

Detection of Retinal Affection among Arc Welders Using Optical Coherence Tomography

BY

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Abstract

Introduction: Arc welders are at high risk for developing phototoxic maculopathy, as diagnosed by using Optical Coherence Tomography (OCT), which describes some structural changes in the fovea of welders with maculopathy, as disruption of the inner high reflective layer corresponding to the outer neurosensory retina. **Aim of work:** To evaluate the use of Optical Coherence Tomography (OCT) as a method for monitoring workers involved in arc welding for early detection of any retinal damage. **Materials and methods:** The study included 66 exposed workers in an automobile factory in Helwan, Cairo. A matched group of 66 control subjects were included from administrative workers in the same factory. Diabetic and hypertensive were excluded from both groups. The studied groups were subjected to full history taking including occupational history, clinical eye examination, fundus examination using ophthalmoscope, Best Corrected Visual Acuity testing (BCVA) and Optical Coherence Tomography testing. **Results:** All exposed workers reported using welding goggles or face shield during welding. Diminution of vision and manifestations of photo-kerato-conjunctivitis were significantly more prevalent among exposed group compared to the controls. Best Corrected Visual Acuity (BCVA) was significantly lower among the exposed group with significant negative correlation between BCVA and duration of exposure. Fundus ophthalmoscopic examination of the exposed group revealed yellowish spots of the macula and fovea. OCT findings among the exposed workers included mainly macular edema, inner/outer segment disruption of the retinal pigment epithelium and macular thinning. **Conclusion:** OCT is useful in the diagnosis of welders' maculopathy. Using welding goggles and face shield might not provide enough protection against welders' maculopathy.

Keywords: Welding, Maculopathy, Macular edema, Retinal pigment epithelium disruption and Optical Coherence Tomography.

Introduction

Welding is a fabrication process that joins materials, usually metals, by causing coalescence. This is often done by melting the work pieces and adding a filler material to form a pool of molten material that cools to become a strong joint, with pressure sometimes used in conjunction with heat to produce the weld (Syed et al., 2010).

There are approximately 60 different welding processes. The two major types of welding are: shielded metal arc and gas (oxyacetylene) welding (Meo and Al-Khlaiwi, 2003), both of them are associated with adverse health effects from chemical and physical agents (Antonini, 2003).

A welding arc emits a wide spectrum of radiation, from IR (Infra red) to UV (Ultra violet), visible light and beyond. The cornea and the lens absorb UV and far-IR radiation, whereas visible light (VL) and near-IR radiation penetrates to the retina (Mahindrakar et al, 2013).

Arc welders are at high-risk for developing phototoxic maculopathy, as diagnosed by using Optical Coherence Tomography (OCT) (Li and Zhang, 2014).

The damage to the retina from welding arc units comes from the visible light especially the 400-440 nm range and from the potential 300-310 nm “window” which may penetrate the cornea and the crystalline lens causing welder’s maculopathy (Mainster et al, 2006).

Unprotected and prolonged exposure to ultraviolet (UV) light from arc welding lead to outer retinal damage. The photoreceptors and retinal pigment epithelium located in the posterior pole are particularly susceptible to this radiation (Begai and Schaal, 2018).

Previous publications have used OCT to describe these structural changes at the fovea in welder’s maculopathy, reciting it as disruption of the inner high reflective layer (HRL) corresponding to the outer neurosensory retina. However with the advent of high resolution OCT imaging, we have now better ability to visualize and stratify the outer retinal layers (Lucas et al, 2007).

Fundus photography corresponding to the areas of disruption of the Inner segment/Outer segment junction of the retinal pigment epithelium (RPE) on the OCT scans, usually reveals a small, round, or oval, dark-yellow macular lesion with an obscure boundary (Yung et al, 2012).

Aim of work

To evaluate the use of Optical Coherence Tomography (OCT) as a method for monitoring workers involved in arc welding for early detection of any retinal damage.

Materials and methods

Study design: This study is an observational comparative cross-sectional analytical study.

Place and duration of the study: This study was done in a plant for automobile manufacture in Helwan, Cairo. It was done along 3 months from August to October 2018.

Study sample: The study included an exposed and a non-exposed groups. The exposed group included all workers involved in arc welding in the factory who met the inclusion criteria. They were 66 male workers after excluding subjects with any of the exclusion criteria. The non-exposed group included 66 administrative workers in the same factory after excluding subjects having any of the exclusion criteria.

Inclusion criteria: Exposed workers should have been involved in welding for at least one year. Control group

included administrative workers with matching age, and smoking habits, who had never worked in welding. Exclusion criteria: Subjects with history of eye injuries, eye diseases, diabetic and hypertensive were excluded from both groups.

Study methods: The study groups were subjected to the following:

1-Full medical history: This included personal, present, past, family and occupational history, face to face interview included questions on a variety of ophthalmological symptoms, chronic conditions, medication use and smoking habits.

2-Clinical examination: All subjects were assessed clinically to detect any eye diseases.

Visual Acuity: All subjects were tested for Best Corrected Visual Acuity testing (BCVA).

Fundus Examination: All subjects were examined using direct ophthalmoscope.

Optical Coherence Tomography (OCT): Retinal examination was done using 3D OCT-1 Maestro device provided by Topcon Medical Systems, Inc. (www.Topconmedical.com).

Consent

An informed verbal consent was taken from subjects who agreed to participate in the study before the start of work with assurance of confidentiality and anonymity of data.

Ethical approval

Approval of the administrative authority of the factory was obtained. The study protocol was approved by the Ethical Committee of the Department of Occupational and Environmental Medicine, Faculty of Medicine, Cairo University (N=162-2018).

Data management

Data were analyzed using Statistical Package for Social Science version 17 (SPSS 17). The mean values and standard deviation (SD) were estimated for the quantitative variables, while the qualitative variables were presented as numbers and percentages. Comparisons between the exposed and control groups were done using Chi Square test for qualitative variables and independent samples t- test. P values less than 0.05 ($p < 0.05$) were considered statistically significant, and less than 0.001 ($p < 0.001$) were considered highly statistically significant.

Results

Table (1): Eye manifestations of the studied groups.

Eye manifestations	Exposed group No =66		Control group No =66		X ²	p value
	No	%	No	%		
Diminution of vision	20	30%	3	4.5	16.5	<0.001**
Lacrimation	11	16%	0	0	13.20	<0.001**
Burning sensation	9	13.6%	2	3	5.98	<0.05*
Foreign body sensation	6	9.0%	0	0	3.77	<0.05*
Blurring of vision	8	12%	1	1.5	5.84	<0.05*
Redness	5	7.5%	0	0	5.23	<0.05*
Dry eye	2	3%	0	0	2.03	>0.05
Musca Volitans	2	3%	1	1.5	0.34	>0.05
Cataract extraction	2	3%	0	0	2.03	>0.05
Glaucoma	1	1.5%	0	0	1.08	>0.05
One eye loss of vision	1	1.5%	0	0	1.08	>0.05

*Statistically significant

**Highly statistically significant

Table (2): Mean and SD of visual acuity among the studied groups.

Items	Exposed group No =66	Control group No =66	t	p value
Right eye	0.51±0.26	0.86± 0.16	6.48	<0.001**
Left eye	0.41± 0.27	0.78± 0.14	6.94	<0.001**

**Highly statistically significant

Table (2) shows that visual acuity among exposed group is markedly reduced with a highly statistically significant difference ($p < 0.001$) compared to the control group in both eyes.

Table (3): Correlation between the duration of exposure to arc welding and the best corrected visual acuity (BCVA) among the exposed group.

Parameters	r	p value
Right eye	-0.74	<0.001**
Left eye	-0.83	<0.001**

**Highly statistically significant

Table (3) shows that there is a highly significant negative correlation between the duration of exposure to arc welding and the BCVA of both eyes among the exposed group.

Table (4): Fundus examination findings among the exposed group

Findings	No	%
Normal fundus	37	56%
Yellowish macular spots	23	34.8%
Yellowish-white foveal spots	5	7.6%
Retinal detachment in one eye	1	1.5%

Table (4) shows that yellowish macular spots are the most common abnormal finding of fundus examination among the exposed group, followed by yellowish-white foveal spots, and one case of retinal detachment in one eye.

Table (5): Optical Coherence Tomography (OCT) results among the exposed group.

Findings	No	%
Normal OCT	6	9%
Peripheral macular edema with inner/outer segment retinal pigment epithelium disruption	13	19.6%
Central macular thinning	12	18.1%
Peripheral macular edema	11	16.6%
Peripheral macular edema with perifoveal and parafoveal edema	9	13.6%
Central macular thinning with inner/outer segment retinal pigment epithelium disruption	9	13.6%
Central macular and parafoveal thinning	3	4.5%
Parafoveal thinning	2	3%
Unilateral retinal detachment	1	1.5%

Table (5) shows that the most common abnormal OCT findings among the exposed group are peripheral macular edema with inner/outer segment disruption of the retinal pigment epithelium (RPE), followed by central macular thinning, then peripheral macular edema without and with perifoveal and parafoveal edema, with the latter having the same prevalence as central macular thinning with inner/outer segment disruption of RPE. Other less common findings included central macular and parafoveal thinning, parafoveal thinning and one case of unilateral retinal detachment.

Discussion

Although welding induced retinal injury is rare, welders still have a risk of developing phototoxic maculopathy (Pabley and Keeney, 1984).

This study aimed at evaluating the use of Optical Coherence Tomography (OCT) as a method for monitoring retinal affection among arc welders. The exposed group included 66 male welders in automobile manufacture plant in Helwan, Cairo, with a mean duration of exposure 30.71 ± 10.41 years. The non-exposed group included 66 administrative workers in the same factory who had never worked in welding. All participants were subjected to full history taking, clinical eye examination, testing of Best Corrected Visual Acuity (BCVA), fundus examination and Optical Coherence Tomography (OCT).

The control group was matched with the exposed group as regards age and special habits of medical importance. Both groups did not include diabetic or hypertensive. Mean age of the exposed group was 51.27 ± 8.23 years old, while mean age of the control group was 54.43 ± 8.81 years old, with no statistically significant difference between both groups.

All exposed workers confirmed using protective equipment in the form of goggles or face shield all the time during the process of welding.

Diminution of vision was more prevalent among the exposed group compared to the control group with a highly statistically significant difference (Table 1). Best Corrected Visual Acuity (BCVA) among the exposed group was 0.51 ± 0.26 for the right eye and 0.41 ± 0.27 for the left eye, which were highly statistically significantly lower than the control group (Table 2).

This was in agreement with the cases report discussed by Vedantham (2006) and Bonyadi (2013). Both of them reported diminution of vision among their cases who worked as welders. They detected that BCVA of their cases was 0.5 each. This diminution of vision was explained by macular degeneration in both studies.

Moreover, a highly significant negative correlation was found between duration of exposure and BCVA (Table 3). This was also consistent with the case reported by Kim et al (2007), who described a case of macular degeneration in an individual with nearly 20 years of employment as an arc welder. The worker was diagnosed as having macular edema and decreased

visual acuity, with no history of diabetes or hypertension. He continued working as a welder for five years later, during which his vision deteriorated and was diagnosed as maculopathy and neovascularization.

The current study revealed that photo-keratoconjunctivitis, manifested by lacrimation, foreign body sensation, burning sensation, blurring of vision and redness of the eye, was the second most common manifestation among the exposed workers and was significantly more prevalent among the exposed group compared to their controls (Table 1). This was similar to the results declared by Davies et al. (2007), who studied ocular effects of chronic exposure to welding light and found that keratoconjunctivitis was significantly more common among exposed workers compared to their controls.

This was also consistent with the results obtained by Syed et al., 2010, who studied welding associated ocular injuries and found that bilateral photo-keratoconjunctivitis was the second most common finding among the exposed workers due to smoke and irritant gases from welding rod materials.

The current study revealed that yellowish macular spots were the most common abnormal findings of the

fundus among the exposed workers, followed by yellowish white foveal spots (Table 4). This confirmed the results obtained by Lucas et al (2007), who studied Optical Coherence Tomography findings among welders' maculopathy, and found yellowish foveal spots in the fundus examination of their case series.

It was also in agreement with the findings described by Vedantham (2006) in his case report. He stated that a reddish-yellow cystic lesion was found at the level of the retinal pigment epithelium (RPE) in both eyes.

Magnavita (2002) also found a circular bright-yellow foveal oedematous lesion in both eyes of a 45 years old male who has been working as a welder for more than 25 years.

Tsang (2007) and Bonyadi (2013) detected some pigmentary foveal changes and discoloration of the macula on examination of the fundus of their case reports of welder's maculopathy.

Optical Coherence Tomography of the exposed workers in the current study revealed that macular edema was the most common finding, followed by central retinal thinning. Inner/outer segment disruption of the retinal pigment epithelium (RPE) was also one of the common features in the exposed workers' OCT (Table 5). This was

consistent with the results obtained by Vedantham (2006), Lucas et al. (2007), Tsang (2007) and Bonyadi (2013). All of them reported the presence of inner/outer segment disruption of RPE as the main finding of OCT among welders. Also Macular edema has been found in cases with relatively mild welder's maculopathy (Magnavita, 2002).

In our study in spite of the fact of using personal protective equipment (goggles and face shield) during welding processes as reported by all studied workers, still there are detected cases of welder's maculopathy that might be explained by improper type of the used safety goggles or face shields.

Conclusion

In conclusion, using Optical Coherence Tomography (OCT) together with visual acuity and fundus examination can be used in periodic monitoring, among welders for early detection of chronic welder's maculopathy. The use of proper personal protective equipment (goggles and face shield) during welding process is very important for protection against welder's maculopathy.

Conflict of interest

Authors have declared that no conflict of interest exists.

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