Radiographically anatomical structures in the maxillofacial region have some features related to the nature of X-rays. Their images on radiographs or digital screens can be very different from those we are accustomed to perceiving from anatomical atlases and histological specimens.

They are generally divided into bones of the cerebral skull and bones of the facial skull. The first group includes the frontal, parietal, occipital, temporal and sphenoidal bones. Jaws with teeth, as well as nasal and zygomatic ones, belong to the second group - the bones of the facial skull. Although, by definition, the hyoid bone and the vertebrae of the cervical spine do not relate to this area their radiological images are of importance, because they are often present in the radiographs of this complex and can affect images of its bones (see Figure 1).

When performing X-rays, some of the X-rays are trapped by the bones, and the denser the portion of bone they pass through, the more significant part of them does not reach the X-ray film. Thus, on radiographs, bones are depicted in different shades of grey, depending on their density. The denser areas of the bone (such as the cortical plate), are seen with a higher intensity of grey ("whiter" – radiopaque shadows), than those with less density, such as spongiosis, which is "more grey" (Fig. 1).

X-ray imaging of teeth and jaws uses different sizes of x-rays (or sensors for digital x-rays). Depending on the size of the area of interest, we also choose the appropriate film size (sensor). For example, if we are interested in the area of the two maxillary bones, we will focus on a film and a method that will include their images (Figure 2A). However, if we are
only interested in a part of the maxilla (for example, the molar area), we will choose another size (X-ray method, respectively) (Fig.2B).

Fig.2. A – Waters projection. B – intraoral x-ray image.

There are several aspects to consider when choosing the size of the area to be X-rayed. The first is that the x-ray examination of a larger anatomical section of the patient is associated with a greater radiation load of the patient (a broad area is irradiated, and more radiation is needed to obtain the image). The second is that most often the depicting of a larger section costs the resolution of the image. Third - it should be remembered that every anatomical area is part of the entire maxillofacial complex and cannot be depicted separated from it. Neighbouring structures affect the image and very often "superimpose" on our area of interest, thus reducing its information value, for example, in the X-ray of Fig. 4A, the images of the teeth have no diagnostic value due to the superimposition of the images of adjacent bone structures. And last but not least, two-dimensional X-ray images are often geometrically non-isometric (Figure 3). Or in other words, the radiographic dimensions of the anatomical structures do not correspond to their actual ones.

Fig.3. Intraoral radiograph of upper incisors - notice the elongated silhouette of the roots.
It was mentioned above that besides the size of the film for the depicting of the respective anatomical area, the X-ray method is also important. A method or projection of radiography means the position of the patient, respectively, the anatomical area of interest, against to the film (sensor) and the X-ray tube (rays). For example, in standard tooth imaging, the film is positioned as close to the lingual surface as possible, and the X-ray is directed orthoradial (or perpendicularly to the tooth axis) (Figure 4A). However, in this position, the roots (when a tooth has a vestibular and lingual root) as they are behind each other in the course of the beam, on the image they appear as a united shadow of one root. The shift of the beam horizontally (horizontal angulation) will reveal the second root (Fig. 4B).

This superposition of the images is of great importance in the diagnostic interpretation of the images in the dental imaging diagnostic because they determine the different X-ray norms of the anatomy of the structures at different projections. For example, the image of Figure 5 shows the shadow formed by the boundaries of the maxillary sinus, "V" - like shadow of the zygomatic process and the shadow of part of the muscular process of the mandible. And these shadows are a normal finding in all intraoral images in this area.
The specificity of the various radiographic methods is not a subject of this topic, so we will focus only on the comparative interpretation of the main anatomical markers in radiography without going into detail about the methods themselves.

**X-ray anatomy of the maxillar bone**

The main radiographic markers of maxillary anatomy that are visible on radiographs depend on the direction of the x-ray towards the bone. In the beam directed to the sagittal plane, the alveolar process, the area of the maxillary tuber, the radiopacity of the zygomatic process and the contours of the boundaries of the maxillary sinus can be clearly distinguished (Fig. 6, Fig. 7, Fig. 8).

![Diagram of the maxillary bone with labeled anatomical markers](image)

Fig.6. Main anatomical markers in the lateral part of the maxillar bone.
Fig. 7. Intraoral x-ray – with the green dotted line the contour of the floor of the maxillary sinus is marked. A yellow dotted line follows the radiopaque line of the zygomatic process.

Fig. 8. Telerentgenography – lateral view. With the green dotted line maxillary sinus, alveolar process and zygomatic process are outlined.

By directing the beam to the transverse plane, the outline of the infraorbital edge, the infraorbital foramen, apertura piriformis, the intermaxillary suture (maxillar symphysis), the incisal canal and foramen, the hard palate, the nasal septum and crista zygomatico-alveolaris are well distinguished. Sometimes especially in intraoral images, over the area of the frontal teeth, the shadow of the nose’s soft tissue is superimposed. (Fig.9, Fig.10, Fig.11).
Fig. 9. Main anatomical landmarks in the frontal part of the maxilla.

Fig. 10.
Fig. 11. 1. Frontal edge of the apertura piriformis. 2. Spina nasalis anterior. 3. Soft tissue of the nose. 4. Sutura intermaxillaris. 5. Foramen incisivum.

If the X-ray beam is horizontally angulated, a part of the maxillary sinus may also fall into the final image (Fig. 12).

Fig. 12. 1. maxillary sinus. 2. Nasal septum.

If the x-ray beam is vertically angulated on the obtained rentgenographic image, the shadow of the lower nasal concha could be seen (fig. 13).
In the radiographs, where the whole skull is included the maxillary bones are superimposed with the bones on the path of the X-rays, that’s why only their contouring structures remain visible (Fig. 14).

Fig. 13.1. Anterior ridge of apertura piriformis. 2. Concha nasalis inferior.

Fig. 14. Waterd projection. 1. Foramen infraorbitale. 2. Sinus maxillaris sin. 3. Crista zygomaticoalveolaris. 4. Margo infraorbitalis.
When the beam is directed to the occlusal plane, due to the superposition of other skull bones in the vertical direction, much fewer elements from the maxillar bone are recognized in the resulting image (Fig. 16).

![X-ray image of the mandible](image)

Fig.16. 1. Septum nasale. 2. Foramen incisivum.

**X-ray anatomy of the mandible**

Because the lower jaw is positioned in the lower third of the maxillofacial complex, its projections on radiographs do not suffer from the superposition of adjacent areas as much as those of the maxillary bones. As a result, the appearance of its major anatomical markers are very well distinguished in different X-ray projections against the sagittal, transversal, and occlusal planes.

Projections in the sagittal plane or with the beam directed vestibulo-lingually, in the lateral part of the mandible are clearly visible: the two processes and the notch between them, the mandibular and mental orifices, the mandibular canal, the angle of the lower jaw,
oblique line, the mylohyoid line (Fig.15, Fig.16, Fig.17, Fig.18).
Fig. 16.

Fig. 18. Section of panoramic x-ray. 1. Linea obliqua. 2. Linea mylohyoidea. 3. Lingula mandibulae.
When the X-rays are directed to the transverse plane on the X-rays, on the final images, with different intensity could be seen shadows of: protuberantia mentalis, spina mentalis, foramen lingualis (sometimes there are few orifices) (Fig. 19, Fig. 20, Fig. 21).

Fig. 19.

Fig. 20.
Changing the X-ray beam direction strongly affects the visibility of the individual markers. For example, if the frontal section of the mandible is X-rayed with the direction of the rays towards the horizontal (occlusal) plane, the shadow of the spina mentalis is outlined (Fig.22).
X-ray anatomy of the teeth

X-rays images are the result of varying degrees of attenuation of X-rays as they pass through objects of different densities. Because the teeth and structures around them are with varying density (enamel, dentin, etc.), their X-ray images reflect this histological feature (Fig. 23).

![X-ray anatomy of the teeth](image)

Fig.23. 1. Enamel. 2. Dentin. 3. Pulp chamber. 4. Root canal. 5. Periodontal space. 6. Marginal ridge of the alveolar bone. 7. Lamina corticalis. 8. Cancellous bone.

When interpreting X-ray images as mentioned above, the direction of the rays is also of great importance. The X-ray of Fig. 23 shows the difference between the depiction of the root canals in the medial and distal roots. The radiography is done with the orthoradial direction of the beam (perpendicular to the axis of the roots) accordingly, the overlap of the two medial roots reduces the intensity of the shadow of their canals.

The interdental septa in different groups of teeth have different shape and thickness. This is reflected in their X-ray image. In the area of the molars and premolars, they are pyramidal in shape (Fig. 24) or truncated cone and thicker than those in the frontal sections of the jaws where they are triangular and thinner (Fig. 25). For this reason, interradicular septa around the front teeth may not be displayed up to the enamel-cement border.

![Form of the interradicular alveolar bone around molars and premolars](image)

Fig.24. Form of the interradicular alveolar bone around molars and premolars.
Fig. 25. The triangular shape of the interradicular septa at frontal teeth.

The stage of tooth root development is also important for their x-ray appearance. From a radiological point of view, there are three stages of root development:

- Stage of unfinished root
- Stage of unfinished root apex
- Stage of completed root

In the last stage, the root is completely finished with a periodontal space uniformly formed around its surface and also visible parallel to the root surface lamina corticalis. The periodontal space has a uniform width along the approximal root surfaces and almost imperceptible extensions to the enamel-cement borders and around the root apex. The root canals repeat the shape of the roots, being the widest in their cervical part and gradually narrow apically.

In the unfinished root stage, the periodontal space is shaped to the level of root development, with a slight radiolucency of the growth zone in its apical part. The form of the root canal is inverted - it is widest to the growth zone and narrower in the cervical part. In the unfinished root apex stage, the root canals are of uniform width, with the visible apically residuals from the growth zone (small round-shape radiolucency). The apex of the tooth is not shaped, and no apical periodontal space is visible (Fig. 26).
The characteristics of the X-ray anatomy of the teeth and jaws described so far concern two-dimensional radiographs. Very widely is used in modern dental medicine the three-dimensional (3D) Cone-beam computed tomography (CBCT) (Fig. 27).

CBCT images do not suffer from the geometric distortion of the 2D images and the superposition of adjacent structures, but they are not a universal solution because of the comparatively high radiation dose for the patients and the potential expression of multiple artefacts that can significantly degrade image quality.