Raitz R., Assunção J.A.N, Fenyó-Pereira M., Corrêa L., De Lima L.P. Assessment of using digital manipulation tools for diagnosing mandibular radiolucent lesions. *Dentomaxillofac Radiol* 2012; 41: 203-10.
13. Abesi F., Nikafshar N., Haghaniifar S., Khafri S., Hamzeh M. Can the inversion filter improve the visibility of the mandibular incisive canal? *Iran J Radiol* 2016; 13: 4-7.
14. Scaf G., Morihisa O., Loffredo L.D.C.M. Comparison between inverted and unprocessed digitized radiographic imaging in periodontal bone loss measurements. *J Appl Oral Sci* 2007; 15: 492-4. <https://doi.org/10.1590/S1678-77572007000600007>

15. Freitas D.Q, Ramos-Perez F.M.M., De-Azevedo S.L.V., Bóscolo F.N., Almeida S.M. Teaching of Oral Radiology in Brazilian Dental Schools. *JJ Dent Res* 2014; 2: 1-5.
16. Madlum D.V., Gaêta-Araujo H., Brasil D.M, Lima C.A.S., Oliveira M.L., Haiter-Neto F. Influence of the file format and transmission app on the radiographic diagnosis of caries lesions. *Oral Surg Oral Med Oral Pathol Oral Radiol* 2020; S2212-4403(20): 31390-0.
17. Miranda-Viana M., Madlum D.V., Oliveira-Santos N., Gaêta-Araujo H., Haiter-Neto F., Oliveira M.L. Influence of the image file format of digital periapical radiographs on the diagnosis of external and internal root resorptions. *Clin Oral Investig* 2021; 25 (8): 4941-4948. Epub 2021 Jan 26.
18. Costa E.D., Martins L.A.C., Cral W.G., Peroni L.V., Freitas D.Q., Oliveira M.L. Assessment of dentists' behaviour on the use of patients' images. *Eur J Dent Educ* 2020; 24: 513-7.



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