Med. J. Cairo Univ., Vol. 93, No. 1, Accepted 3/2/2025
DOI: 10.22608/MJCU. 237-242, March 2025
www.medicaljournalofcairouniversity.net

Diagnostic and Predictive Value of Multidetector Computed Tomography in Craniofacial Trauma Patients to Detect Incidental and Clinically Unassessable Causes of Visual Impairment

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Abstract

Background: Craniofacial trauma is a public health issue of pivotal relevance with a high frequency and number of accesses to the Emergency Departments and can cause damage to the eye and orbit, resulting in significant impairment if not timely diagnosed and properly managed.

Early ophthalmologic examination is mandatory for appropriate management of ocular injuries. In the setting of acute trauma, clinical examination is often limited by peri-orbital soft tissue swelling or damage, severe pain and patient's general condition. Therefore, the role of imaging is most important in such situations for evaluation of injuries to brain, skull, facial bones and thequick and three-dimensional evaluation of the orbital cavity.

Because CT imaging is widely used in the initial evaluation of patients with head and facial trauma, radiologists will often interpret CT examinations before detailed ophthalmologic evaluation has been done.

Aim of Study: Was to show the role of CT in assessing orbital injuries where neuro-ophthalmologic exploration is limited such as in hyphema, traumatic cataract or uncooperative patients like comatosed ones and its ability to detect early causes of visual impairment. We also suggested the possibility of traumatic optic neuropathy (TON) on the basis of CT findings and determined the specific CT findings that can be used to predict TON in patients with craniofacial trauma.

Patients and Methods: We included 42 patients (34 males and eight females) who suffered from life-threatening trauma and received a polytrauma CT scan between April 2022 and October 2022 at the Emergency Department of Kasr Al-Ainy hospital. All patients had eye injuries with hindered ocular examination either due to local obscuring injury or consciousness affection preventing proper clinical evaluation and were referred to the Diagnostic Radiology Department at Kasr Al-Ainy Hospital for CT evaluation.

Results: Blunt trauma was the most common type of trauma and was seen in 26 patients (61.9%) while penetrating trauma was seen in 16 patients (38.1%).Non cooperative status was the most common cause that limited proper clinical examination. Association between type of trauma (blunt or penetrating) with type of injuries found on CT, showed statistically significant association between orbital wall fractures and blunt trauma (*p*-value <0.001) and between open globe injuries and penetrating trauma (*p*-value <0.001).

Conclusion: The results of our study speak in favor for combined early ophthalmological consultations and radiological imaging. Diagnostic and treatment of possible orbital injuries should be remembered in a polytrauma patient.

Key Words: *Orbit – Trauma – CT.*

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Introduction

CRANIOFACIAL trauma is a public health issue of pivotal relevance with a high frequency and number of accesses to the Emergency Departments and can cause damage to the eye and orbit, resulting in significant impairment if not timely diagnosed and properly managed **[1].**

The most common eye injuries among poly-trauma patients are orbital wall fractures, periorbital swelling, hematoma, sub-conjunctival hemorrhage, ocular adnexal injuries, optic nerve injuries, penetrating globe injuries and blow-out fracture of the orbit **[2].**

Early ophthalmologic examination is mandatory for appropriate management of ocular injuries. In the setting of acute trauma, clinical examination is often limited by peri-orbital soft tissue swelling or damage, severe pain and patient's general condition (decreased mental status, sedation, or comorbid injuries, irritability, unconsciousness and non-cooperative patients) **[1].**

Therefore, the role of imaging is most important in such situations for evaluation of injuries to brain, skull, facial bones and thequick and three-dimensional evaluation of the orbital cavity **[2].**

Because CT imaging is widely used in the initial evaluation of patients with head and facial trauma, radiologists will often interpret CT examinations before detailed ophthalmologic evaluation has been done. Furthermore, CT imaging may reveal orbital injuries that would be missed based upon the initial survey **[3].** High-resolution multi-slice CT (MSCT) CT imaging may help to guide the decision of immediate surgery, delayed surgery, or non-operative management **[4].**

Aim of the work:

The aim of our study was to show the role of CT in assessing orbital injuries where neuro-ophthalmologic exploration is limited such as in hyphema, traumatic cataract or uncooperative patients like comatosed ones and its ability to detect early causes of visual impairment.

We also suggested the possibility of traumatic optic neuropathy (TON) on the basis of CT findings and determined the specific CT findings that can be used to predict TON in patients with craniofacial trauma.

Patients and Methods

This prospective study was approved by our Hospital Ethical Committee and a written informed consent was obtained from the patient's relatives.

We included 42 patients (34 males and eight females) who suffered from life-threatening trauma and received a polytrauma CT scan between April 2022 and October 2022 at the Emergency Department of Kasr Al-Ainy Hospital. All patients had eye injuries with hindered ocular examination either due to local obscuring injury or consciousness affection preventing proper clinical evaluation and were referred to the Diagnostic Radiology Department at Kasr Al-Ainy Hospital for CT evaluation.

CT technique:

Multi-slice CT examination of the orbit with acquisition of both axial and coronal images was done in all patients with 3mm sections.

Patient positioning axial view: The patients were examined in the supine position with the beam parallel to the orbito-meatal line. The images of patients with trauma were studied in bone window setting to assess fractures, and soft tissue window setting was used to assess orbital soft tissue injuries. The axial sections included images of the entire brain, especially the retro-orbital optic apparatus (with additional magnified views of the orbits).

MPR and 3D reconstruction: These were performed for fractures and to localize foreign bodies. MPR was used to reconstruct coronal and sagittal images. Coronal images were important as cross-sectional evaluation of all intra-orbital structures is optimal (e.g., extraocular muscles, optic nerve sheath, nasal complex, vessels, and globe). This plane is also imperative for assessing the spread of disease from the surrounding structures (e.g., paranasal sinuses, trauma, and tumor).

The MPR images were viewed as thin as possible to detect subtle fractures, but when images were noisy, the noise level was reduced by fusing thin slices into thicker images. This fusion of images may also give additional important information such as depth. Varying scan planes can help in avoiding excessive hardware artifacts.

Statistical analysis:

Data were coded and entered using the statistical package for the Social Sciences (SPSS) version 28 (IBM Corp., Armonk, NY, USA). Data was summarized using mean, standard deviation, median, minimum and maximum for quantitative data and using frequency (count) and relative frequency (percentage) for categorical data.

For comparing categorical data, Chi square ($\chi 2$) testwas performed. Exact test was used instead when the expected frequency is less than 5 **[5].** *p*-values less than 0.05 were considered as statistically significant.

Results

This study included 42 patients (34 males and eight females) and was conducted over a period of 6 months starting from April 2022 to October 2022. All patients had eye injuries with hindered ocular examination either due to local obscuring injury or consciousness affection preventing proper clinical evaluation and were referred to the Diagnostic Radiology Department at Kasr Al-Ainy Hospital for CT evaluation.

The age of patients ranged from 1 to 72 years with a mean of 33.76±15.12.

Patients demographics and admission characteristics are shown in Table (1).

Table (1): Demographics and admission characteristics of the studied patients.

	Count	%
Gender:		
Female	8	19.0
Male	34	81.0
Mechanism of injury:		
Assault	5	11.9
Fall	11	26.2
Gunshot	3	7.1
RTA	11	26.2
Work accident	6	14.3
Other	6	14.3
Type of trauma:		
Blunt	26	61.9
Penetrating	16	38.1

Male patients were more commonly affected than female patients by eye trauma with percentage 81% to 19% in the studied group.

The most common causes of eye trauma were road traffic accidents and fall from height, each seen in 11 patients (26.2%), followed by work accidents and other causes (not further specified in medical history) in 6 patients each (14.3%), assaults in five patients (11.9%) and gunshot in three patients (7.1%).

Blunt trauma was the most common type of trauma and was seen in 26 patients (61.9%) while penetrating trauma was seen in 16 patients (38.1%).

The distribution of conditions obscuring proper ophthalmic examination in the studied group is shown in Table (2).

Table (2): Distribution of conditions obscuring proper ophthalmic examination in the studied group.

Conditions obscuring proper ophthalmic examination	Yes		No	
	Count	%	Count	%
Eyelid swelling	15	35.7	27	64.3
Hyphema	13	31	29	69
Non cooperative	20	47.6	22	52.4
Irritable	19	45.2	23	54.8
Unconscious	2	4.8	40	95.2
Severe pain	15	35.7	27	64.3
Traumatic cataract	7	16.7	35	83.3

N.B: More than one condition could be found in the same patient.

Non cooperative status was the most common cause that limited proper clinical examination.

Table (3): Distribution of CT findings in the studied cases.

	Yes		No	
	Count	%	Count	%
Right eye affection	22	52.4	20	47.6
Left eye affection	23	54.8	19	45.2
Orbital wall fractures n=20:				
Orbital floor fracture	14	33.3	28	66.7
Orbital roof fracture	1	2.4	41	97.6
Orbital medial wall fracture	10	23.8	32	76.2
Combined fracture	5	11.9	37	88.1
Open globe injuries n=14:				
Rupture globe	7	16.7	35	83.3
Intraocular air	12	28.6	30	71.4
Intra-orbital FB	9	21.4	33	78.6
Intraocular FB	4	9.5	38	90.5
Vitreous hemorrhage	4	9.5	38	90.5
Closed globe injuries n=3:				
Periorbital edema	3	7.1	39	92.9
Vitreous hemorrhage	4	9.5	38	90.5
Lens subluxation	1	2.4	41	97.6
Adnexal injuries n=12:				
Periorbital soft tissue thickening	15	35.7	27	64.3
Extra-orbital FB	2	4.8	40	95.2
Retro-bulbar lesions n=4:				
Traumatic Optic nerve injury (TON)	4	9.5	38	90.5
Retro-bulbar hematoma and proptosis	1	2.4	41	97.6

- More than one CT finding was found in the same patient, and the distribution of CT findings in our patients is shown in Table (3).

Orbital wall fractures were the most common eye injuries and were seen in 20 patients followed by open globe injuries seen in 14 patients, then adnexal injuries in 12 patients, retro-bulbar lesions seen in 4 patients and closed globe injuries in three patients.

Traumatic optic neuropathy (TON) was reported in 4 patients (9.5%).

The presence of intra, extraconal hemorrhage, swelling and hematoma of the optic nerve on CT scan were the most common findings in the traumatic optic neuropathy group (Fig. 1).

Association between type of trauma (blunt or penetrating) with type of injuries found on CT, showed statistically significant association between orbital wall fractures and blunt trauma (p-value <0.001) and between open globe injuries and penetrating trauma (p-value <0.001).

Fig. (1): A 55-year-old male patient suffered a gunshot injury. He presented to the emergency room. He had hyphema with redness and edema. CT was done and revealed relatively small sized left eye globe with vitreous hemorrhage (red arrow) (A) TON as the left optic nerve appeared relatively thickened with mild irregularities (yellow arrow) (C) and multiple radio-dense foreign bodies, one of them seen at the left intra-conal region (white arrow) (B). The patient required urgent surgical intervention.

Discussion

CT is the first-line modality for radiologic evaluation of the orbit in the acute traumatic setting Le Bedis et al., **[6]**. In the current study, our aim was to analyze the role of CT as a useful diagnostic tool in the diagnosis of traumatic orbital lesions in emergent settings, especially when clinical examination is not possible or does not reach a final diagnosis to manage and avoid permanent vision loss.

In this series, 42 patients with clinically proven traumatic orbital lesions were included. Male patients were more commonly affected than female patients by eye trauma, with a male to female ratio of 4.25: 1. Other studies by M Dawoud et al., **[7]** Soliman et al., **8]** and Cillino et al., **[9]** confirmed the male predominance in eye trauma epidemiology.

In our study, patient's age ranged between 1 and 72 years old, with a mean of 33.76±15.12 SD. This was in contrast to other studies, where the proportion of pediatric eye injuries was higher than in our studied group Cillino et al., **[9]** and Rahman et al., **[10]**. However, the proportion of pediatric eye injuries in our study was similar to that in two previous studies done in the Mediterranean region, one of them by M. Dawoud et al., **[7]** and the other by Soylu et al., **[11]**.

In our study, ophthalmic examination was hindered in studied patients (42 of total 42 patients) due to presence of multiple causes. Non-cooperation was the most common cause that limited proper clinical examination (20 patients) followed by irritable status (19 patients), then severe pain and eyelid swelling (15 patients), hyphema seen in 13 patients, traumatic cataract in 7 patients and unconscious patients (2 patients). Patients may have more than one cause that contributed in obscuring the optimal clinical examination. Compared to a previous study by Stephanie et al., **[12]** clinical examination was hindered in 118 of a total 250 patients. Sedation due to severity of the multiple traumas was the most common cause that limited clinical examination.

In our study, road traffic accidents and falling from height were the most common causes of trauma-associated eye injuries. These findings agreed with those of previous studies by M. Dawoud et al., **[7]** and Georgouli et al., **[13]**. Also, falls represented a higher percentage than assaults. This was concomitant with other studies M. Dawoud et al., **[7]** and Georgouli et al., **[13]**.

The most commonly reported eye injury in our study was orbital wall fracture in 20 eyes (47.6%); this was associated in the majority of cases with periorbital swelling or hematoma. This percentage

was in close agreement with a previous study by M. Dawoud et al., *[7]* and Georgouli et al., *[13]* but in contrast to another study by Stephanie et al., *[12]* which showed a lower percentage (23.3%) of orbital wall fractures.

Open globe injuries were second in frequency (about 33.3%). This percentage was higher than reported in M. Dawoud et al., *[7]* (32.3%) and lower than that reported by Soliman et al., *[8]* (80%).

In our study, ocular adnexal injuries were the third most commonly reported injury (28.6%) and retrobulbar lesions were reported in four patients (9.5%). This agreed with previous studies, which put adnexal injuries before retrobulbar lesions. One of them by M. Dawoud et al., *[7]*, and others by Soliman et al., *[8]* and Georgouli et al., *[13]*.

Proptosis following trauma can be attributed to a number of reasons. It may arise as a result of retrobulbar hemorrhage, swelling of the retrobulbar contents (following accumulation of air or edema), or from bony or soft tissue (e.g. Brain) displacement into the retrobulbar region. Ultimately, these varied pathologies can result in a 'final common pathway' of ischemia to the optic nerve or retina, and, if not reversed, loss of vision will occur.

In our study retrobulbar hemorrhage was the cause of post-traumatic proptosis. This was in contrast with a prospective 6-year study by Perry et al., *[14]* performed to identify the nature of acute severe post-traumatic proptosis revealed that in all cases proptosis was due to retrobulbar edema and not hemorrhage.

In our study, blunt trauma was the most common type of trauma that was found in 26 patients (61.9%). This percentage was lower than reported By M. Dawoud et al., *[7]* (73.3%). While penetrating trauma was seen in 16 patients (38.9%). This percentage was higher than found by M Dawoud et al., *[7]* (26.7%).

A statistically significant association between orbital wall fractures and blunt traumas was found with percentage of 69.2% and (p-value <0.001) and between open globe injuries and penetrating trauma with percentage of 87.5% and (p-value <0.001).

TON was reported in 4 patients (9.5%), this percentage was in close agreement with a study by Robert et al., *[15]* (10%). The presence of intra, extraconal hemorrhage, swelling and hematoma of the optic nerve on CT scan were the most common findings in the TON group. Compared to a study by Stephanie et al., *[12]*, the presence of intraconal hemorrhage and optic nerve hematoma were the most common findings in the TON group. Additionally, in our analysis, we noticed a close association between damage of the optic canal and an altered morphology of the visual nerve in the CT images. This is in agreement with Stephanie et al., *[12]* and Lee et al., *[16]*. The studies done by the authors mentioned showed that the impairment of the optic nerve occurs on a microscopic level.

There are some limitations to this study: Detecting optic nerve sheath hematomas and evaluating optic nerve integrity, diagnosing posterior globe rupture where there is a concurrent anterior globe rupture with loss of volume causing scleral infolding resembling discontinuity. Although, CT scan is adequate for most foreign bodies, it shows low sensitivity for small pieces of glass and wood. Further MRI and B-scan may be considered for further characterization of soft tissue or optic nerve injuries and in the evaluation of non-metallic orbital foreign bodies.

Furthermore; full ophthalmological examination could not be obtained due to the presence of serious injuries that obstruct this examination. Findings were only evaluated in cases in which globe injuries were detected by CT. Therefore, false negative cases were not evaluated. A comprehensive study by evaluating the ophthalmologic findings of polytrauma patients with tomographic findings is likewise recommended.

It is sometimes not possible to place trauma patients in a proper position in the gantry. In such cases, a symmetrical appearance in both eyes cannot be achieved in every patient. Using dedicated workstation to perform MPR measurements is required.

Conclusion:

Ocular injuries are not often given immediate concern as patients with life-threatening conditions need to be stabilized first. Undetected serious eye injuries might lead to a reduced or lost vision, which could result in severe limitations of quality of life.

In our study we researched for possible injuries to the eye and orbit in patients who suffered from polytrauma, in settings where clinical ophthalmological examination is obscured by either local cause (e.g. hyphema) or general cause (e.g. coma). We assessed 42 patients with severe trauma, who were treated at Kasr Al-Ainy Hospital between April 2022 and October 2022.

Orbital wall fractures were the most common eye injuries following trauma (47.6%). Computed tomography (CT) showed positive findings of causes of visual impairment including orbital fractures, open globe injuries, closed globe injuries, adnexal injuries and retrobulbar injuries including traumatic optic neuropathy.

The results of our study speak in favor for combined early ophthalmological consultations and radiological imaging. Diagnostic and treatment of possible orbital injuries should be remembered in a polytrauma patient.

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القيمة التشخيصية والتنبؤية للتصوير المقطعى متعدد الكواشف فى مرضى إصابات الجمجمة والوجه للكشف عن الأسباب العرضية وغير القابلة للتقييم السريرى لفقدان البصر

تُعد إصابات الجمجمة والوجه قضية صحية عامة ذات أهمية بالغة، نظرًا لارتفاع معدل حدوثها وكثرة زيارات أقسام الطوارئ المرتبطة بها. يمكن أن تسبب هذه الإصابات أضرارًا للعين والمحجر، مما يؤدى إلى إعاقة كبيرة إذا لم يتم تشخيصها فى الوقت المناسب ومعالجتها بشكل صحيح.

يُعد الفحص العينى المبكر أمرًا ضروريًا للإدارة المناسبة لإصابات العين. ومع ذلك، في حالات الإصابات الحادة، يكون الفحص السريرى محدودًا غالبًا بسبب تورم الأنسجة الرخوة حول العين أو تلفها، أو الألم الشديد، أو الحالة العامة للمريض. لذلك، يكون دور التصوير الطبى بالغ الأهمية فى هذه الحالات لتقييم إصابات الدماغ والجمجمة والعظام الوجهية، بالإضافة إلى التقييم السريع ثلاثى الأبعاد لتجويف العين.

نظرًا لاستخدام التصوير المقطعى (CT) على نطاق واسع في التقييم الأولى لمرضى إصابات الرأس والوجه، غالبًا ما يقوم أطباء الأشعة بتفسير نتائج الفحوص قبل إجراء التقييم التفصيلى للعيون.