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Orbital wall fractures. Conventional views and CT*†

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SUMMARY

In order to evaluate the benefit derived by conventional views in the initial diagnosis of fractures of the orbital walls, a clinical study was designed to compare the results of evaluations by plain films and coronal CT scans. The conventional Caldwell's and Waters' views will provide a fairly reliable result as to the presence of orbital fractures: orbital floor (anterior in 78%, posterior in 73%), medial orbital wall (anterior in 71%, posterior in 72%), and ethmoid-maxillary plate in 64%. False-negative diagnosis was seen at the anterior portion of the floor in 13%, at the anterior portion of the medial orbital wall in 7%, and at the ethmoid-maxillary plate in 11%. False-negative diagnosis was seen at the orbital floor (anterior in 9%, posterior in 10%), at the medial orbital wall (anterior in 21%, posterior in 29%), and at the ethmoid-maxillary plate in 21%. Our results agree well with those of the past reports.

Key words: orbital wali, fractures, CT, plain radiography

INTRODUCTION

Conventional imaging modalities by standard views, such as Caldwell's and Waters', still play important roles in the initial diagnosis of facial trauma. In order to evaluate the benefit derived by conventional viewing the fractures of orbital walls, a clinical study was designed to compare the results of evaluations by conventional views (Caldwell's and Waters') and coronal CT scans. Fifty-nine cases clinically suspect of orbital wall fractures were included in the study. Our results were compared with those of earlier reports.

MATERIAL AND METHODS

Among the cases of facial trauma seen at our clinic, cases clinically suspect of fractures of the orbital wall were first evaluated by plain films of Caldwell's and Waters' views. Coronal CT scans were performed to confirm and to look for the details of fractures seen on the plain films.

The cases comprised 34 isolated orbital wall fractures (15 floor, 9 medial and 10 combined floor and medial orbital wall fractures) and other facial fractures (1 zygomatic plus medial orbital wall, 2 zygomatic plus orbital floor plus medial orbital wall, and 22 zygomatic fractures). Male-to-female ratio was 45:14; right-to-left ratio was 32:27. The mean age was 30.3±19.1 years. The duration between the sustention of trauma and imaging was 4.0±5.0 days for conventional views and 6.7±6.1 days for CT. CT was performed with a Toshiba TCT 60A/60 with a slice thickness of 5 mm and the images were processed by bone window settings (window width 800–900 and window level 10–50).

The radiographical anatomy of the orbital walls, compiled from Bouchet et al. (1955), Merrell et al. (1968) and Yanagisawa et al. (1968), are shown in Figure 1. Both the medial wall and floor are divided into two portions of anterior and posterior. The anterior portion of the medial wall by Caldwell's view corresponds to the medial orbital wall along the posterior lachrymal crest, whereas the posterior portion corresponds to the posterior compartment of the orbital plate of the ethmoid. The anterior portion of the medial orbital wall by Waters' view corresponds to the anterior-superior aspect of the medial orbital wall along the posterior lachrymal crest, whereas the posterior portion corresponds to the posterior-inferior aspect of the medial orbital wall close to the ethmoid-maxillary suture. The posterior portion of the orbital floor by Caldwell's view corresponds to the posterior bulge of the floor in front of the inferior orbital fissure, whereas the anterior portion by Waters' view corresponds to the anterior concave area of the floor, where the depth is most pronounced. The ethmoid-maxillary plate is seen at the junction of the medial orbital wall and the floor, and is a sharp plate separating the maxillary sinus from the posterior ethmoidal cells. Images of coronal CT scans were evaluated at the corresponding sections in the anatomy.

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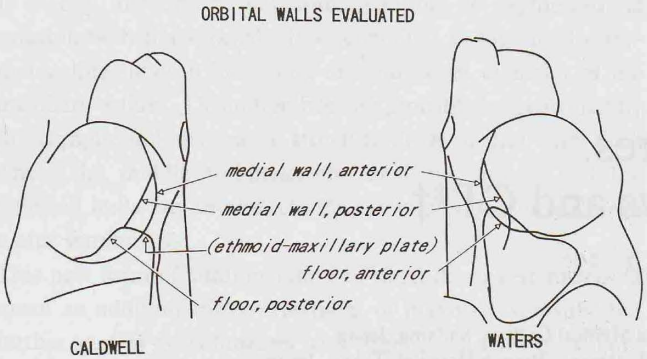

Figure 1. Radiographical anatomy of the orbital walls.

The direct diagnostic criteria for the fractures by Schneider et al. (1984) were adopted as follows: (1) discontinuity of the cortical line; (2) displacement of the fractured pieces; (3) separation of the sutures. Indirect signs of fractures such as opacity and soft tissues in the sinuses were not included in our criteria.

To minimize variations among observers, the evaluations were done by the senior author alone. Before the evaluation of images, the general clinical background (i.e., age, gender, conditions of trauma, and orbital signs) was briefly informed. The conventional views were first interpreted all through the cases without the benefit of CT. Occasionally, CT scans were next interpreted. Not all patients had a full set of conventional views in two projections and CT in coronal sections, because other injuries or significant pain precluded their completing the full set. Therefore, the final evaluation was performed using available combinations such as: Caldwell's view and coronal scan, and Waters' view and coronal scan. These two sets of paired images were analyzed and compared. The result of CT was presumed to be of true-positive diagnosis.

The result by conventional views was classified in comparison to these of CT according to the criteria of diagnosis used in diagnostic radiology:

1. *true-positive diagnosis:* the results by plain films matched those of CT,
2. *false-positive diagnosis:* the positive evaluation of fracture by plain films was negative by CT,
3. *false-negative diagnosis:* the negative evaluation of fracture by plain films was positive by CT,
4. *inconclusive:* plain films were not suitable for evaluation due to technical faults or due to the images themselves (opacity and unidentifiable structures, et cetera).

RESULTS

Fractures of the orbital floor

By Waters' view, 32 pairs were eligible for the study, and in Caldwell's 30 pairs (Table 1). By Waters' view and at the anterior orbital floor, true-positive diagnosis was about 78%, false-positive was 13%, false-negative was 9%, and inconclusive none.

By Caldwell's view and at the posterior orbital floor, true-positive was about 73%, false-positive none, false-negative 10%, and inconclusive 17%.

Table 1. The result of imaging of the orbital floor.

types of diagnosis	orbital floor	
	anterior Waters' (n=32)	posterior Caldwell's (n=30)
true positive	25 (78.1%)	22 (73.3%)
false positive	4 (12.5%)	0
false negative	3 (9.4%)	3 (10.0%)
inconclusive	0	5 (16.7%)

Table 2. The result of imaging of the medial orbital wall.

types of diagnosis	medial orbital wall				ethmoid-maxillary plate
	anterior		posterior		
	Caldwell's (n=20)	Waters' (n=22)	Caldwell's (n=21)	Waters' (n=21)	Caldwell's (n=19)
true positive	14 (70.0%)	16 (72.7%)	14 (66.7%)	16 (76.2%)	12 (63.3%)
false positive	1 (5.0%)	2 (9.1%)	0	0	2 (10.5%)
false negative	5 (25.0%)	4 (18.2%)	7 (33.3%)	5 (23.8)	4 (21.1%)
inconclusive	0	0	0	0	1 (5.3%)

Fractures of the medial wall

The numbers for the pairs in each views are shown in Table 2. Since the medial orbital wall in the anterior and posterior portions was evaluated both by Caldwell's and Waters' views, the results will be compared in a set of two views.

At the anterior portion of the medial orbital wall, true-positive diagnosis was about 70% (Caldwell's) and 73% (Waters'), false-positive 5% and 9%, respectively, false-negative 25% and 18%, respectively, and inconclusive in none.

At the posterior portion of the medial orbital wall, true-positive was about 67% (Caldwell's) and 76% (Waters'), false-positive none, false-negative was 33% and 24%, respectively, inconclusive none. At the ethmoid-maxillary plate, true-positive was about 63%, false-positive 11%, false-negative 21%, and inconclusive 5%.

DISCUSSION

Before the advent of CT, perhaps few of us escaped the frustration to arrive at satisfactory judgements for the fractures of the orbital walls with the aids of multiple plain films and conventional tomography. Our imaging approach to the fractures of the orbital wall now indicates that a limited number of plain films should be confirmed by CT when the former suggests fractures. By plain films of Caldwell's and Waters' views, applying criteria for fractures, certain degrees of practical information could be obtained to varied satisfaction. Our present study was designed to assess the validity of this clinical impression. A limited number of reports has engaged with the similar design and these will be briefly reviewed and compared. Table 3 is the result of reports in which the description of plain films is not specified, i.e., conventional views are not separately discussed. In these reports, the true-positive diagnosis for fractures of the orbital floor varies from 57% to 100%, and for those of the medial wall from 7% to 50%. Table 4 is the result of reports in which Caldwell's and Waters' views were separately analyzed. Our

Table 3. Reports of fractures of the orbital walls (number of true positive Dx/total number with percentages in parentheses).

authors	year	orbital floor	medial wall
Ord et al.	1981	-	6/12 (50.0%)
Hammerschlag et al.	1982a	-	2/30 (6.7%)
Drobisz et al.	1983	24/24 (100%)	2/24 (8.3%)
Irnberger	1985	33/58 (56.9%)	3/42 (7.1%)

Table 4. Reports of fractures of the orbital floor (number of true positive Dx/total number with percentages in parentheses).

authors	year	Waters' view	Caldwell's view
Hammerschlag et al.	1982a	26/30 (86.7%)	25/30 (83.3%)
Langen et al.	1989	16/19 (88.9%)	18/22 (81.8%)
this study	1993	25/32 (78.1%)	22/30 (73.3%)

Table 5. Reports of fractures of the medial orbital wall (number of true positive Dx/total number with percentages in parentheses).

authors	year	Waters' view	Caldwell's view
Langen et al.	1989	2/18 (11.1%)	2/15 (13.3%)
this study	1993	16/22 (72.7%) ant. 16/21 (76.1%) post.	14/22 (63.7%) ant 14/21 (66.7%) post.

results analyzed the floor in the anterior and posterior portions and the averaged results are shown in Table 4. The results by Waters' view (78-89%) were slightly better than those by Caldwell's view (73-83%). Table 5 is the result of reports of the fracture of the medial wall when two views were separately analyzed. The results of two reports differ rather markedly, and can be explained in two ways. In the report by Langen et al. (1989) such cases as sustaining complex fractures of the skull and orbital fractures were included. This might lead to many inconclusive interpretations. In contrast, our cases comprised only such cases as sustaining minor and uncomplicated facial trauma. In Langen's report, the radiographical anatomy of the medial orbital wall is not specifically elucidated and this might contribute to the results of true-positive diagnosis. Grove et al. (1978) stated that coronal CT permits visualization of all four orbital walls, and all extra-ocular muscles. When the condition of the patient precludes obtaining direct coronal scans, these will be substituted by reformatted coronal images which will often prove to be sub-optimal in quality. Our report throws no light upon the accuracy of recognizing fractures of the orbital wall by coronal CT scans. Hammerschlag et al. (1982a) states that CT underestimates the size and complexity of blow-out fractures of the orbit, particularly in the determination of non-depressed comminuted segments, while assessment of depressed segments is reasonably accurate.

CONCLUSIONS

Plain films by Caldwell's and Waters' views, when compared to coronal CT scans, yield fairly high percentages (63-78%) of true-positive diagnosis in cases of orbital wall fractures. With respect to the orbital floor, false-positive diagnosis was seen only at the anterior portion in about 13%, and false-negative diagnosis was seen in about 10%, both at the anterior and posterior portions. In the medial orbital wall, false-positive diagnosis at the anterior portion was 5% (Caldwell's view) and 9% (Waters' view) and none at the posterior portion, false-negative diagnosis at the anterior portion was 25% (Caldwell's view) and 18% (Waters' view), and at the posterior portion, it was 33% (Caldwell's view) and 24% (Waters' view).

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