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The influence of application of 3D CT reconstructions on classification of maxillofacial fractures

The attempts at classification of complex maxillofacial fractures have been made by many authors, including LeFort. In Poland it was Wanyura(12) who presented a new classification of maxillofacial fractures. Nevertheless classifying complex fractures to individual groups basing only on radiograms and computed tomography results remains a challenging task. Therefore the aim of the work was to study the influence of the use of three-dimensional CT (3D CT) reconstructions on diagnostics and classification of maxillofacial fractures.

MATERIAL AND METHODS

The material consisted of 97 patients presenting with maxillofacial trauma who underwent CT examination in the 2nd Department of Medical Radiology of the Medical University of Lublin in the years 1995-2001. The CT examinations were performed using the Somatom AR-T scanner (Siemens, Erlangen, Germany). Coronal and axial images, 2 and 3 mm thick, were acquired. Then 3D CT reconstructions were obtained. The reconstructions were rotated, parts of them cut away and direction of light changed as that supplied additional information. All cases of maxillofacial trauma were classified according to Wanyura first on the basis of radiograms and CT examination, next on the basis of 3D CT reconstructions.

According to the classification given by Wanyura (12), maxillofacial traumas are divided into fractures caused by: low lateral facial trauma (zygomatico-orbital fractures, zygomaticomaxilloorbital fractures and isolated fractures of the orbital floor); low medial facial trauma (orbitonasal dislocations, dislocations of the upper massive of the facial skeleton); high medial cranial trauma (frontoorbitonasal fractures); high lateral cranial trauma (frontoorbital fractures).

RESULTS

The results of the two analyses differed in cases of properly diagnosed zygomaticoorbital fractures and orbitonasal dislocations, which were lower during the first reviewing. It was proved that 3D CT reconstructions were almost useless in visualisation of isolated fractures of the orbital floor. In other types of classified maxillofacial fractures application of 3D CT reconstructions gave results equivalent to analysis of conventional radiograms combined with axial and coronal CT images. However, in 6 cases it was impossible to definitely classify fractures according to Wanyura as there co-existed orbital floor fractures with fractures caused by high cranial trauma, which did not fit within the confines of the applied classification.

DISCUSSION

One of the first classifications of complex maxillofacial fractures has been given over 100 years ago by a French surgeon Rene LeFort. However these days his classification falls short of expectations as the described classic fracture lines, mainly resulting from trauma caused by assault, are hardly encountered any more. The development of technology, for the most part motorisation, created new causes of maxillofacial trauma (10). Considering modern diagnostic possibilities as well as expectations of maxillofacial surgeons an attempt was made to adapt the hitherto existing classifications to contemporary conditions (7). In Poland a new classification of maxillofacial fractures was presented by Wanyura (12). Yet classifying complex facial fractures on the basis of radiograms and computed tomography remains a challenging task (4, 8). Moreover, the introduction of a uniform classification of maxillofacial fractures will facilitate evaluation of the extent of trauma and will influence the choice of surgical approach and technique in planning of surgery. Such classfication is also indispensable in elaboration of diagnostic algorithms in imaging of maxillofacial trauma (11).

In case of zygomaticoorbital type, the fracture line begins at the front end of the lower orbital fissure, then runs towards the lower margin of the orbit, continues to the frontal wall of the maxilla near the maxillozygomatic suture and goes around the body of the zygomatic bone. The second fracture line goes up the lateral wall of the orbit along the sphenozygomatic suture. The third line cuts the zygomatic arch. Three-dimensional CT reconstructions are extremely useful in evaluation of such complex fractures and are far superior to conventional radiograms as well as to axial and/or coronal CT slices (9).

Zygomaticomaxilloorbital fractures are similar to zygomaticoorbital fractures, but additionally the orbital floor and the anterior wall of the maxillary sinus are affected. This type is distinguished due to serious ophthalmological complications. In case of this type of fractures 3D CT reconstructions are useful. However, coronal images clearly present-

Fig. 1. Three-dimensional CT reconstruction well presents zygomaticomaxilloorbital fracture

Fig. 2. Large defect in left orbital floor can be a manifestation of an isolated fracture of the orbital floor, but reliable diagnosis is not possible on the basis of the 3D CT reconstruction as the defect can also be an artifact

ing damage to orbital floor are also valuable in classifying midfacial fractures as presence of this injury differentiates zygomaticomaxilloorbital fractures from zygomaticoorbital type (9).

Isolated fractures of the orbital floor comprise three subtypes: "blow-out" type (collapse of orbital floor), "en clapet" type (triangular bony flaps opening towards the ethmoidal cells through which orbital tissues are indented and get impacted) and "trapdoor" type (single fracture line running transversely through the orbital floor along which orbital soft tissues get impacted). Three-dimensional CT reconstructions proved useless in imaging of this type of fracture as bone fragments are too small to be well visualised due to partial volume artefact. Moreover, this artefact is also responsible for appearance of pseudo-apertures hindering diagnosis (9). On the other hand, coronal CT scans are extremely useful in classifying isolated fractures of orbital floor (6).

Orbitonasal dislocations are "telescopic" fractures encompassing, depending on the severity of trauma, the nasal bones, their dislocation, fracture of the frontal process of the maxilla and even the intraorbital space. Three-dimensional reconstructions better depict "telescopic" character of this type of fractures and their classification on the basis of 3D CT images is less demanding than on the basis of conventional radiograms and CT scans.

In dislocations of the upper massive of the facial skeleton the superior portion of the maxillofacial skeleton is totally or partially separated from the base of the skull. At the same time it is fractured on different levels by main fracture lines running sometimes along the lines of decreased resistance according to LeFort types II and III as well as cut into small bone fragments by additional fracture lines. Anatomical structure of the upper massive of the facial skeleton is completely destroyed. An analysis of such fractures only on the basis of computed tomograms is very complex and application of 3D CT reconstructions is extremely useful in evaluation of the extent of midfacial damage. However, as far as classification of such fractures is concerned, both imaging modalities proved equivalent.

Frontoorbitonasal fracture is a fracture of the anterior wall of frontal sinus or of its anterior and posterior walls in severe trauma, fracture of the superior margins and walls of the orbits as well as of the upper ethmoidal cells. On the other hand, frontoorbital fracture is a unilateral asymmetric fracture with simultaneous lowering of the superior margin and wall of the orbit with dislocation of the eyeball and impairment of its mobility. In these types of maxillofacial fractures, the use of 3D CT reconstructions did not influence classification as the fracture lines were well visible on computed tomograms before post-processing (10).

Coronal and/or axial CT images as well as 3D CT reconstructions are widely used for evaluation of maxillofacial fractures as conventional radiological examinations in the case of complex facial fractures are not sufficient and often not precise enough (2, 3, 5). The reconstructions allow assessment of extensive trauma with numerous fractures, invaginations and dislocations of bone fragments (1). The so-called three-dimensional

depth facilitates evaluation of fractures and assigning them to individual groups of the Wanyura classification. Only 3D reconstructions make it possible to present spatial relationships between structures located on different levels. However, coronal CT slices are far superior to 3D CT reconstructions in visualisation of isolated fractures of the orbital floor. Three-dimensional CT images in these patients are of little help and can mislead the surgeon (3). It was found that 3D CT reconstructions were generally useful in classifying the maxillofacial fractures with the exception of fractures of paper thin walls of the orbits such as medial orbital wall due to appearance of pseudo apertures which may cause mistakes in interpretation (9).

CONCLUSIONS

1. Three-dimensional CT reconstructions proved useful in classifying maxillofacial fractures because they clearly presented fracture range, extent, as well as the type of indentation and impaction of bone fragments into paranasal sinus and orbits.

2. Classification of complex midfacial fractures was facilitated owing to the use of 3D CT reconstructions in comparison with the analysis on the basis of conventional radiograms and CT images.

3. The 3D reconstructions were not appropriate for evaluation and classification of isolated fractures of orbital floor.

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SUMMARY

The aim of the paper was to study of the influence of application of three-dimensional CT reconstructions on diagnostics and classification of maxillofacial fractures. The material comprised 97 patients presenting with maxillofacial trauma who underwent CT examination in the 2nd Department of Medical Radiology of the Medical University of Lublin in the years 1995-2001. The CT examinations were performed using the Somatom AR-T machine in coronal and axial slices, 2 and 3 mm thick. Then the 3D CT reconstructions were obtained. All cases of trauma were classified according to Wanyura first on the basis of radiograms and CT examination, next on the basis of 3D CT reconstructions. The results of the two analyses differed in cases of properly diagnosed zygomatico-orbital fractures and orbitonasal dislocations, which were less numerous during the first reviewing. It was found that 3D CT reconstructions were generally useful in classifying the maxillofacial fractures with the exception of isolated orbital floor fractures.

Wpływ zastosowania rekonstrukcji trójwymiarowych TK na klasyfikację złamań twarzoczaszki

Celem pracy jest ocena wpływu zastosowania rekonstrukcji pseudotrójwymiarowych TK na diagnostykę i klasyfikację złamań części twarzowej czaszki. Materiał stanowiło 97 pacjentów po urazach części twarzowej czaszki, którzy mieli wykonane badanie metodą

tomografii komputerowej w II Zakładzie Radiologii Lekarskiej AM w Lublinie w latach 1995-2001. Badania wykonywano w przekrojach czołowych i osiowych, na których podstawie następnie otrzymywano rekonstrukcje pseudotrójwymiarowe. Wszystkie przypadki złamań były klasyfikowane według Wanyury, najpierw na podstawie konwencjonalnych zdjęć rentgenowskich oraz osiowych i czołowych przekrojów TK, a następnie w oparciu o rekonstrukcje przestrzenne TK. Wyniki dwóch analiz różniły się w zakresie prawidłowo sklasyfikowanych złamań jarzmowo-oczodołowych oraz dyslokacji oczodołowo-nosowych, których ilość była mniejsza podczas pierwszej oceny. Stwierdzono, że rekonstrukcje 3D TK są przydatne w klasyfikowaniu złamań części twarzowej czaszki, z wyjątkiem izolowanych złamań dna oczodołu.