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Guidelines for dental radiography immediately after a dento-alveolar trauma, a systematic literature review

INVITED REVIEW

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Abstract – The objective with this study was to search for and to analyze the presence of scientific papers, guidelines, and recommendations in dental literature regarding which radiographs should be prescribed after a dento-alveolar trauma. We know from earlier that guidelines and recommendations are available in general in dental traumatology. The International Association of Dental Traumatology (IADT) has earlier developed guidelines for the management of dental trauma cases in general. There are also recommendations about useful intraoral radiographic methods when caries and periodontal disease are studied. An additional objective was to provide some guidelines for general practitioners about the most accurate radiographic examination immediately after a dento-alveolar trauma using intraoral radiographs or a common extraoral imaging method. Because radiographs are an important diagnostic tool for establishing a correct differential diagnosis after a trauma, radiographic guidelines and recommendations are of importance to be able to start the correct treatment. PubMed Central, Cochrane and World Wide Web were searched and the identified existing guidelines for different intraoral radiographic methods in dentistry were analyzed and found to be very few. Those that were identified were in general not so detailed and specific. In conclusion, we found an explicit need for more detailed guidelines regarding which intraoral and other dental radiographs should be prescribed initially in dental traumatology.

Traumatic injuries to the teeth and the maxillofacial structures are a common occurrence, with the majority affecting the dento-alveolar structures (1). Such injuries maybe caused by road traffic or sport accidents, violence, in addition to many other causes (2). The incidence of traumas varies considerably with age and the type of injury (1, 2), with complicated crown fractures being the commonest injury, mostly affecting children between 8–9 years of age.

For optimal treatment outcome, correct diagnosis of the severity of the injury is essential and must be achieved through a detailed history taking, clinical, and radiographic assessment (2 – p. 258, 3).

Radiographs are essential tools in establishing differential diagnosis of traumatic dental injuries. (4 – p. 541, 5 – p. 267). Intraoral views are usually sufficient in assessing most dento-alveolar injuries. They help to identify the location, type, and severity of injuries. In addition, dental radiographs can help in assessing the stage of root development in young permanent teeth, periapical pathology, and assess the relationship of displaced primary teeth to developing successors and proximity of pulp tissue to fractures of teeth.

The optimal choice of radiographs, however, should be individualized to the unique needs of each patient and should therefore be based on the outcome of the detailed history taking and clinical examination (6).

Soft tissue injuries, with possible embedded tooth fragments or foreign objects, can be adequately assessed with intraoral radiographs taken using low exposure.

Several published case reports reported on patients having no immediate post-trauma symptoms, with radiographic pathological changes developing a few weeks, months or even years later (7). Radiographic assessment of all cases of dento-alveolar trauma is, therefore, essential at the immediate postinjury period. The risk of radiation exposure, however, has to always be weighted against the potential benefits. Clinicians must, therefore, use the least possible amount of radiographic exposure indicated, with the as low as reasonably achievable (ALARA) principle taken into consideration. This principle refers to that we always should use the least possible amount of radiation exposure.

It that has been agreed upon by the International Commission of Radiological Protection (ICRP), which is an advisory body providing recommendations and guidance on radiation protection (8).

Traumas are quite common among children and because children are particularly vulnerable to develop radiation-related complications (9–11), special guidelines

including recommendations have to be developed to ensure appropriate use of radiography during childhood. Moreover, it has also been suggested that trauma diagnostics during childhood is more difficult (12) than in grown-up persons. These authors reported that the sutures of the skull are wider and that more adipose tissue covers the bones, which will complicate the diagnostics accuracy.

Fortunately, intraoral radiographs give a very low radiation dose if correct technique and a good X-ray equipment is used (4 – p. 35, table 3-3) making it ethically indicated to prescribe intraoral radiographs for adults and children whenever the clinical examination indicates that a more severe dental injury might exist.

With the recent advancement in digital radiography, the diagnostic quality of digital radiographs has become comparable to that of is conventional radiographs (13) with the added advantage of utilizing lower radiation doses (14).

Establishing differential diagnosis of traumatized teeth and the orofacial skeleton is a big challenge (15, 16). Owing to the presence of anatomically complex, mid-facial bone structures are the radiographic signs of trauma difficult to evaluate. Intraoral, two-dimensional radiographs have limitations owing to superimposition of structures and projecting geometry. A tomographic method can be used to get rid of superimposed structures without any interest (17). There are cases described showing the importance of having access to a more advanced digital method like computed tomography (CT) after trauma injuries (15) and also when post-traumatic root resorption cases are evaluated (18).

Conventional CT has been commonly used during the past for assessing suspected maxillofacial fractures (12, 19–21). This X-ray method gives us a possibility of three-dimensional viewing of injuries without any super-imposition of neighbor structures that are of no interest. Recently, a new tomographic imaging method has started to be used, cone beam CT (CBCT) (22). Both regular CT and CBCT have a high diagnostic accuracy in cases of traumatic dental and maxillofacial injuries. But intraoral radiographs are a good start and are accurate enough if we only suspect dental injuries or minimally displaced bone fractures according to other researchers (23). However, three-dimensional CT is mandatory in patients with comminuted and displaced mid-face and mandibular fractures (23).

Periapical pathology with or without resorption is a common late consequence in trauma patients.

Studies have been published on trauma patients, where the ability of diagnosis of periapical pathology using CBCT and conventional intraoral imaging methods (24, 25) was compared. Both these research groups found that a high resolution 3D technique like CBCT was better to use than conventional intraoral technique, during diagnostics of periapical pathology. Andreasen et al. (26) studied assessment of resorption using a standardized intraoral technique. They found a problem to visualize small resorption areas using conventional radiographs.

However, when using CT, we do have to keep the ALARA principle in our mind. This is because 3D CT methods deliver the patient a higher effective equivalent radiation dose. If, however, a multislice, 3D imaging method is indicated, our choice of selection should be a CBCT, which gives a much lesser dose than conventional CT (27). Suomalainen et al. (28) recommended a use of CBCT when conventional intraoral and extraoral radiographs were insufficient for the diagnostic task in dentistry. In general, in dental trauma, CBCT should only be prescribed in selected cases, where conventional radiographs provide inadequate information for treatment planning (29).

In managing traumatic dental injuries, radiographs should be used at the initial assessment phase, as well as in follow-up assessments. Currently, there are no commonly accepted guidelines or norms for radiographic assessment of traumatic dental injuries (30).

The aim of this study was to identify and highlight available X-ray recommendations in dental literature as well as finding articles pertaining to radiography in dento-alveolar injuries and to review the current literature in relation to the initial radiographic assessment of common dento-alveolar injuries. Another aim was to provide general practitioners with some guidelines to use in the initial assessment of such injuries. Follow-up assessment as well as assessment of more advanced skeletal injuries are beyond the scope of this study. Advanced imaging methods will be very briefly discussed.

Methods

The review started with an electronic search for recommendations or guidelines regarding which radiographs should be taken in trauma cases using the PUBMED interface of Medline and the portal of Cochrane.

The first search that was accomplished using PUBMED using the following search terms:

- dental trauma and radiographs
- dental trauma and intraoral radiographs
- oral trauma and radiographs
- maxillofacial trauma and radiographs
- guidelines dental traumatology
- recommended radiographs dental trauma
- dental trauma and radiography

When using Cochrane was 'dental trauma' and 'radiographs in trauma' used.

To find also national recommendations that are not classified as scientific articles, World Wide Web search machines http://www.altavista.com and http://www.google.com were also used and we searched also the web pages of well-known international Radiology organizations:

- http://www.eadmfr.org/
- http://www.sedentexct.eu/guidelines
- http://www.aaomr.org/
- http://www.ada.org

Results

In Table 1, the retrieved Medline papers for each search and their numbers can be seen.

Sometimes the same reference was found using different keywords.

Table 1. Showing the indexed search using Medline

Dental trauma and radiographs	398	5
Dental trauma and intraoral radiographs	26	1
Oral trauma and radiographs	584	5
Maxillofacial trauma and radiographs	220	2
Guidelines radiographs dental trauma	13	0
Recommended radiographs dental trauma	10	0
Dental trauma and radiography	1822	10

The second column shows the papers which contained 'some' sort of recommendation/advice regarding which radiographs can be exposed in dental trauma cases.

In general, many articles were found initially, more than 2000. But very few were real trauma articles with any guidelines or recommendations regarding which radiographs should be exposed in trauma cases, only 23.

When using Cochrane searching for 'dental trauma', abstract or as keywords were only 45 references returned immediately and none of these discussed radiographic techniques or indications in dental trauma cases. When searching for 'radiographs in dental trauma' none reference was returned.

The remaining number of references in our review, 36 came during our search using well-known search engines or by using well-known radiology web pages.

Discussion

In official Dental Radiology Protection documents, very few guidelines seem to exist regarding which X-rays should be taken in dento-alveolar traumatology and also about how to take them.

In US and European guidelines about radiation protection and selection of patients (3, 31), it is only recommended to take intraoral radiographs after trauma. As it is written in the ADA Guidelines 2004, 'Intraoral radiography is useful for the evaluation of dento-alveolar trauma. If the area of interest extends beyond the dento-alveolar complex, extraoral imaging may be indicated.'

In a review article, an official report from the Academy of Oral and Maxillofacial Radiology describing parameters of radiological care (32) are no guidelines for trauma patients included. Some recommendations for trauma cases were made in a recent review of the present state-of-the art maxillofacial imaging by Boeddinghaus and Whyte (33). But these recommendations mostly referred to imaging in more advanced trauma cases, no recommendations were given regarding the most useful intraoral radiographs.

American Association of Endodontists (34) issued treatment guidelines for traumatic dental injuries. For luxating injuries of permanent teeth, four radiographs were recommended but the only available instruction was that some radiographs should have an eccentric projection and occlusal views were mentioned as useful. For coronal fractures in the permanent dentition, the recommendation was to take one radiograph. In cases of root or alveolar fractures four intraoral radiographs. These recommendations can be difficult to adhere to, because we seldom know beforehand which root fractures there are, based only upon the clinical examination.

Regarding luxating injuries, did Andreasen et al. (35) recommend already in 1985, that it is important to use film holders when imaging luxation injuries and occlusal radiographs were found to be best for disclosing lateral luxations.

The European Academy of Pediatric Dentistry (EAPD) published guidelines (2003) on prescription of dental radiographs in general for children (36). In this study, radiography was discussed as an aid in detecting caries, but trauma was also mentioned as a selection criterion for prescription of radiographs. No further guidelines were issued.

The International Association of Dental Traumatology and Dental Traumatology Journal have published several guidelines on the evaluation and management of traumatic dental injuries in 1988, 2001 and later updated in 2007 (37–41).

These guidelines recommended that at least one intraoral radiograph should be taken in all cases with a complicated or an uncomplicated crown fracture of a permanent tooth. For suspected or clinically confirmed root fracture, should radiographs using four different angulations be prescribed. However, these guidelines did not specify exactly which angulations should be used.

Recently, some researchers found that teeth with a crown fracture have an increased risk of having a root fracture as well (42). As a result, they recommended that multiple radiographic projections should be prescribed in cases with a clinical crown fracture. The same authors also strongly supported and stressed the use of radiographic projections at different vertical angulations ($+15°$ and $-15°$ vertical angulation in relation to the original tube position) to rule out root fractures. Earlier, have other researchers supported this in a textbooks in Traumatology (5). However, Molina et al. did not have enough scientific proof to recommend exactly how many radiographs which should be taken, whether three or four radiographs was the best protocol.

To detect vertical or horizontal root fractures, it was recently recommended by Wenzel et al. (43) to take digital intraoral images of the affected area with two different vertical and three different horizontal angles. It was a difference of 15° between these projections in both the horizontal and the vertical dimension. This can be accomplished by making a total of at least three exposures making sure that two of the images with a different horizontal angulation also had a different vertical angulation.

In the latest textbook in Dental Traumatology is the recommended radiographic examination described in a chapter about Examination and Diagnosis of Dental Injuries (5, p. 255–279).

It's suggested that all injured or sustained to trauma teeth should be examined and that all traumatized teeth should be assessed radiographically using three different angulations. For a traumatized anterior region, one occlusal film and three periapical exposures are recommended, where the central X-ray beam is directed between the lateral and central incisor and the two central incisors.

Other useful radiographic methods in dental traumatology are shortly described (5). It's recommended to take extraoral radiographs in trauma cases with dislo-

cated intruded primary teeth (5, p. 268). And the usefulness of 3D imaging in special cases using CBCT is stressed.

Different opinions are, however, present and some other researchers do not recommend using lateral extraoral radiography (44) in cases with intruded primary incisors. These authors found that it was very seldom that lateral extraoral radiographs contributed in the diagnosis, the clinical and intraoral exam was enough in almost all trauma cases.

If we need to take extraoral radiographs, it is an important radiation protection rule to use a cassette and screen according to radiation protection recommendations (31).

Research has shown similar effectiveness of both conventional and digital radiography in detecting root fractures (14, 45). But the lower radiation does in digital radiography favors this modality. Following dental injuries, the choice of appropriate radiography should be governed by several factors, such as patient history, clinical findings, the required information and image quality, as well as the delivered radiation dose (15). Keeping in mind that radiographs are indicated only if they yield useful diagnostic details.

Surprisingly, there are trauma cases where radiographs are not prescribed at all (46), against recommendations and our current knowledge and clinical experience. These researchers found among general practitioners an under-prescription of radiographs for trauma patients when compared to recommendations in guidelines in England. The researchers concluded that one reason could be that many of these practitioners did not in reality have access to the guidelines and further clarification and research was requested.

Considering that we have to select an imaging method in view of delivered dose, required image and its information as well as clinical circumstances will CBCT be of great importance in the future in trauma cases (19, 33, 47, 48), but like all radiographic methods will it never be a routine method. Radiographs, when ionizing radiation is used, should always only be used on certain indications, when there is a need for additional information.

Recommendations

In general, we found a lack of evidence-based research and consensus regarding which radiographic methods and projections which are most accurate to take in trauma cases.

However, based on existing guidelines, our retrieved articles and own experience can the following radiology techniques and projections be recommended.

Panoramic radiography including other extraoral imaging

Panoramic radiography can provide useful diagnostic information in cases of mandibular including condylar fractures (16, 34, 49). But panoramic radiographs have shortcomings in detecting the most common fracture of the mandible in the condyle area (49). In such cases, a Reverse Towne's posterior-anterior view can be recommended, or even a CT examination (50, 51) according to some researchers. Panoramic radiography cannot be recommended if mid-facial fractures are suspected (52), because this method is inaccurate in disclosing fractures in this area.

Panoramic radiography is a widely used technique giving a non-detailed image of the teeth and the examination is simple for the patient (53). A large area is covered to a low radiation dose. The shortcomings are that only structures within the focal through are clearly viewed and accordingly can injuries be undetected and the image is less detailed than intraoral radiographs.

It has been reported that panoramic radiographs are over prescribed many times in traumatic dental injury cases. In 2001, Sewell et al. (54) reported close to 40% inappropriate prescriptions. This fact causes an unnecessary increase in radiation dose delivered to our patients. These authors concluded that intraoral periapical radiographs would have provided more details with less radiation than the inappropriate panoramic radiographs.

Both CT and CBCT imaging can be very useful to have access to in dental trauma cases (19, 23).

CT methods are better than CBCT to discriminate between different types of tissues, they are better in cases where the soft tissues in the trauma area are important to evaluate. However, cone beam CT has a higher spatial resolution which can be important in dental radiography where we need imaging of small details.

But above all does CBCT give much less radiation to the patients, a very important matter from the viewpoint of ALARA (8). Nowadays are CBCT machines also becoming very common.

CBCT can be recommended when we still think that we do not have enough of information regarding trauma injuries after conventional plain radiographs and when our clinical findings indicate the need for more knowledge to be able to make the correct treatment.

Radiographic intra-oral examination

Occlusal, size 4 films and intraoral films of a more regular size can be used. An occlusal film can record a wider area and the used vertical angulation during exposure is different than during use of smaller films. Many times can the used beam angulation be optimal for disclosing a root fracture when taking occlusal views, because the X-ray beam have a greater chance to be parallel to the fracture line of the root.

Choice of projections

This choice is affected by which injuries we suspect based upon the clinical exam.

Crown fracture

Crown fractures are always easy to find clinically and radiographs are not always necessary for the sake of the crown fracture. But they can disclose the proximity to the pulp.

However, because there is an increased risk for these traumatized teeth to also have a root fracture can

the same radiographs as described below be recommended.

Suspected root and or alveolar bone fracture

A minimum of two intraoral films has been recommended, using a different horizontal angulation of the X-ray beam. At least also two different vertical angulations should be used (5, 41).

To reveal a fracture, it is of importance that the X-ray beam is in alignment with the plane of the fracture (14, 38, 40, 55). Earlier experiments have revealed that a fracture line will only be disclosed with an angulation of the central beam from $+10°$ to $-20°$ in relation to the 'normal' angulation perpendicular to the long axis of the root during X-raying.

A suspicion of a vertical root fracture establishes a need for different horizontal angulations to be used during exposure and a transverse fracture needs different vertical angulations.

To get optimal imaging, two different vertical and three different horizontal angles (43) should be used in a traumatized dental area. This can be accomplished by making a total of at least three exposures making sure that two of the images with a different horizontal angulation also had a different vertical angulation.

In addition to the correct radiographic angulation, fracture line visibility is also affected by the degree of displacement or separation of the fragments. It has been reported that conventional radiographs have low sensitivity in detecting minimally displaced root fractures (15). Conventional CT and CBCT provide better sensitivity but high costs and the radiation dose make at least CT inappropriate especially in children as a routine method (56).

In children with the primary dentition still persisting is it even more difficult to diagnose a root fracture with conventional intraoral radiographs, owing to superimposition of the permanent teeth. This is one reason why CBCT could be an acceptable option in special cases, where there is a problem to find a clinically suspicious root fracture.

Suspected alveolar bone fractures

The same regime is used as when a root fracture is suspected. Take three intraoral radiographs, as described above. Different vertical and horizontal angulations of the X-ray beam are necessary to detect the fracture.

Suspected displaced or luxated teeth

The same regime as when a root fracture is suspected. Take three intraoral radiographs. Different vertical and as well as horizontal angulations of the X-ray beam are necessary to detect misalignment of a tooth.

Suspected foreign object in the soft tissues

Intraoral films placed intraorally using a very short exposure time are very useful. Can be placed between the teeth and the cheek of lip where we have an injury (57).

Additionally, lateral extraoral views with a very low exposure time using a cassette and a screen if the film is outside the mouth can aid in detecting foreign objects in soft tissues.

It is important to take two views at right angles to each other (58) like, for example, a frontal and a lateral view. This will ensure that we will be able to localize the object.

If conventional radiographs are not enough, CT or ultrasound should be used (59) to localize foreign objects in soft tissues.

Conclusion

We found a lack of evidence-based research and lack of specific recommendations regarding which radiographic methods should be used in dento-alveolar trauma cases.

New recommendations were suggested.

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