RESEARCH ARTICLE

Digital dental radiology in Belgium: a nationwide survey

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Objectives: The aim of this study is to analyse the use of digital dental radiology in Belgium, by focussing on the use of extraoral and intraoral radiographic techniques, digitalisation and image communication.

Methods: A nationwide survey has been performed amongst Belgian general dentists and dental specialists. Questionnaires were distributed digitally via mailings lists and manually on multiple refresher courses and congresses throughout the country. The overall response rate was 30%.

Results: Overall, 94% of the respondents had access to an intraoral radiographic unit, 76% had access to a panoramic unit, 21% has an attached cephalometric arm. One in five Belgian dentists also seem to have direct access to a cone beam CT. 90% of all intraoral radiography unit worked with digital detectors, while this was 91% for panoramic units (with or without cephalometrics). In 70% of the cases, general dental practitioners with a digital intraoral unit used a storage phosphor plate while in 30% of the cases they used sensor technology (charge-coupled device or complementary metal-oxide-semiconductor). The most common method for professional image transfer appeared to be email. Finally, 16% of all respondents used a calibrated monitor for image analysis.

Conclusions: The survey indicates that 90% of the respondents, Belgian dentists, make use of digital image techniques. For sharing images, general dental practitioners mainly use methods such as printout and e-mail. The usage of calibrated monitors, however, is not well established yet.

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Introduction

Dental radiography is increasingly used in the general dental practice. In Belgium, there are 2.8 million intra-oral radiographs taken each year, which may proportionally account for a fifth of all diagnostic radiographs taken annually.¹

The type and use of digital radiographic equipment has already been subject of several studies in multiple countries in the past.^{2–7} These studies have shown an increased availability of dental radiographic units throughout the years, with an exponential increase in digitalisation.⁸ In Belgium, these evolutions are also noticeable.^{7,9} A study

of Gijbels et al in 2005 indicated that 34% of the Belgium general dental practitioners (GDPs) already use digital techniques.⁷ In a more recent survey in 2014 by Vandyck et al 80% of the respondents reported using digital radiography for intraoral imaging.¹⁰ Digital oral radiography can be divided into charge-coupled device (CCD) based and storage phosphor (SR) based imaging techniques. The most common choice to date is the SR technique: two-third of the GDPs used SR.^{7,11}

Digital images need to be viewed and analysed on a digital display. There are several ways to view these images, namely, via a standard consumer monitor, via a digital imaging and communication in medicine (DICOM) calibrated monitor or via more modern ways such as tablet, computer or smartphone.^{12,13}

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Digital images facilitate the sharing of images with colleagues, specialists and patients. So far, it remains unknown whether dentists use dedicated displays rather than standard screens. Also, it remains unclear which methods are used for professional image communication regarding dental radiographs. Accumulating descriptive statistics and further evidence in this regard is often crucial to set new guidelines or take new measures nationwide in relation to digital radiology, communication and radiation protection.

The main objective of the present study was, therefore, to determine the prevalence and types of radiographic equipment in the Belgian dental office, as well as the displays used for interpretation of the radiographs. In addition, the different ways of exchanging dental radiographs to colleagues and patients was assessed to get a complete overview of the current dental radiographic situation in Belgium.

Material and methods

A questionnaire-based cross-sectional study was conducted amongst Belgian general dentists, periodontists, orthodontists, endodontists and maxillofacial surgeons. Two distribution methods were used: (1) by digitally distributing the questionnaire via mailings lists of professional dental associations in Belgium. (2) By distributing the questionnaire manually on multiple refresher courses and congresses throughout the country. Participation was voluntary and confidential. One e-mail reminder was sent a week later to request completion. A total of 1689 e-mail-based surveys were distributed via mailing lists of the professional dental associations in Belgium and a total of 482 paper-based surveys were handed to conference delegates of multiple national congresses and refresher courses: 2176 GDPs were reached on a total of 9280 dentists in Belgium.

The questionnaire comprised four sections, namely (a) demographic characteristics and clinical features of dentists, (b) radiographic equipment and if digital radiography was used, (c) communication of dental radiographic images and (d) type of display to view dental images.

The questionnaires were analysed anonymously. The data from the questionnaires was transferred to Microsoft Excel (2016). The paper-based surveys were manually entered in a database by one investigator. A second investigator checked 20% of the manual records to ensure satisfactory entry. The e-mail-based surveys were automatically registered in the database. Errors in these questionnaires were noticed automatically. The data was transferred into SPSS 22 (IBM Corp. Armonk, NY) software for analysis. For descriptive analysis, percentages were used for qualitative variables and associations were tested by Pearson's χ^2 analysis. The significance of differences in means and proportions was reported at a significance level of $p < 0.05$. The Institutional Ethics Committee had approved the conduct of the survey.

Furthermore, the survey was conducted according to the principles described in the Declaration of Helsinki.

Results

Results of the survey

A total of 2176 GDPs were reached with the survey. There was a response rate of 78% for the paper questionnaires and 21% for the digital questionnaires. The GDPs returned a total of 741 questionnaires of which 645 contained valid responses, which is 30% of the target population (Figure 1). 93 of the questionnaires were excluded due to errors while filling out the questionnaire or considering an incomplete answer. Responses from GDPs who retired were also excluded.

Demographic characteristics and professional status of the respondents

Out of the 645 respondents, 354 respondents were male and 291 were female (55–45% ratio). Moreover, 53% had more than 25 years of experience (range 1–45 years). A total of 139 respondents (21%) had additional dental postgraduate qualifications such as aesthetic dentistry, paediatric dentistry, periodontics or endodontics. 75% of the respondents had an accreditation, *i.e.* for following refresher courses. Of the 645 respondents, 555 (86%) identified themselves as working in a group practice. Of these 68%, 14% also worked in a hospital-related setting. We also noted that there was a regional variation in response rate: 60% for Flanders vs 40% for Wallonia.

Characteristics of the radiographic equipment

Respondents were asked to provide details of their X-ray equipment. Of the respondents, 94% had routine access to an intraoral radiographic unit, 76% to a panoramic unit, 21% had an additional cephalometric arm, while 20% had access to a cone beam CT (CBCT). Table 1 indicates the availability of radiographic units sorted by postgraduate specialty. Significant differences in radiographic equipment between a standard GDP practice and specialists are also shown in Table 1.

There is no significant difference between the availability of radiological units between solo practices and group practices ($p > 0.05$). From all respondents with an intraoral radiography unit, 90% used a digital detector, while the remaining 10% still made use of analogue methods such as film. Furthermore, panoramic units and cephalometric arms follow the same trend. From the respondents with availability of a panoramic unit, 91% used a digital sensor and only 9% an analogue alternative. For those who had cephalometric arms available, 92% worked with a digital sensor and 8% with an analogue version (Figure 2). In 70% of the cases, GDPs with a digital intraoral unit used a SR plate and in 30% of the cases, they used a CCD. A statistically significant difference was found between years of practice and the

Figure 1 Study design— flowchart displaying inclusion criteria and study populations (questionnaires considered for analysis) $n =$ numbers. GDP, general dental practitioners.

use of film ($p < 0.006$). There was an inverse relation between years of practice and digitalisation. Indeed, GDPs with more than 25 years of experience used significantly more conventional film than their younger colleagues.

More than half of the intraoral units (53%) worked with a kilovoltage (kV) of ≥ 70 . The remainder of the units worked with a kilovoltage between 60 and 70

(29%) and 2% used less than 60 kV. For the remaining 16%, dentists were not able to indicate the kilovoltage level of their machine (Figure 3).

Insufficient knowledge regarding the brand or equipment type of an intraoral device was observed for 22%

Table 1 Availability of radiographic units sorted by specialty (in %)

	Intraoral	Panoramic	Cephalometric	CBCT
GDP	94	72	14	9
Oral & maxillofacial surgeons	58*	89*	43*	60*
Orthodontists	64*	94*	79*	12
Periodontologists	100	88*	21	63*

CBCT, cone beam CT; GDP, general dental practitioner.

Significant differences ($p < 0.05$) in radiographic equipment between a standard GDP practice and specialists are indicated with an asterisk.

Figure 2 Distribution of digital and analogue detectors (%).

Figure 3 Kilovoltage (kV) of the intraoral units sorted in three categories according to the European guidelines.

of the respondents. The results of insufficient knowledge for panoramic units, cephalometric arms and CBCT are 17, 2 and 2%, respectively.

Dental image communication

Different ways of sharing dental images with their patients and colleagues was inquired with the respondents. E-mail was found to be by far the most common method to share images in both situations. A printout was mainly used for direct patient interaction, while the use of data storage devices such as USB, CD or DVD were also made available for both professional and patient communication (Figure 4). More suitable options with regards to safety and encryption such as DICOM, picture archiving and communication system on Web and eHealth were hardly used by dental

Figure 5 Influencing factors for selecting a display for radiography viewing.

practitioners. Cloud based storage was used by very few GDPs.

Use of calibrated monitors for viewing digital images

All respondents had a computer available in their practice. These computers were mainly used for patient data registration and viewing of dental radiographic images. Only 16% of the respondents had a computer monitor specially calibrated for optimal rendering of digital images. Figure three indicates the factors influencing the decision to purchase a radiological monitor. Key factors seem to be resolution and diameter. Price seems less dominant and so are brand and design of the monitor (Figure 5).

Discussion

Survey

To investigate in what extent digital radiography is used among Belgian dentists. Moreover, to investigate their method of image communication and use of calibrated monitors. Here, we distributed a survey to 2176 dentists and dental specialists. The survey had a total response rate of 21%. There was a remarkable difference in response rate between the paper-based survey and the e-mail-based survey (78 vs 21% respectively). The main

Figure 4 Distribution of different methods of dental digital image communication (%). DICOM, digital imaging and communications in medicine.

reason for this phenomenon is because the investigators handed the paper-based surveys personally. So, people feel more obligated to complete the questionnaire. Moreover, e-mail-based surveys are less personal, and people need to use their spare time to complete it. A suggestion to raise the response rate is to provide an incentive (such as gift cards or discounts). However, this can result in bias because the respondents can rush the questionnaire only to get the reward. The investigators were aiming for a higher response rate, but anonymously mailed surveys tend to have lower response rates even with follow-up mailings.¹⁴ Nonresponse bias does not affect the results of dental surveys on a typical dentist response rate.¹⁵

Use of radiological equipment

Almost all dentists in Belgium had access to intraoral dental radiographic equipment. The results of our survey are comparable to findings in existing literature.^{2,3,10} Access to a panoramic unit was available to most GDPs: 76% of the dentists had routine access. Similar surveys in the past showed a rising percentage throughout the years. In 1988, only 6% of the Australian dentists had access to a panoramic unit, while in 1990, 47% of the United States practices had a panoramic unit and in 2003, 61% of the British dentists had access to a panoramic unit.^{2,16,17} Cephalometric units and CBCT are less common due to their specific use in orthodontics and implant dentistry.

The use of conventional intraoral film radiography decreased throughout the years. A Norwegian study in 2001 showed that 14% of the GDPs used digital radiography.¹⁸ A Belgian survey performed in 2004 showed that 30% of the GDPs used a digital sensor.⁷ According to Ilgüy et al.'s study, which had been reported in 2005, 14% of dentists used digital radiography in Turkey.³ Brian's analysis in 2007 showed that 20% of dentists own a unit with digital sensors, while a Belgian analysis, performed in 2014, showed that 80% of the dentists owned a unit with a digital sensor.^{10,19} Furthermore, our survey followed this progression, as 90% of the respondents used digital techniques. It is possible to conclude that there exists a tendency towards digital dentistry, whilst film becomes obsolete. In Belgium more specifically, we observed a progressive increase in digital dental radiography. Within a twelve-year time period, there was a progressive increase from 30 to 90% (current study).⁷

Although, the practising profile across many categories was unrelated to age, the use of film showed an age association: GDPs with more than 25 years of experience used significantly more film than their younger colleagues. This is related to GDPs who recently graduated are expected to be more familiar with digital radiographic examinations, considering the recent development of digital technology. Key factors for using digital radiography are avoidance of processing chemicals, patient acceptance, dose reduction, time gain and ease of image storage.^{18,19} SR is used by two-third of the GDPs, while one-third used a CCD. These findings

are similar to findings in relevant literature, except in Sweden where most GDPs used CCD.^{6,11,20}

The respondents' knowledge concerning the details of their equipment was limited: 22% of the respondents did not have any knowledge about the brand and specifications of their radiographic equipment. GDPs have a better knowledge of the features of their equipment if the purchasing cost is higher. The percentage of GDPs without knowledge of their equipment is probably higher than 22% considering the study protocol where respondents can check the manuals of their equipment before responding to the questions. These findings are consistent with the literature.^{2,9}

The fact that 2% of the intraoral radiographic units worked with a voltage capacity less than 60kV deserved some attention. Both the European guidelines on radiation protection in dental radiology and the Belgian Federal Agency for Nuclear control consider this as unacceptable low kV as more scattered radiation may be involved.^{21,22}

With respect to radiation protection of the patients, radiographic units with a voltage capacity between 60 and 70 kV are recommended. The long operational period and the purchase of these units before the current rules became in use are possible explanations. In a Belgian survey in 2010, 46% of the respondents used units older than 17 years. Also 5% used a voltage capacity below 60kV, which is comparable to our results. The different detector types for panoramic units are similar to the 2010 survey.⁹ 20% of the respondents had access to CBCT, due to the considerable increase in accessibility. While in the past only a few CBCT units were registered at the level of the Federal Agency for Nuclear Control, the current observation that a fifth of all dentists have nowadays direct access to a CBCT, is at least surprising.¹⁰ It seems that the last 10 years an exponential growth of the market has taken place.

Dental radiograph communication

Digital images are routinely used in dental practices for multiple purposes: the assessment of dental caries and oral pathology as well as pre-surgical and pre-orthodontic treatment assessment. With the introduction of digital dental radiographic systems for diagnostic imaging, the need arose for a standard method for the transfer of images and associated information between devices that are manufactured by various vendors, and for second opinions and specialists' advice on treatment planning. Many systems and formats are available for producing, storing, retrieving, viewing, and sharing these images. The DICOM standard is designed to ensure compatible systems and formats, so that an image produced in a small private practice today can be viewed next year in a large hospital.

Despite the introduction of the DICOM system, the results of our survey showed that most of the GDPs in Belgium use methods such as e-mail and printout to communicate dental radiographic images with their

patients and colleagues. The popularity of these options is due to their availability, user-friendliness and low cost. However, the security of these methods is debatable. Security measures are important and should involve encryption and restricted opening of the transferred files. Dental radiographs are part of the medical files from the patient and need to be treated accordingly. An important reason why cloud storage should not be allowed is because the data is stored on corporate-owned servers.

Use of calibrated monitors

In the survey, 16% used a DICOM calibrated display to view dental radiographic images. DICOM-calibrated consumer grade display is significantly better than uncalibrated consumer grade display, slightly better than tablet and almost equal to medical displays in the interpretation of enamel and dentinal caries in bite-wing radiographs.²³ The lighting conditions in the practice have an influence on caries perception as well.¹³ It is remarkable that resolution and diameter are the key factors when buying a display, while standard consumer displays are less accurate than DICOM calibrated displays. The use of mobile devices such as tablets and smartphones in dentistry is rising. Studies have shown that viewing dental images on tablets give comparable results and almost approaches the same detection levels as DICOM calibrated displays.^{12,24,25} Standard computer monitors are used by most GDPs for the analysis of digital dental radiographs while the use of calibrated monitors may result in an improved diagnostic observation. Hence, the use of calibrated monitors should be encouraged.

References

- Barbier D. Overzicht uitgave RIZIV voor orale radiologische verstrekkingen 2010-2015 [Internet]. 2017. Available from: <http://www.riziv.fgov.be>.
- Tugnait A, Clerehugh V, Hirschmann PN. Radiographic equipment and techniques used in general dental practice: a survey of general dental practitioners in England and Wales. *J Dent* 2003; **31**: 197–203. doi: [https://doi.org/10.1016/S0300-5712\(03\)00013-7](https://doi.org/10.1016/S0300-5712(03)00013-7)
- Ilgüy D, Ilgüy M, Dinçer S, Bayirli G. Survey of dental radiological practice in Turkey. *Dentomaxillofac Radiol* 2005; **34**: 222–7. doi: <https://doi.org/10.1259/dmfr/22885703>
- Mutyabule TK, Whaites EJ. Survey of radiography and radiation protection in general dental practice in Uganda. *Dentomaxillofac Radiol* 2002; **31**: 164–9. doi: <https://doi.org/10.1038/sj.dmfr.4600685>
- Svenson B, Söderfeldt B, Gröndahl H. Knowledge of oral radiology among Swedish dentists. *Dentomaxillofac Radiol* 1997; **26**: 219–24. doi: <https://doi.org/10.1038/sj.dmfr.4600253>
- Svenson B, Ståhlacke K, Karlsson R, Fält A. Dentists' use of digital radiographic techniques: Part I - intraoral X-ray: a questionnaire study of Swedish dentists. *Acta Odontol Scand* 2018; **76**: 1–8. doi: <https://doi.org/10.1080/00016357.2017.1387930>
- Gijbels F, Debaveye D, Vanderstappen M, Jacobs R. Digital radiographic equipment in the Belgian dental office. *Radiat Prot Dosimetry* 2005; **117**: 309–12. doi: <https://doi.org/10.1093/rpd/nci761>
- Dölekoğlu S, Fişekçioğlu E, Ilgüy M, Ilgüy D. The usage of digital radiography and cone beam computed tomography among Turkish dentists. *Dentomaxillofac Radiol* 2011; **40**: 379–84. doi: <https://doi.org/10.1259/dmfr/27837552>
- Aps JK, . Flemish general dental practitioners' knowledge of dental radiology. *Dentomaxillofac Radiol* 2010; **39**: 113–8. doi: <https://doi.org/10.1259/dmfr/52763613>
- Van Dyck J, Willemens E, Helsen L, Jacobs R, Bottenberg P, Jacquet W. De Belgische tandarts en radiologie. In: *Het tandheelkundig jaar 2017*. Houten: Bohn Stafleu van Loghum; 2016. pp. 235–46.
- Wenzel A, Møystad A. Experience of Norwegian general dental practitioners with solid state and storage phosphor detectors. *Dentomaxillofac Radiol* 2001; **30**: 203–8. doi: <https://doi.org/10.1038/sj.dmfr.4600613>
- Tadinada A, Mahdian M, Sheth S, Chandhoke TK, Gopalakrishna A, Potluri A, et al. The reliability of tablet computers in depicting maxillofacial radiographic landmarks. *Imaging Sci Dent* 2015; **45**: 175–80. doi: <https://doi.org/10.5624/isd.2015.45.3.175>
- Hellén-Halme K, Lith A. Effect of ambient light level at the monitor surface on digital radiographic evaluation of approximal carious lesions: an in vitro study. *Dentomaxillofac Radiol* 2012; **41**: 192–6. doi: <https://doi.org/10.1259/dmfr/15422221>

Conclusion

This report provides the results of a nationwide survey documenting the current digital dental radiological situation in Belgium. The survey shows an ongoing process of digitalisation in dental radiology and an increasing number of GDPs with access to image modalities in comparison to previous research performed Belgium. Following this trend, is the remarkably increase of the CBCT units, with a fifth of all dentists reporting a direct access in the practice. For sharing images, GDPs use fast and user-friendly methods such as printout and e-mail. Safer alternatives are available, but these methods seem not widely implemented. Finally, standard computer monitors are used by most GDPs for the analysis of digital dental radiographs while the use of calibrated monitors results in higher detection sensitivity. Hence, the use of calibrated monitors should be encouraged.

Informed consent

Informed consent was obtained from all individual participants included in the study.

Ethical approval

All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki Declaration and its later amendments or comparable ethical standards.

14. Baruch Y, Holtom BC. Survey response rate levels and trends in organizational research. *Human Relations* 2008; **61**: 1139–60. doi: <https://doi.org/10.1177/0018726708094863>
15. Hovland EJ, Romberg E, Moreland EF. Nonresponse bias to mail survey questionnaires within a professional population. *J Dent Educ* 1980; **44**: 270–4.
16. Kantor ML, Hunt RJ, Morris AL. An evaluation of radiographic equipment and procedures in 300 dental offices in the United States. *J Am Dent Assoc* 1990; **120**: 547–50. doi: <https://doi.org/10.14219/jada.archive.1990.0089>
17. Monsour PA, Kruger BJ, Barnes A. X-ray equipment used by general dental practitioners in Australia. *Aust Dent J* 1988; **33**: 81–6. doi: <https://doi.org/10.1111/j.1834-7819.1988.tb00645.x>
18. Wenzel A, Møystad A. Decision criteria and characteristics of Norwegian general dental practitioners selecting digital radiography. *Dentomaxillofac Radiol* 2001; **30**: 197–202. doi: <https://doi.org/10.1038/sj.dmfr.4600612>
19. Brian JN, Williamson GF. Digital radiography in dentistry: a survey of Indiana dentists. *Dentomaxillofac Radiol* 2007; **36**: 18–23. doi: <https://doi.org/10.1259/dmfr/18567861>
20. Jacobs R, Vanderstappen M, Bogaerts R, Gijbels F. Attitude of the Belgian dentist population towards radiation protection. *Dentomaxillofac Radiol* 2004; **33**: 334–9. doi: <https://doi.org/10.1259/dmfr/22185511>
21. Horner K, Rushton V, Tsiklakis K N, Hirschmann P, Stelt PF, Glenny A-M. *European guidelines on radiation protection in dental radiology; the safe use of radiographs in dental practice*. European Commission, Directorate-General for Energy and Transport. Brussel, Belgium: EU; 2004.
22. FANC. Intra-orale radiografie - Richtlijnen bij het gebruik van röntgenapparaten voor een optimale bescherming in de tandheelkunde [Internet]. 2009. Available from: http://fanc.fgov.be/nl/system/files/intra-orale_radiografie.pdf [cited 2018 Jan 27].
23. Kallio-Pulkkinen S, Huumonen S, Haapea M, Liukkonen E, Sipola A, Tervonen O, et al. Effect of display type, DICOM calibration and room illuminance in bitewing radiographs. *Dentomaxillofac Radiol* 2016; **45**: 20150129. doi: <https://doi.org/10.1259/dmfr.20150129>
24. Shintaku WH, Scarbecz M, Venturin JS. Evaluation of interproximal caries using the iPad 2 and a liquid crystal display monitor. *Oral Surg Oral Med Oral Pathol Oral Radiol* 2012; **113**: e40–. doi: <https://doi.org/10.1016/j.oooo.2011.11.008>
25. Caffery LJ, Armfield NR, Smith AC. Radiological interpretation of images displayed on tablet computers: a systematic review. *Br J Radiol* 2015; **88**: 20150191. doi: <https://doi.org/10.1259/bjr.20150191>