Original Article

Clinical Application of X-ray, B-scan, and CT in the Diagnosis of Ocular Foreign Bodies

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Abstract

Purpose: To analyze the sensitivity and specificity of X-ray, B-ultrasound, and CT scan in diagnosing ocular foreign bodies and to compare the accuracy of applying these three imaging tools in locating ocular foreign bodies.

Methods: A retrospective review was conducted of radiographic and clinical eye examination data from 62 patients (66 eyes) who were suspected with ocular foreign bodies at first presentation to Zhongshan Ophthalmic Center between August 2007 and October 2011. The sensitivity and specificity of X-ray, B-ultrasound and CT scan in the diagnosis of ocular foreign bodies were investigated and their accuracy in locating ocular foreign bodies was compared.

Results: A total of 75.8% of subjects had ocular foreign bodies; 66% of these were metal materials. The patients with intraocular, eyeball wall, and extraocular foreign bodies accounted for 46, 28, and 26%, respectively. The sensitivity of applying X-ray, CT scan, and B-ultrasound in the diagnosis of ocular foreign bodies was 58.3, 61.7, and 75%, the specificity was 63.3, 100, and 87.5%, and the accuracy of locating foreign bodies was 73.4, 94.7, and 86.5%, respectively. The properties of foreign bodies affected the diagnosis of X-ray, but exerted little impact upon B-ultrasound and CT scan.

Conclusion: A fairly high incidence of ocular foreign bodies was noted in patients suspected with ocular foreign bodies at their first presentations. X-ray combined with CT scan or X-ray in combination with B ultrasound showed a relatively high sensitivity and specificity in diagnosing ocular foreign bodies. The CT scan had the highest accuracy in locating ocular foreign bodies. (***Eye Science 2013; 28:-***)

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Ocular foreign bodies refer to particles penetrating into eye tissues at a high speed; these can be caused by beatings, incisions, shootings, and explosions, etc. and they lead to severe initial damage to eye tissues. In addition, ocular foreign body trauma is one of the main causes of infectious endophthalmitis. Definite diagnosis of ocular foreign bodies is a vital principle for penetrating ocular injury therapy and precise localization of foreign bodies is essential for foreign body extraction. Direct detection of ocular foreign bodies is difficult since conventional eye examination cannot detect posterior chamber, ciliary, vitreous base, eyeball wall, and orbital soft tissues. In addition, ocular foreign body traumas are commonly complicated by media opacity, ocular edema, exudation, and hemorrhage, etc. At present, X-ray, B-ultrasound, and CT scan are the three main imaging tools used in the diagnosis of ocular foreign bodies, and each has its respective strengths and weaknesses. This study is designed to analyze the use of these three imaging tools for ocular foreign object diagnosis and localization and to explore an optimal imaging scheme.

Materials and methods

Study subjects

A total of 63 patients suspected to have ocular foreign bodies at first presentation to Zhongshan Ophthalmic Center between August 2007 and October 2011 were enrolled in this study. Inclusion criteria: the subjects who were suspected with ocular

foreign bodies due to ocular trauma, decreased visual acuity and uveitis during first presentation; the patients who had complete X-ray, B-ultrasound, and CT scan data; the patients found to be positive by X-ray who further underwent corneal metal ring localization of foreign bodies; and those with confirmed diagnosis outcomes. Exclusion criteria: those with complete imaging examination data but without confirmed diagnosis results due to transferring, those refusing to undergo surgery or those with loss of contact were excluded from this study. A total of 62 patients (66 eyes)–47 males and 15 females, aged 33.04±13.34 years on average (aged from 4 to 70 years)–were included.

Statistical analysis

All participants received X-ray, B-ultrasound and CT scan for qualitative diagnosis and the patients with positive outcomes were categorized into extraocular, eyeball wall and intraocular foreign bodies. The location and property of extracted foreign bodies were statistically analyzed. The final diagnosis outcome was confirmed. The sensitivity and specificity of X-ray, B-ultrasound, and CT scan in the diagnosis of ocular foreign bodies were investigated and their accuracy in locating intraocular foreign bodies was statistically compared. Enumeration data were expressed as frequency and percentage. The differences in percentage were compared using χ^2 analysis. The consistency between imaging diagnosis and final clinical diagnosis was analyzed by Kappa value. $P<0.05$ was considered as a statistical significance.

Results

Clinical characteristics of ocular foreign bodies

Sixty-six eyes were suspected to have foreign bodies at first presentation and 50 (75.8%) were confirmed to have foreign bodies by final clinical diagnosis, including 23 cases of intraocular foreign bodies (46%), 14 cases of eyeball wall foreign bodies (28%), and 13 cases of extraocular foreign bodies (26%); 33 eyes had metal foreign bodies and 17 contained non-metal materials (34%). The foreign bodies were lodged in the eyes for 28 days on average and up to 17 years at most (Table 1).

Table 1 Clinical characteristics of ocular foreign bodies in 50 cases (unit: eye)

	Location of foreign bodies			Total (%)
	Intraocular	Eyeball wall	Extraocular	
Metal	15	10	8	33(66%)
Non-metal	8	4	5	17(34%)
Total(%)	23(46%)	14(28%)	13(26%)	50(100%)

Qualitative diagnostic outcomes of subjects with ocular foreign bodies by three imaging examination tools

The sensitivity of applying X-ray, CT scan, and B ultrasound in the diagnosis of ocular foreign bodies was 58.3, 61.7, and 75%, and the specificity was 63.3, 100, and 87.5%, respectively (Table 2). Parallel combined diagnosis improved diagnostic sensitivity. The sensitivity and specificity of parallel combined diagnosis was calculated based on the following equation: sensitivity=sensitivity A+(1-sensitivity A)x sensitivity B, specificity=specificity Ax specificity B. The results showed that the specificity and sensitivity of X-ray combined with CT were 87.4 and 75%, they were 84.0 and 87.5% for X-ray combined with CT scan, and they were 82.9and 65.6% for B-ultrasound in combination with CT scan.

Table 3 Diagnostic outcomes of localization of ocular foreign bodies by three imaging examination tools (unit: eye)

	X-ray (n=35)			CT(n=38)			B-scan(n=37)		
Clinical diagnosis	Intraocular	Eyeball wall	Extraocular	Intraocular	Eyeball wall	Extraocular	Intraocular	Eyeball wall	Extraocular
Intraocular	13	2	2	19	2	0	14	2	0
Eyeball wall	2	6	2	0	12	0	1	10	1
Extraocular	0	1	7	0	0	5	1	0	8
Accuracy	(25/35)74.3%			(36/38)94.7%			(32/37)86.5%		
Kappa	0.602			0.911			0.792		
P	<0.001			<0.001			<0.001		

Diagnostic outcomes of localization of ocular foreign bodies by three imaging examination tools

Thirty-five eyes with positive foreign bodies were accurately diagnosed by X-ray, 38 by CT scan and 37 by B-ultrasound. The foreign bodies were precisely located in 25 eyes by X-ray (74.3%), in 36 by CT scan (94.7%), and in 32 by B-ultrasound (86.5%). CT scan had the highest accuracy for foreign body localization (Kappa =0.911, P <0.001), as shown in Table 3.

Table 2 Qualitative diagnostic outcomes of subjects with ocular foreign bodies by three imaging examination tools

	X-ray(n=66)		CT(n=66)		B-scan(n=66)	
	+	−	+	−	+	−
Eyes with foreign bodies	35	15	38	12	37	13
Control eyes	0	16	4	12	2	14
Sensitivity	58.3%		63.3%		61.7%	
Specificity	100%		75%		87.5%	

Differences in diagnostic accuracy of metal and non-metal foreign bodies by three imaging examination tools

The accuracy of X-ray in qualitatively diagnosing metal foreign bodies was 90.9%, significantly higher than 29.4% for non-metal foreign bodies (P<0.001); the accuracy of X-ray in locating metal foreign bodies was 73.3% and 80% for non-metal foreign bodies (P=0.65); no statistical significance was noted in qualitative and localization diagnosis of metal and non-metal foreign bodies for both CT scan and B-ultrasound (P>0.05), shown in Table 4.

Table 4 Diagnostic outcomes of metal and non-metal foreign bodies by three imaging examination tools (unit: eye)

	Accuracy of qualitative diagnosis			Accuracy of localization diagnosis		
	X-ray	CT	B-scan	X-ray	CT	B-scan
Metal	90.9%	72.7%	72.7%	73.3%	95.8%	84.6%
Non-metal	29.4%	82.4%	76.5%	80%	92.9%	76.9%
P	<0.001	0.45	0.96	0.65	0.69	0.21

Discussion

The clinical characteristics of patients with ocular foreign bodies admitted to Zhongshan Ophthalmic Center between August 2007 and October 2011 were retrospectively analyzed in this study. These subjects were suspected to have ocular foreign bodies at first presentation, and 75.8 of them were finally diagnosed with ocular foreign bodies. Metal particles easily lodge in the eyes of young migrants while thrashing metals, accounting for approximately 66% of all cases with ocular foreign bodies. Half of cases with ocular foreign bodies were intraocular foreign bodies, which is consistent with the findings of relevant epidemiological studies[1]. In addition to subjects with a history of penetrating ocular injuries and ocular foreign bodies, the patients presenting with repeated onset of uveitis, unique eye cataracts, ocular siderosis, or single eye vitreous opacity, and especially young males aged below 40 years, were advised to undergo further eye imaging examinations to confirm the possibility of ocular foreign bodies[2].

The sensitivities of X-ray, CT scan, and B-ultrasound were all<65% for qualitatively diagnosing ocular foreign bodies, mainly because these three imaging tools differ in their imaging features of foreign bodies with various properties and sizes[3,4]. X-ray radiographs show the overlapping images of skull bone and soft tissues, thus they cannot represent foreign objects that absorb X-rays or those small particles that stop X-rays[5]. For eye CT scan, a 3-10 mm slice gap exists between layers; this makes it difficult to represent foreign bodies located between layers, small wooden objects, or low-density non-metal bodies, or to distinguish them from proliferative ocular tissues[6]. B-ultrasound yields low-resolution images in near field and is likely to miss the diagnosis of foreign bodies in anterior segment and anterior orbit. In addition, it poorly represents the foreign bodies located deep in the orbit due to beam attenuation and detection depth.

The presence of ocular foreign bodies, especially intraocular foreign bodies, is a vital risk factor of the prognosis of endophthalmitis and poor visual acuity[7,8]. Therefore, enhancing the sensitivity of radiographic identification of ocular foreign bodies and reducing missed diagnosis are of significance for improving the prognosis of eye trauma. A parallel combination of any two methods can increase diagnostic sensitivity but decrease diagnostic specificity.

The results confirmed that X-ray has 100% specificity in identifying ocular foreign bodies, and main-

tains a relatively high specificity in conjunction with B-ultrasound or CT scan, which is consistent with the findings of previous investigations[9]. Precise localization of ocular foreign bodies provides evidence for foreign object extraction and surgical designs[10,11]. Additionally, for the patients finally diagnosed with ocular foreign bodies, CT scan shows the highest accuracy of locating foreign bodies (94.7%) among three radiographic examinations. CT scan yields a slice scanning of whole orbital tissues and explicitly represents eye ring, thereby determining the relationship between foreign bodies and eyeball ball. CT scan data can be utilized for preliminary evaluation of the properties of foreign objects, for precise measurement of the size[12], and to provide more evidence for surgically extraction of foreign bodies.

Previous studies suggested that CT scan in conjunction with X-ray can enhance the diagnostic outcomes of ocular foreign body removal[13]. In this study, CT scan combined with X-ray has a sensitivity of 87.4% and specificity up to 75%. In this study, two cases of intraocular foreign bodies were misdiagnosed as eyeball wall foreign bodies. It was surgically confirmed that they were metal foreign objects, with a diameter of 4 to 5 mm, surrounded by evident radial pattern artifacts. Therefore, misdiagnosis is likely due to the overlapping of foreign body shadows and the eye ring.

This study suggested that X-ray has a accuracy of 29.4% in the qualitative diagnosis of non-metal foreign bodies, whereas CT scan and B-ultrasound are not affected by metal properties in terms of qualitative and localization diagnosis. Although X-ray is inferior to CT scan and B-ultrasound in determining the relationship between foreign bodies and the eyeball wall, X-ray is inexpensive, easy to operate, and can be widely applied. Moreover, X-ray is highly specific in identifying ocular foreign bodies (specificity=100%), so X-ray can serve as a screening diagnosis for ocular foreign bodies. When X-ray yields negative results, while clinical eye examination indicates the possibility of positive outcomes, X-ray should be combined with CT scan or B-ultrasound to further identify and localize the ocular foreign bodies.

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