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Diagnostic algorithm in high (cranial) maxillofacial fractures

Algorytm postępowania diagnostycznego w przypadku złamań górnego piętra masywu twarzoczaszki

The observed rapid development of modern diagnostic equipment makes the conventional roentgenodiagnostics recede into the background. It is the new techniques of visualization of organs that soon will be in the lead because even now they combine the advantages of morphological and functional examinations at the same time eliminating to a great extent the X-rays, which allows the reduction of diagnostic risk (MRI imaging, ultrasound). This is crucial especially in examinations of complex anatomical structures of the maxillofacial region. Nowadays a surgeon will not begin an operation without the results of imaging diagnostics examinations. Many surgical procedures in the field of dental and maxillofacial surgery are based on diagnostic imaging and without it the operation is impossible. The examples are numerous. Imaging by means of computed tomography (CT) allows for earlier planning of a surgery like it is in the case of complex maxillofacial fractures when the use of mini- or microplates is indispensable in order to stabilize the reduced bone fragments. Three-dimensional reconstructions in CT allow for preparation and preliminary adjustment of tissue grafts to the existing bone defects and skeletal asymmetry.

However, it is an error to consider the hitherto existing tested techniques of standard radiological examination useless. Their cost-effectiveness justifies their use in the years to come, sometimes as the only source of information in the field of radiology, sometimes as the initial selection of patients. In the times of changes in the system of Health Care in Poland the reduction of the cost of treatment, including diagnostics, is indispensable. That is why it is necessary to elaborate diagnostic algorithms in different disease entities because the planning of a cost-effective treatment is based on thorough diagnostics.

MATERIAL AND METHOD

The material consisted of analysis of 99 case records of 81 patients after maxillofacial trauma examined in the years 1995-1999 in the Department of Dental and Maxillofacial Radiology and the II Department of Medical Radiology of Medical University of Lublin. From the case reports of all the patients studied in that period there were selected the X-ray pictures as well as the results of other imaging examinations of persons with high maxillofacial fractures resulting from lateral trauma as well as high maxillofacial fractures caused by central trauma according to the classification of W a n y u r a (12). As high (so--called cranial) trauma there is regarded such trauma which affects the area of the frontal vault, frontal eminence, superciliary arch or glabella. In that classification the fractures are further divided according to the zone of applied force into fronto-orbitonasal fractures and cranio-orbital fractures. A fronto-orbitonasal fracture is a fracture of the anterior wall and the floor of the frontal sinus as well as of the superior margins of the orbits, superior orbital wall and superior wall of the ethmoid sinus in more powerful trauma. On the other hand, the cranio-orbital fracture is a unilateral asymmetrical deformation with fracture and simultaneous downward displacement of the superior margin and wall of the orbit accompanied by downward displacement of the eyeball and impairment of its mobility.

In all analysed case reports there were noted the initial and final diagnosis, as well as the number and order of undertaken imaging examinations: 1) Panoramic X-ray; 2). PA of the skull; 3) Lateral projection of the skull; 4) Waters' view (standard occipitomental X-ray); 5) Louisette projection; 6) X-ray of the nasal bones; 7) X-ray of the orbit; 8). Other X-ray pictures; 9) Computed tomography of the maxillofacial region or of orbits; 10) Ultrasound examination of eyeball and orbital structures; 11) Other imaging modalities.

The analyzed X-rays of the skull and maxillofacial region were taken according to standard rules of radiography. The Louisette view X-rays were taken by means of the modification of Friedle's technique using a special cassette 30x24cm equipped with an

incision for patient's neck. In this technique a sitting patient holds the cassette under his chin, parallel to the occipitomeatal line, while the central ray inclined $30^0$from the perpendicular was centered on the *bregma* point (9).

The CT examinations were performed using the Somatom AR-T machine by Siemens equipped with a 512x512 pixels matrix of high contrast and special resolution. In the examinations of the maxillofacial region there were used the coronal and axial scans, 2 and 3 mm thick, without contrast enhancement. The axial scans were obtained in supine patients. The scans were parallel to the Frankfurt plane (occipitomeatal line). The coronal scans were taken in prone patients in the plane as perpendicular to the hard palate as it was possible. In some patients who could not maintain the prone position due to pain, weakness or casts, the coronal scans were obtained in supine position with the head tilted as much backwards and downwards as it was possible.

After the examinations the CT data were further elaborated and multiplanar reconstructions (MPR) were obtained in sagittal plane as well as in axial or coronal planes whenever it was possible. The multiplanar reconstructions along the axis of the optic nerve were valuable in evaluation of possible injuries.

Also three-dimensional reconstructions (3D CT) at the threshold from +150 HU to +250 HU were gained in order to achieve spatial image of maxillofacial bones. The options of the software were used to rotate the 3D reconstructions, the direction of light was changed which allowed for better visualization of sometimes earlier undetected fractures. Also parts of the reconstructions were cut away and some previously hidden details of anatomical structures could be seen.

RESULTS

In the group of fractures caused by high (cranial) lateral trauma the first examination was usually the PA and lateral X-rays of the skull, on which the fracture lines were first

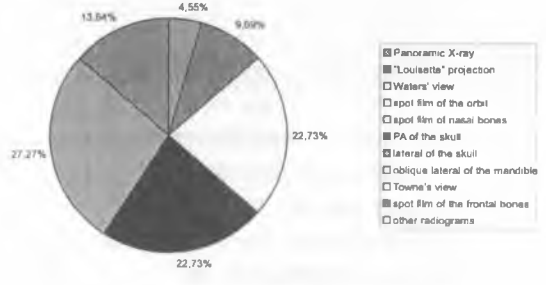

Fig. 1. Proportions of imaging modalities applied in cases of high (cranial) maxillofacial fractures caused by lateral trauma

detected (Fig. 1). As in this group of traumas the fractures affect also the frontal sinus, the next X-ray projection used in evaluation of this structure was the standard occipital X-ray (Waters' view) or/and the spot film of the frontal sinus. Computed tomography was valuable in determination of the extent of injury to the eyeball when the bone fragments were dislocated to the orbit. The 3D CT reconstructions presented the three-dimensional configuration of the fractures and dislocations (Fig. 2).

Fig. 2. Three-dimensional reconstruction shows displacement of a bone fragment into the left orbit

Like in the above discussed group of fractures, in the case of injuries caused by high central trauma, the PA and lateral X-rays of the skull were taken in the first place followed by standard occipitomental (Waters' view) X-rays (Fig. 3). In case of these central high fractures it is indispensable to use spot films of nasal bones because these structures are extremely often affected in such trauma. The computed tomography examinations, especially the 3D CT reconstructions, allowed for better visualization of bone fragments indentations due to the so-called spatial depth (Fig. 4).

On the basis of the obtained results the diagnostic algorithms in case of high (cranial) maxillofacial fractures caused by lateral and medial trauma were proposed and presented in Figure 5 and Figure 6, respectively.

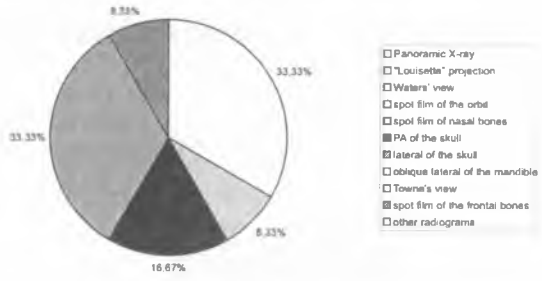

Fig. 3. Proportions of imaging modalities applied in cases of high (cranial) maxillofacial fractures caused by medial trauma

Fig. 4. Three-dimensional reconstruction shows the indentation of fractured frontal bone into the frontal sinus

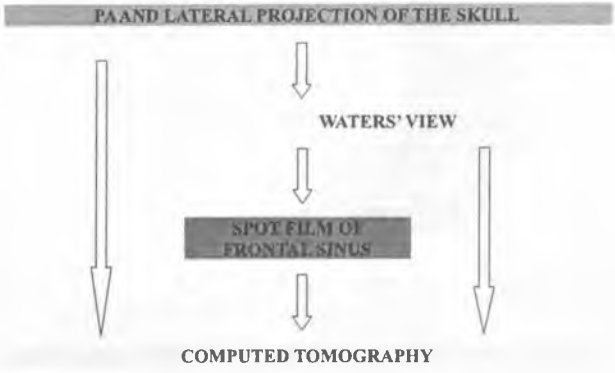

Fig. 5. Diagnostic algorithm in high (cranial) maxillofacial fractures caused by lateral trauma

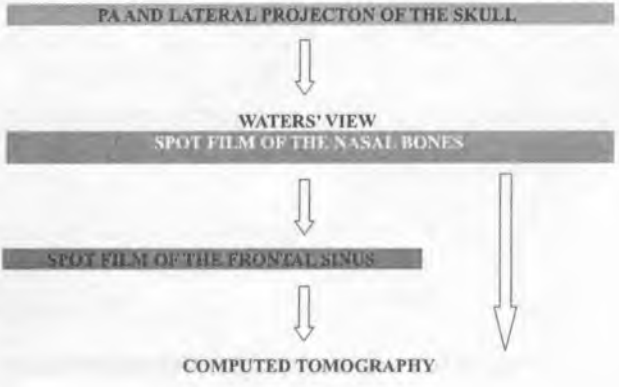

Fig. 6. Diagnostic algorithm in high (cranial) maxillofacial fractures caused by medial trauma

DISCUSSION

Radiological visualization of maxillofacial area is difficult due to complex anatomical structures that compose this region. With the increase in number of traffic accidents, the incidence of maxillofacial trauma is higher and higher. Numerous methods of diagnostic imaging are employed in evaluation of maxillofacial trauma. However, none of them is considered universal and they all complement one another. In the diagnostics of maxillofacial diseases many conventional radiograms are used. Most often there are utilized the panoramic X-rays, standard occipitomental (Waters' view) X-rays, "Louisette" projection

(9) as well as PA and lateral projections of the skull (3, 5, 8). Nowadays it is the computed tomography that comes to the fore.

The diagnostics of trauma requires thorough analysis of bone structures. The evaluation of multiple maxillofacial fractures, especially in the midface and in the high parts of the face, by the use of conventional radiological examinations is difficult and sometimes very inaccurate (1). It is crucial to choose an appropriate algorithm of imaging modalities in order to shorten the diagnostic procedure and at the same time maximize the obtained information.

As far as the fractures of superior margins and walls of the orbits are concerned, the maximum diagnostic information was acquired on the basis of PA and lateral X-rays of the skull as well as standard occipitomental projections (Waters' view). The spot films of the frontal sinus were considered supplementary. In case of injuries caused by central trauma apart from the above-mentioned projections, the X-rays of the nasal bones were indispensable (11).

Iinuma et al. (6) compared the results of evaluation of conventional X-rays in Caldwell's and Waters' views in the case of orbital fractures. According to their data these X-rays provided a reliable result as to the presence of orbital fractures in the orbital floor in 75% cases (78% anterior and 73% posterior part), while in the fractures of medial orbital wall: 71% in the anterior part and 72% in the posterior area. As far as the superior orbital wall injured most often in the case of high maxillofacial trauma is concerned, the specificity of the conventional radiography reached only 64% (6). False-negative diagnosis was seen at the anterior part of the orbital floor in 9% and 10% in the posterior one, while 7% at the anterior portion of the medial orbital wall and at the ethmoid-maxillary plate in 11%.

In all patients analysed in the current paper there was performed the CT examination in coronal or axial plane, or in both of them. The examination was supplemented by multiplanar reconstructions (MPR) as well as three-dimensional reconstructions (3D TK). The multiplanar reformatting provides images in additional planes such as sagittal one, along a chosen straight or irregular line, which is important especially in case of injury to eyeballs, optic nerves or orbital muscles (10). The 3D option supplies spatial information on relationships between bone structures of the face (7, 13). Due to the so-called spatial depth, the 3D CT reconstruction enables the analysis of extensive trauma with numerous fracture lines, indentations and dislocations of bone fragments. The presentation of spatial relationships between the structures lying on different levels and of configuration of fractures is possible only by means of 3D CT reconstruction (2, 7, 11, 13).

According to Fox et al. (4) 3D and CT had a similar performance in detection of fractures and were markedly better than the MPR reconstructions. The authors correctly identified 10% more orbital fractures by means of CT in comparison with 3D CT, while at the same time they identified 10% fewer zygomatic fractures in this method.

The results of the CT examination facilitated classification of maxillofacial fractures and thus the planning of a surgery (11, 12).

CONCLUSIONS

1. The possible variants of imaging modalities in high (cranial) maxillofacial fractures were discussed and the most effective method was indicated.
2. The diagnostic algorithms in cases of high (cranial) maxillofacial fractures caused by central and lateral trauma were elaborated.
3. There was proved the usefulness of 3D CT reconstructions in classification of maxillofacial fractures.
4. There was proved the usefulness of 3D CT reconstructions in visualization of high maxillofacial fractures with indentations of bone fragments.

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STRESZCZENIE

Radiologiczna wizualizacja struktur twarzoczaszki jest trudna ze względu na złożoną budowę tej części ludzkiego organizmu, zwłaszcza że wraz ze wzrostem częstości urazów i wypadków komunikacyjnych ta właśnie część ciała ludzkiego jest narażona na znaczne obrażenia. Istnieje szereg metod obrazowania części twarzowej czaszki, z których żadna nie jest metodą uniwersalną, a są one wzajemnie komplementarne w zależności od rodzaju zmian patologicznych. W czasach obecnych zmian w systemie opieki zdrowotnej minimalizacja kosztów leczenia, a więc i diagnostyki, jest nieodzowna. Dlatego też na podstawie zebranego materiału, który stanowiły zdjęcia i wyniki badań obrazowych pacjentów badanych w latach 1995-1999 w Samodzielnej Pracowni Rentgenodiagnostyki Stomatologicznej i Szczękowo-Twarzowej oraz w II Zakładzie Radiologii Lekarskiej Akademii Medycznej w Lublinie, przedyskutowano możliwe warianty metod diagnostycznych w odniesieniu do różnych procesów patologicznych twarzoczaszki ze wskazaniem najefektywniejszej metody w danych warunkach. Opracowano algorytmy postępowania diagnostycznego w przypadku złamań górnego masywu części twarzowej czaszki o bocznym i centralnym punkcie przyłożenia i przedstawiono je w postaci schematów. Wykazano przydatność rekonstrukcji 3D TK do klasyfikowania złamań twarzoczaszki oraz wizualizacji złamań z wgłobieniami.