Unexpected metallic foreign bodies on panoramic scans – a narrative review

Unerwartete metallene Fremdkörper auf Panoramaschichtaufnahmen – eine Übersicht

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Key words
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Results and Conclusion A total of 37 different unexpected metallic foreign bodies were found. They can be categorized as jewelry, clothing, personal protective equipment, medical devices, iatrogenic foreign bodies, and rare incidental findings. Radiopaque foreign materials in the OPG are often relatively easy to recognize as artifacts because of their location, and they are avoidable in most cases. If unclear, a three-dimensional radiograph was helpful for determining the location. Radiopaque areas caused by foreign bodies can lead to misinterpretation or partial or complete non-evaluability and should therefore be avoided.

Key Points:
- The OPG is the standard radiograph for dentists, oral surgeons, and oral and maxillofacial surgeons.
- Foreign bodies made of metal can lead to non-evaluability of panoramic radiographs. Based on a review of the literature and exemplary radiographs, this article provides an overview of rare but typical metallic foreign bodies in OPG, thus addressing the problem of the subfield of radiography by making radiologists more familiar with these images.
- The spectrum of unexpected metallic foreign bodies includes unremoved earrings with the typical ghost images on the contralateral side, piercings, hearing aids, acupuncture needles, rare iatrogenic foreign bodies, incidental findings in infants in the nose and external auditory canal, vascular clips after surgical interventions, and ritual subcutaneous foreign materials.

Citation Format

ZUSAMMENFASSUNG

Hintergrund In der zahnärztlichen Praxis stellt die digitale Panoramaschichtaufnahme (Orthopantomogramm, OPG) als konventionelle Röntgenaufnahme die Standardröntgentechnik zur Basisdiagnostik dar. Eine korrekt angefertigte Aufnahme bietet eine gute Übersicht über Zähne und Kiefer, während röntgendichte Fremdmaterialien z. B. aus Metall relevante Befunde verschleiern können.
Introduction

The imaging techniques used in dentistry include digital panoramic radiography (orthopantomography), single-tooth radiography, bitewing X-ray, digital volume tomography (DVT), as well as computed tomography (CT) of the head, magnetic resonance imaging of the temporomandibular joints, and recently magnetic resonance imaging (dental MRI) [1–3]. Dental imaging comprises approximately 40% of radiography examinations performed in Germany. For this reason, profound of dental imaging is essential for clinical radiologists [3]. Panoramic radiography is considered the standard imaging technique among dentists, oral surgeons, orthodontists, and oral and maxillofacial surgeons [4].

Orthopantomography is a projection radiography method and is based on conventional X-ray tomography. Refer to the corresponding literature for information regarding the complex techniques of the panoramic radiography method [3, 5, 6]. The orthopantomogram (OPG) includes the teeth of the upper and lower jaws, the temporomandibular joints, and parts of the maxillary sinus [3]. The OPG thus provides an overview of all teeth and the jaws and information about neighboring regions. The following three radiological quality features are defined for panoramic radiographs [3]:

1. Free symmetrical projection of the mandibular ramus including the condylar process,
2. Grayscale differentiation, and
3. A “real” dimensionally accurate representation of the dental crowns of the maxillary anterior teeth.

Typical disadvantages and artifacts of the imaging technique, e.g., fuzzy projection of radiopaque foreign bodies on the opposite side, are known [3]. Further issues are a certain unsharpness of the image, summation effects, enlargement and distortion of individual regions due to the cross-sectional imaging method [7].

Method

The PubMed, Cochrane Library, and Google Scholar databases were searched for unexpected metallic foreign bodies in panoramic radiography. The search terms included “panoramic radiograph”, “orthopantomogram”, “dental radiography”, “incidental finding”, “metal” and “foreign body”. Studies published between 1990 and 2022 in German or English were included.

Metallic foreign bodies regularly seen in dentistry, oral surgery, and oral and maxillofacial surgery at a specific location in the clinical routine were excluded. These include amalgam fillings, gold inlays, partial crowns, crowns, bridges, endodontic posts, enossal implants, and osteosynthesis material. Panoramic radiographs collected by the authors in the clinical routine at various centers over many years for training purposes were used for result presentation.
The examiners divided the radiopaque materials into two categories: intentional and unintentional insertion [9].

A clear-cut categorization as intentional/unintentional is not always possible. In this respect, after review and evaluation of the literature and comparison with our own cases involving metallic foreign bodies on OPG, the foreign bodies were able to be divided into six categories: jewelry, clothing, personal protective equipment, medical devices, iatrogenic foreign bodies, and rare incidental findings (Table 1).

Table 1 Categorization of found metallic foreign bodies.

<table>
<thead>
<tr>
<th>Category</th>
<th>Examples</th>
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<tbody>
<tr>
<td>I. Jewelry</td>
<td>• Earrings in various shapes and sizes</td>
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<td>• Extraoral and intraoral piercings</td>
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<td></td>
<td>• Necklaces</td>
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<td></td>
<td>• Barrettes and hairpins</td>
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<td></td>
<td>• SUSUKS and charm needles</td>
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<td>II. Clothing</td>
<td>• Zippers</td>
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<td>• Buttons</td>
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<td>III. Personal protective equipment</td>
<td>• Face mask</td>
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<td>IV. Medical devices</td>
<td>• Lead apron</td>
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<td></td>
<td>• Glasses</td>
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<td></td>
<td>• Hearing aids/cochlear implants</td>
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<td>• Acupuncture needles</td>
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<tr>
<td>V. Iatrogenic foreign bodies</td>
<td>• Surgical needles</td>
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<td></td>
<td>• Broken instruments, e.g. diamond burs, Lindemann burs, elevator blades, injection needles, etc.</td>
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<td></td>
<td>• Metallic vascular clips for stopping blood flow during surgical interventions</td>
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<td>• Temporary prostheses</td>
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<td>• Permanent dental prostheses</td>
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<td>• Epitheses</td>
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<td>• Stents</td>
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<td>• Wire ligatures for fixation of a drainage tube</td>
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<td>• Plates and screws in cervical spine spondylodensis</td>
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<tr>
<td>VI. Other rare incidental findings</td>
<td>• Shrapnel, pellets, shell splinters</td>
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<td></td>
<td>• Earrings impacted in the earlobes</td>
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<td></td>
<td>• Foreign bodies in the outer ear canal in children, e.g., jewelry, small batteries, buttons, etc.</td>
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<td></td>
<td>• Foreign bodies in the nose, primarily in children, e.g., beads, staples, etc.</td>
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<td>• “Missing” orthodontic fastening elements</td>
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<td>• Thin gold threads for face lift</td>
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Results

The literature includes numerous case reports, case series, and pictorial essays. Also, some general information and radiographs can be found in dental radiology textbooks, for example, the textbook by Andreas Fuhrmann (2013), which includes a section in the chapter on panoramic radiographs that discusses the problem of radiopaque metallic structures in the beam path and contains a collection of cases [5]. The textbook on panoramic radiographs by Jürgen Düker (2000) also contains some corresponding images [6]. However, only two articles report unexpected radiopacity of foreign bodies in dentistry. The study by Omezli et al. (2015) is a retrospective evaluation of 11 887 panoramic radiographs including 62 images (0.6%) with foreign bodies in the jaw. In this study, the foreign bodies included only filling materials (amalgam, root canal material), a staple, and shrapnel [8]. The study by Hwang et al. (2019) included panoramic radiographs as well as CT scans and DVT scans and the foreign bodies were not limited to metal objects. The authors of this study investigated 508 images with foreign bodies. 19 different types of foreign bodies were found.

I. Jewelry

Earrings

Earrings are seen on panoramic radiography in various numbers, sizes, and shapes (Fig. 1, 2). Earrings not removed for the scan can potentially result in projection-dependent artifacts (ghost images) on the contralateral half of the face (Fig. 3). The literature includes publications that provide a detailed technical description of the ghost image phenomenon [10, 11]. Ghost images can obscure or completely mask relevant findings. In a case report of a 30-year-old patient who said she could not easily remove her earrings for the radiography examination, the earrings were projected onto an ectopic wisdom tooth high in the maxillary sinus on the lower edge of the eye socket so that it was completely masked by the artifact on the OPG and could only be detected on a new radiograph without her earrings [11].

Extraoral and intraoral piercings

Piercings not removed from the nose, upper lip, lower lip (Fig. 4) or other external skin areas in the region of the head and neck are rare but typically foreign bodies on panoramic radiographs. Intraoral piercings of the tongue, frenulum, and the uvula can also mask findings on radiographs.

Necklaces, barrettes, and hairpins

Necklaces not removed prior to imaging can be clearly seen on radiographs. Metallic barrettes and hairpins (Fig. 5) result in...
Localized artifacts on the upper edge of the image. The metal core of hair ties can cause shadows (Fig. 6). Certain synthetic hair extensions can also result in diagnostic difficulties [12]. These can be seen on panoramic radiographs as linear or curvilinear opacities with diffuse edges that stretch vertically over the entire image [13].

Susuks

Susuks or charm needles are a special type of cultural practice in Southeast Asia, primarily in Malaysia, Thailand, Singapore, Indonesia, and Brunei [14–16]. Susuks are thin metal pins made of silver, gold, or alloys thereof that are between 5 and 10 mm long and have a diameter of approximately 0.5 mm. Susuks are supposed to make the wearer more attractive, maintain youth, promote health, reduce pain, and bring success in business or career [15, 17]. These objects are implanted under the skin primarily in the orofacial region, especially the chin. On panoramic radiography, they appear as radiopaque needle-like objects [17]. Some case reports include panoramic radiographs with one or more susuks and charm needles [15–17]. The authors agree that susuks can be confusing since they are not overtly visible and palpable [14–17].
II. Clothing

Buttons or zippers made of metal on the front or back of a patient’s clothing are usually easy to identify on radiographs due to location and texture.

III. Personal protective equipment

As a result of COVID-19 protective measures, radiological examinations were often performed with patients still wearing a face mask. The metal nose clips incorporated in masks to ensure a better fit to the contours of the face are seen as a curvilinear opacity with one, two, or even three rows, depending on the design. These lines are typically located median to the upper edge of the image or are superimposed on the nasal conchae (▶ Fig. 7). The course depends on the projection but asymmetrical placement of the mask also affects the course of the artifact.

IV. Medical devices

Medical devices include lead aprons, glasses, hearing aids, and acupuncture needles. A lead apron that is positioned too high results in artifacts in the lower jaw-anterior tooth region (▶ Fig. 8). Glasses have a strange appearance on radiographs (▶ Fig. 9) but can be readily identified as such and these artifacts are certainly easily avoidable [6]. External hearing aids and cochlear implants can also be easily identified on panoramic radiographs because of their typical location (▶ Fig. 10). Acupuncture needles can also appear on radiographs as incidental findings.

V. Iatrogenic foreign objects

Rotating instruments

Broken dental and Lindemann burs are relatively common findings in panoramic radiography [18]. Lindemann burs are used for the surgical extraction of wisdom teeth or for the formation of bone blocks for bone augmentation. They can usually be easily identified based on their location and shape (▶ Fig. 11). However, the exact position cannot be determined with a two-dimensional scan. In their case report, Chen et al. (2020) describe the recovery of a fissure bur that broke during extraction of the left mandibular...
Brauer HU et al. Unexpected metallic foreign body: The case of a retained injection needle led to the extraction of a third molar. The authors used a reference frame to remove the fragment in a targeted manner [19]. Broken twist drills in dental implantation have also been reported [20].

Surgical instruments

Other iatrogenic metallic foreign bodies can certainly cause diagnostic difficulties. For example, Demirkol (2015) reported an object with pronounced radiodensity on OPG in the region of the extraction wound of tooth 16 in a 45-year-old patient. This foreign body imitated a dental implant with respect to its location, axial alignment, and size. The patient reported a traumatic tooth extraction but no dental implant. The location of the radiopaque foreign body was determined with a DVT scan. The foreign body was located in region 16 within the maxillary palatal mucosa. Under local anesthesia a broken elevator blade was able to be removed [21].

The literature also includes several case reports on surgical needles left in the surgical field. One report describes a case involving a 23-year-old patient who underwent panoramic radiography due to tooth pain. A needle was visible in the angle of the jaw on the right side beneath the mandibular canal. According to the patient’s medical history, she had undergone a tonsillectomy when she was 4 years old [22]. However, retained suture needles are more commonly the result of oral surgery as described by Sencimen et al. (2010). In this study, a needle accidentally left in the pterygomandibular space during extraction of the upper third molar was removed intraorally using C-arm fluoroscopy [23].

Injection needles

Broken injection needles used for local anesthesia are a rarity today due, among other things, to the introduction of disposable injection needles [24–28]. Nonetheless, there are occasionally reports of this rare event and the removal of needles broken during the administration of nerve block. For example, an 18-year-old patient underwent extraction of four wisdom teeth one year prior by her dentist. The injection needle used to anesthetize the right mandibular nerve broke and was left in place because recovery of the fragment deemed possible [27]. The patient was referred to an oral and maxillofacial surgery clinic one year later due to pain. The acquired OPG showed the needle in the right pterygomandibular space. Removal was performed after a CT scan with the support of a surgical navigation system [27]. In a similar case in which removal was performed without the use of three-dimensional radiography, the authors specified incorrect administration of the local anesthesia, movement of the patient during injection, and manufacturing defects as the reasons for the fracture of the 35-mm needle used to administer the nerve block [25].

Amalgam

Further metallic foreign bodies typically seen in the oral cavity include small pieces of amalgam dispersed into the jaw bone or tissue during tooth extraction (Fig. 12) and implants that migrated into the maxillary sinus or the paranasal sinuses [29, 30]. These cases are often implants that were implanted in bone with a low residual bone height in the upper jaw posterior region and there was a subsequent lack of osseointegration or implants that were driven into the maxillary sinus by mechanical trauma. Due to the location in the paranasal sinuses, these foreign bodies are considered unexpected.

Vascular clips for stopping blood flow

Further iatrogenic foreign bodies include vascular clips used in the head and neck region, e.g. to stop blood flow during neck dissection (Fig. 13). These non-ferromagnetic clips are often made of titanium or titanium alloys or can be made of absorbable plastic. Vascular clips are intentionally left in place and are not foreign bodies requiring removal.

Removable dental prostheses and epilithes

If the patient was not asked to remove a removable dental prosthesis prior to radiography, the resulting images may not be diagnostic [7]. In addition to permanent removable dental prostheses (total prostheses with metal frame, partial dentures, and telescopic prostheses) (Fig. 14), removable prostheses can also be
A temporary prosthesis with hand-bent wires (Fig. 15).

Moreover, ephepeses can have metal parts, e.g., the anchoring elements. Therefore, if they are not removed during imaging and are located in the beam path, they can result in foreign bodies on the OPG.

As a further type of iatrogenic foreign body, stents used for keeping vessels open can be visualized as tube-shaped spiral wire prostheses on panoramic radiographs (Fig. 16). Wire ligatures for securing drainage tubes can also be unintentionally visualized (Fig. 17). Stabilizing interventions involving the cervical spine, such as plates and screws used in cervical spine spondylodesis, can also be visualized on panoramic radiographs (Fig. 18).

VI. Other rare incidental findings

There are other foreign bodies that cannot be assigned to the aforementioned categories and cause very rare incidental radiological findings. This includes shrapnel, pellets, and shell splinters [8, 31–33] as well as accidental insertion of foreign bodies into the earlobes, the outer ear canal, and the nose [34]. The literature includes a case report of a 16-year-old patient referred to an orthodontic clinic for extraction of her wisdom teeth. A foreign body was seen on the preoperative OPG in the region of the right earlobe. According to her parents, an earring had disappeared 12 years earlier. Surgical incision revealed an impacted earring. In summary, the patient history was decisive for diagnosing the problem [35]. Foreign bodies made of metal can also be seen in the outer ear canal – in addition to the already mentioned hearing aid [36, 37].

Some case reports discuss foreign bodies commonly seen in the noses of children. The spectrum of objects ranges from jewelry to small batteries, buttons, and toys [34, 38]. For example, Habibullah et al. (2010) report on an unusual OPG of an 8-year-old boy with hyperactivity. Surgery was planned for this patient due to a two-week history of swelling and multiple broken teeth. Preoperative radiography showed an intranasal foreign body. Two beads, one staple, and a piece of an eraser were discovered. Inspection of the ear canals was unremarkable. 3D imaging was not necessary [39]. Of course, such foreign bodies can go undetected for years as described by Tay et al. (2000) in a case report [40].

Another rarity is an orthodontic fastening element lost during orthognathic surgery, which was an incidental finding on a control radiograph.
radiograph (Fig. 19) and was then located with a DVT scan (Fig. 20). Finally an interesting rare incidental finding is the gold thread lift surgical technique in which 0.1-mm gold threads are used to lift the face. These gold threads appear on radiographs as irregular radiopaque, thread-shaped artifacts that make interpretation of an orthopantomogram difficult and can result in mistakes during three-dimensional implant planning [41, 42].

Discussion

Various metallic foreign bodies can cause artifacts on panoramic radiographs. These image artifacts are largely preventable since the presence of metallic foreign bodies is usually known in advance and they can be removed, but sometimes they can be unexpected. Metallic foreign bodies can be divided into avoidable and unavoidable. Such a categorization would certainly be suitable for most foreign bodies. However, it is unclear whether the “migrated” fastening element from Fig. 19 would not have been avoidable based on this argument if the treating physician had not lost it intraoperatively. In some cases, the patient’s medical history was helpful for clarifying the cause of the problem, while in other cases additional three-dimensional imaging was needed for identification or removal of the foreign body. Clear identification and allocation of foreign bodies and careful practices on the part of medical personnel continue to be more important than a formal classification. All jewelry should be removed from the head and neck region prior to acquisition of radiographs [11]. Arguments against removal on the part of the patient, e.g., tongue piercings are difficult to remove, should not be an obstacle to removal. If possible, medical devices should also be removed since they can hide or obscure potentially important findings. When using a lead apron, it must be positioned and placed

Fig. 17 Postoperative OPG after tumor resection and prophylactic stabilization of the ramus with a fracture plate: a wire ligature (blue arrow) for a drainage tube can be seen as an artifact right lateral on the lower edge of the image. In addition, a titanium perforated plate can be seen in the mandible on the right, which includes a blurring structure on the contralateral side.

Fig. 18 An anterior plate for cervical spine spondylodesis (blue arrow) is partially visualized on the radiograph of a severely compromised dentition acquired for the purpose of dental prosthesis planning. Corresponding ghost structures can be seen on the right and left edges of the image. An earring in the left earlobe with corresponding ghost structure on the lower edge of the right eye socket can also be seen.

Fig. 19 Osteosynthesis plates on the mandibular rami and the maxilla can be seen on this routine image acquired after an adjustment osteotomy. An artifact caused by a lead apron can be seen on the lower edge of the image. An orthodontic fastening element (blue circle) that was used for the fixation of splints during adjustment osteotomy became detached intraoperatively and migrated into the medullary cavity of the left ascending mandibular ramus is seen as an incidental finding. It was initially assumed that this fastening element had migrated to the masseter muscle. It was unanimously decided to adopt a watch and wait approach. A DVT scan was acquired two years later to check the consolidation progress. The image showed that the sagittal mandibular osteotomy was the point of entry through which the element migrated between the laminae. Based on this, treatment was still not considered necessary. On the image the “bracket” differs from what was initially assumed to be a piercing based on the significantly higher contrast. Due to the distance from the focal plane, the margin of piercings typically appears less sharp.

Fig. 20 Cross section of the foreign body from Fig. 19 on three planes at the points with the greatest size. Two years postoperative bone has grown around the foreign body in the region of the sagittal osteotomy and in close proximity to the mandibular canal.
correctly. Folds in the apron must be avoided. Iatrogenic foreign bodies in the region of jaw segments with teeth are comparatively less problematic for dentists. In addition to the foreign bodies made of titanium, lead, gold, silver, or the like described here, foreign bodies made of other materials can also be seen on radiographs and can also be problematic during imaging. A three-dimensional image allowing determination of the location and size of the foreign body on all three planes is often helpful in the case of ambiguities [43].

The radiographs shown here elucidate the issues surrounding radiography as a subfield in dentistry. Corresponding knowledge of potential foreign bodies is essential even in the case of a prospective comprehensive introduction of software with artificial intelligence for detecting and classifying structures and treatments.

Conflicts of Interest

The authors declare that they have no conflict of interest.

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