Radiology and Radiation Protection

1. Introduction

This guideline was phrased in such a way that it retains durable validity directed towards the future and is, as far as possible, independent of medical, dental, or technical innovations. In order to accomplish this goal, general principles are taken into account, and for technical details references are provided. Technologies coming to an end are not dealt with any more. For clinical issues, pertinent specialist chapters and external guidelines are indicated.

In contrast to the quality guideline of 2005, particularly the analog X-ray technique is therefore not considered any longer. For this application, the guidelines of 2005 framed at that time remain valid in unchanged form. In our judgment the digital technique has a promising future, and correspondingly it is to be focused upon.

Likewise, this quality guideline refrains from specific statements regarding indications or clinical situations. On the one hand, these issues according to the authors' opinion belong to the respective clinical subchapters, and, on the other hand, details related to some specialist subjects can well exceed the professional competence of the team of authors "Radiology and Radiation Protection". Not least, dentistry in many areas is also so fast-paced that, with the given intervals between new editions of these quality guidelines, the progress cannot be accounted for predictably and adequately. For these reasons, references are partly made to external sources which are subject to a more frequent content-related revision by expert associations and/or consensus conferences.

Quality assurance in the area of radiology starts with the indication. Based on general principles, this has to be related to the individual situation of the patient. Seen from the angle of radiation protection, the best radiograph always is the one that has not been made at all. If radiographic imaging is indicated, it is necessary to select the one available imaging modality that provides the required information with the lowest dose burden. This strategy is summarized in the so-called ALARA principle which implies that the burden by X-rays has to be "as low as reasonably achievable".

For the reasons explained above, the aspects of the indication and selection of the imaging modality are disregarded in this chapter. The focus lies on the subsequent steps: the technically correct operation of an X-ray equipment, the optimal exploitation of the recorded image data, and their further processing and storage.

Digital X-ray Technique

The best preconditions regarding all parameters are provided by the digital intra- and extraoral X-ray systems: low radiation exposure, environment-friendly processing, storage without loss of quality, possibility of backup also at spatially separated locations associated with still high availability.

The aspect of the once more reduced radiation exposure in combination with an unchanged diagnostic value of the directly digital (sensor-based) X-ray technique is an advantage in comparison to indirectly digital techniques (relying on storage phosphor plates). In particular, possible read-in errors (scanning) are eliminated. However, the utilization of the (today still) rather voluminous direct sensors also creates new sources of error associated with the optimal positioning in the oral cavity. Furthermore, not for all imaging techniques (format sizes) sensors are available to date.

When utilizing digital X-ray techniques, it has to be kept in mind that subsequently it should also be worked with the digital image, rather than with a printout (on paper). The latter is almost always of lower quality and in particular does not allow the application of tools for evaluation (adjustment of brightness and contrast, magnification, measurements etc.).

Radiation Protection

The protection of patients against non-diagnostic (scattered) radiation has to be warranted. Lead rubber shielding (X-ray protective aprons, thyroid shield) is – wherever useful – required. The radiation beam and hence the radiation-exposed area of the patient as a matter of principle have to be kept as small as possible. In the case of intraoral radiographs this exemplarily takes place through the utilization of rectangular cones collimating the center beam on the image formats, in combination with image receptor holders. In the case of OPG and CBCT, the exposure area is set on the device (e.g. OPG-partial exposure, adequate volume selection in the CBCT).

Moreover, all employees have to observe the greatest possible distance to the radiation source. The occupationally radiation-exposed personnel have to be trained and consistently wear individual dosimeters for the documentation of accidental radiation exposure.

Duty to Inform

Even though prior to a radiograph certainly no formal informed consent in writing is necessary, it still has to be ensured that the patient, aware of the significance, purpose, and costs of the exposure consents to it.

Reasonably, this consent can be obtained if, in the context of a conversation following the clinical diagnosis, it is pointed to the necessity as well as the goals of the X-ray examination, and the patient does not object to this.

The conversation for the information and consent of the patient can also take place upon admission and be conducted by an organizing assistant (an appropriately trained dental assistant, medical practice assistant, or radiological technologist), for example when exposures are to be accomplished prior to a treatment. Typically, such a case exists if in a patient with a written referral and accompanying existing radiographs additional exposures are intended or apparently necessary for the planned treatment. Particularly, if such additional X-rays have to be made off-site, it obviously makes little sense to summon the patient beforehand to the practice, just for the information about the necessary exposure. However, it should be noted that apart from the communication of the necessity of further imaging, the patient always should be offered the possibility of a conversation with the dentist. As a last consequence, therefore, an appointment for the preliminary discussion of the exposure has to be possible (be it by telephone or in person).

Duty to Document

Of course, the documentation has to meet the legal requirements. However, from the authors' view, for an ideal-typical documentation, requirements are to be defined that in part go beyond.

Thus, for diverse reasons, it seems useful to store all X-rays beyond the period required by law (in effect without limit of time). Technically, this is easily feasible today. By using storage systems with low availability for older exposures costs for storage, space can be limited.

Data protection should correspond to the technological standard. In particular, attention should be paid to daily backups which ideally should also be stored in a decentralized place in order to be secured against major damage (e.g. fire, water, or other damage to property). The consistency and readability of the backups have to be checked regularly. Also, it should be born in mind that old image data formats when needed have to be converted into modern data formats to ensure further and lasting readability and usability.

It should be completely abstained from delegating the duty of storage to the patient as the owner of the data. In this way, as a rule, no long-term archiving including data backup can be expected.

Finally, it remains to be stated that a complete documentation of all processes (indication, admission parameters, finding, discussion, and consequence) in the direct and indirect context of patient treatments is in the very own interest of the dentist.

Training and Continuing Education

During their basic training, dentists and dental assistants acquire basic knowledge in the area of dentomaxillofacial radiology. For both professionals it is regarded as imperative to continuously refresh and extend this knowledge. In particular, new technical possibilities (digital X-ray techniques, three-dimensional exposure technique, data backup and exchange) have emerged after the basic training. Therefore, they partly require extensive attendance of continuing education in order to acquire the necessary theoretical and practical knowledge, particularly also of relevant anatomical structures in all three dimensions. At present, specifically affected thereby is the cone-beam computed tomography (CBCT) which many dentists during their study at best marginally have come into contact with. Hence, a large part of this training – which for the dental daily routine becomes increasingly more important – currently takes place postgraduate.

Responsibility

It is beyond question that the treating dentist bears the full responsibility for the events in their practice. Even if tasks such as the preparation of radiographs in the practice, the organization of exposures to be carried out off-site, or measures of quality assurance are delegated, the ultimate responsibility remains with the dentist. In particular, they cannot even abdicate responsibility, if external patients are referred to their practice "only for X-rays". If they themselves offer the production of X-rays as a service for other colleagues, they still ultimately decide, whether the exposure in the form requested by the referring practitioner is justified. Issues such as "correct indication", "pregnancy anamnesis" and "diagnosis" of course have to be warranted as well. Hence, even in the case of such assignments for the preparation of X-rays, creation of the exposure and diagnosis remain inextricably linked and have to be in one hand.

In this case, the referring colleague makes a detailed letter of referral comprising:

- relevant anamnestic and clinical information;
- a clear and comprehensible question;
- information on the kind of the requested exposure and the region of interest;
- information and, as appropriate, attachment of existing antecedent exposures concerning the region of interest.

In return, the referring colleague obtains a written report about the complete two- or three-dimensional data set. They further receive copies of the original data (ideally in the DICOM standard format), if necessary supplemented by digital images or printouts relevant for the findings.

2. Evaluation Criteria for the Quality Levels A+ to C

	INDICATION	EXPOSURE TECHNIQUE/ IMAGE QUALITY	IMAGE DISPLAY
A+	▪ Superior radiologic overall concept ▪ Based on scientific principles ▪ Based on current guidelines of the dental expert associations	▪ Images of optimal quality enabling easy assessment ▪ Reproducible positioning (e.g. using tools such as right-angle technique)	▪ 3D volumes freely manipulable (turn, measure etc.) at every workplace ▪ All workplaces with adequate monitor quality and anti-glare protection
A	▪ Reasonable indication related to the individual case ▪ Adherence to the ALARA principle	▪ Radiographs are diagnostically suitable but in some circumstances difficult to assess protection. ▪ Good positioning	▪ 3D volumes freely manipulable (turn, measure etc.) at isolated workplaces ▪ 2D radiographs adjustable (brightness, contrast etc.) at every workplace ▪ Isolated workplaces with adequate monitor quality and anti-glare
B	▪ Routine radiography lacking critical indication but considering benefit for the patient ▪ Incomplete adherence to the ALARAprinciple	▪ Consistently radiographs that in subareas cannot be assessed ▪ Unfavorable positioning	▪ 2D radiographs adjustable (brightness, contrast etc.) at isolated workplaces
C	▪ Production of radiographs without indication and previous clinical examination ▪ Unnecessary production and/or repetition of exposures (administrative deficiencies) ▪ Disregard of the ALARA principle	▪ Consistently radiographs that in regard to the problem cannot be assessed ▪ Incorrect exposures or positioning ▪ Frequently repeated exposures necessary	▪ Hardcopies as aid at treatment or consultation places

	RADIATION PROTECTION	CONSTANCY TEST	DOSE SETTING
A+	▪ Check and service "out of sequence" in case of any abnormalities ▪ Transparent communication of dosimeter data ▪ Regular thematization of radiation protection in the team ▪ Optimal radiation protection for the patient: ▫ Great focus-surface distance ▫ High tube voltage ▫ Short exposure time ▪ Optimal radiation protection for the personnel	▪ Additional implementations particularly in case of abnormalities ▪ Check of all monitors in the practice ▪ Complete, always traceable documentation ▪ Understanding in the team of the significance of the test for quality assurance	▪ Settings documented in writing
A	▪ Clear check and service schemes ▪ Consistent wearing and evaluation of the dosimeters ▪ Adequate radiation protection for the patient ▫ Routine collimation of the X-ray (at least down to the film format) ▫ Covering outside the useful beam	▪ Regular implementation ▪ Check of a "diagnostic monitor" ▪ Complete and traceable documentation ▪ Understanding in the team of the significance of the test for the fulfillment of legal obligations	▪ Patient-related individual selection of the settings (kV, mA, positioning, collimation ...) ▪ Exact setup of the X-ray equipment
B	▪ Occasional check and service of the equipment ▪ Minimal radiation protection measures for patients ▪ Minimal radiation protection measures for the personnel ▪ Inconsistent wearing and evaluation of the dosimeters	▪ Careless implementation ▪ Incomplete/non-traceable documentation ▪ Lack of understanding of the constancy test in the team	▪ Use of standard parameters ▪ Uncritical adoption of manufacturer's recommendations
C	▪ Defective X-ray equipment ▪ No check or service of the equipment ▪ Insufficient or missing radiation protection measures for patients ▪ Insufficient or missing radiation protection measures for the personnel ▪ No individual dosimeters ▪ Frequently repetition of exposures necessary ▪ Non-retrievable radiographs	▪ Missing or irregular implementation ▪ No documentation ▪ No equipment book ▪ Constancy test is unknown to the team	▪ Checkout of the correct setting ▪ Compensation of faulty system components (e.g. image disks, sensors) on the side of the dose

	TECHNIQUE	ASSESSMENT	TRAINING AND CONTINUING EDUCATION IN RADIOLOGY
A+	▪ Regular checks of the technical components ▪ Knowledge in the team concerning susceptible/defective components ▪ Immediate repair/maintenance	▪ Every exposure is assessed at a darkened workplace. ▪ Written documentation of the findings ▪ Always comparison with the previous exposures	▪ Regular participation in radiology-oriented advanced training events (e.g. conferences, courses) ▪ Regular advanced training and instruction of the practice employees
A	▪ Regular service of all components ▪ Repair/maintenance in case of abnormalities	▪ Every exposure is thoroughly assessed concerning the problem and possible secondary findings. ▪ The essential facts are written down. ▪ When needed, brightness and contrast are adjusted.	▪ Completion of an additional training in 3D imaging ▪ Awareness in the team of the importance of continuous education in radiology ▪ All practice employees taking X-rays have advanced knowledge in the preparation of radiographs.
B	▪ Acceptance of defects as long as the system is usable ▪ Repair/maintenance on occasion	▪ Exposures are assessed only concerning the problem. ▪ Secondary findings frequently go unnoticed.	▪ Irregular participation in post-graduate trainings in dental radiology ▪ Only individual practice employees have advanced knowledge in the preparation of radiographs.
C	▪ Compensation of system problems by e.g. repeated exposures, changed dose settings … ▪ Acceptance of problems	▪ Exposures are not always examined. ▪ No systematic assessment and no documentation of the findings ▪ Secondary findings are noticed only incidentally.	▪ Training finished as part of the study ▪ No practice employees have specific knowledge.

	IMAGE EXCHANGE WITH OTHER PRACTITIONERS	COMMUNICATION WITH PATIENTS	IMAGE ARCHIVING
A+	▪ Technically safe image exchange considering data protection ▪ Technically safe mutual access to data considering data protection ▪ Use of the DICOM standard	▪ Every exposure beforehand and afterwards is discussed in detail with the patient.	▪ The practice stores the images indefinitely. ▪ Backup of data with storage outside the building ▪ Provisions to prevent data loss due to changing formats ▪ Images immediately available at any time
A	▪ Electronic data exchange ▪ Manual anonymization of the data or explicit consent of the patient for data transmission ▪ Printout on high-quality foil and availability of the respective viewing infrastructure	▪ The patient is informed about the indication and goal as well as the costs of the exposure. ▪ Afterwards, the exposure is briefly discussed.	▪ The practice stores the images according to legal requirements. ▪ Adequate backup of the digital data ▪ Images available within adequate period
B	▪ Printout on foils without availability of the respective viewing infra-structure ▪ Printout on photo paper	▪ The patient gets an opportunity to ask but without request does not obtain further information.	▪ The practice stores copies "without commitment". ▪ Non-retrievable images ▪ Duty of storage is delegated to the patients.
C	▪ Printout/scanning from hardcopies ▪ Faxing of radiographs ▪ Exposures of other practitioners are not obtained but rather new ones are made.	▪ The patient is notified that a radio-graph has to be taken. ▪ A discussion of the exposure is not planned. ▪ No opportunity to ask, the physician possibly unavailable (e.g. busy with another treatment)	▪ Storage takes place exclusively by the patient.

3. References

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