Abstract

A 34-year-old Asian-Indian male presented with a history of sustaining electrical injury with a high-tension wire 10 years ago following which his right arm was amputated. He also gave a history of progressive shrinkage of the right eyeball since then. The right eye showed a deep superior sulcus with an enophthalmos of 6 mm. The rest of the ocular examination was within the normal limits. Various opthalmic complications have been reported after electrical injuries, cataracts being the most common. Enophthalmos without any intraocular changes has not been reported after electrical injury.

Keywords: Electrical injury, electroporation, enophthalmos, high voltage

Introduction

Electrical injuries are associated with high morbidity and mortality. Most electrical injuries are accidental, either due to lightning or in domestic/occupational background. However, suicidal attempts by electrocution have also been reported. Ocular complications due to electrical shocks are varied. We report the case of high-voltage electrical injury presenting as enophthalmos without any damage to other intraocular structures.

Case Report

A 34-year-old male presented with complaints of progressive shrinkage of his right eyeball after sustaining an electrical injury with a high-tension wire 10 years ago. His right arm was amputated at that time. Systemic examination showed an amputated right arm, with scar marks on the left arm and leg. The best-corrected visual acuity was 6/6; N6 in both the eyes. Ophthalmic examination showed a right deep superior sulcus with right enophthalmos of 6 mm on Hertel's exophthalmometry [Figure 1]. Ocular movements were full. The anterior segment and fundus examination were within the normal limits. Computerized tomography (CT) scans of the orbits showed an ill-defined soft-tissue lesion along the right medial and inferior orbit with mild enlargement of the right inferior and medial recti [Figure 2]. There was no evidence of any orbital fracture. He was given the option of cosmetic correction of the enophthalmos with injection of hydroxyapatite gel fillers or autologous fat graft injection which he refused.

Discussion

Electrical injuries can be broadly divided depending on the voltage of the electricity as low voltage (<1000 V), high voltage (>1000 V), and lightning injuries (extremely high voltage for a very short duration).[1]

Electricity induces tissue damage by three major mechanisms:

1. Direct tissue damage, cell membrane resting potential alterations (electroporation), and eliciting muscle tetany
2. Conversion of electrical energy into thermal energy, causing massive tissue destruction and coagulative necrosis. (joule heating)
3. Mechanical injury with direct trauma resulting from falls or violent muscle contraction.[2]

The following several factors determine the severity and the extent of tissue damage in electrical injuries: the type (alternating or direct), amount (high or low voltage),...
duration, pathway of current, the area of contact, and the resistance of the body part in contact with the current. The duration of contact is probably the most important determinant for the severity of the injuries.\textsuperscript{[1]} Nerves are very good conductors since they are designed to carry electrical signals. So are muscles and blood vessels because of their high electrolyte and water content. On the other hand, bone, tendon, and fat have a very high resistance, due to which they heat up and undergo thermal damage. With high-voltage injuries, most of the injuries appear to be thermal, and most histological studies reveal coagulation necrosis, consistent with thermal damage.\textsuperscript{[3]} High-voltage shocks can be responsible for severe injuries, leading to major amputations due to progressive myonecrosis and irreversible ischemia.\textsuperscript{[4]}

High-voltage current can overcome the resistance offered by the body tissues and can flow through the tissues indiscriminately. Consequently, we can find damage to structures at sites distant from the apparent contact and ground points, like in our patient who showed evidence of damage to his left hand, left leg, and right orbit.\textsuperscript{[5,6]}

The ocular electrical injuries usually are due to the cephalic region being the point of entry or exit of the electric current but can be involved in high tension injuries irrespective of the point of contact. Cataract is the most common ocular complication; the incidence ranging from 6\% to 10\%, and it can develop following contact with electrical voltage between 200 and 60,000 V. These cataracts usually develop within 1–18 months but may develop even 11 years following the electric injury.\textsuperscript{[7]} Adnexal involvement due to electrical injuries can be in the form of superficial burns, eyelid edema, or massive necrosis of the lid and adnexal tissues.\textsuperscript{[1]}

Posttraumatic enophthalmos with associated superior sulcus deformity occurs when there is a discrepancy between the volume of the orbital contents and the size of the orbital cavity.\textsuperscript{[8]} Enophthalmos may develop after orbital fractures, orbital fat necrosis and atrophy, tethering of orbital tissues due to scar contracture, and or entrapment or fibrosis of the extraocular muscles.\textsuperscript{[9,10]} The soft-tissue density seen on the CT scans of our patient was the subsequent fibrosis of the extraocular muscles and orbital tissues following the electrical injury. The enophthalmos and superior sulcus deformity in our patient were probably due to orbital fat atrophy and the fibrosis as CT orbits did not reveal any orbital fracture.

The treatment of posttraumatic enophthalmos without associated orbital fracture can be achieved using autologous bone, cartilage, or fat graft. Alloplastic materials in the form of hydroxyapatite implants, silicone blocks, porous polyethylene sheets and wedge implants, composites of titanium mesh with porous polyethylene sheets, or hyaluronic acid fillers can be used as well. Although autogenous bone and cartilage have good survival, they are hard and nonpliable hence are not utilized widely.\textsuperscript{[11]}

Dermal fat grafts are pliable with no risk of rejection but have unpredictable resorption rates, along with risk of fat necrosis so the final correction is difficult to predict. Autologous fat graft injection into the orbit and upper lid for the correction of traumatic enophthalmos and deep superior sulcus in seeing eyes were studied by Chen et al. reporting satisfactory results.\textsuperscript{[12]} Calcium hydroxyapatite fillers in gel form have been used for in anophthalmic globes, but anterior migration of the filler has been reported.\textsuperscript{[13]}

Our patient was given the option of either injection of hydroxyapatite gel fillers or autologous fat graft for the correction of his enophthalmos and superior sulcus deformity. However, he declined any further intervention.

Enophthalmos due to electrical injury has not been reported in literature. The entry point in our patient was the right arm which was amputated due to irreversible necrosis. The presence of enophthalmos suggests that the electricity might have traveled through the right orbit, and due to the resistance of orbital bones, fat and extraocular muscles produced thermal damage with fat necrosis and atrophy resulting in enophthalmos. Nevertheless, what is unique about this case is the presence of enophthalmos alone without any other evidence of intraocular injury.
Electrical injuries can have deleterious consequences. The prevention of such injuries is undoubtedly preferable than any treatment. Ocular complications from electrical burn injuries are uncommon. Enophthalmos can be a presenting feature of remote electrical injury and can manifest without any intraocular changes. However, these patients can develop late visually impairing intraocular sequelae such as cataracts even years after a severe electrical burn injury. Thus, meticulous follow-up is mandatory in these patients.

Declaration of patient consent
The authors certify that they have obtained all appropriate patient consent forms. In the form the patient(s) has/have given his/her/their consent for his/her/their images and other clinical information to be reported in the journal. The patients understand that their names and initials will not be published and due efforts will be made to conceal their identity, but anonymity cannot be guaranteed.

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Nil.

Conflicts of interest
There are no conflicts of interest.

REFERENCES
1. Bah VG. Electric injuries. Ophthalmologica 1969;158:109-17.
2. Ungureanu M. Electrocutations-treatment strategy (case presentation). J Med Life 2014;7:623-6.
3. Hunt JL, McManus WF, Haney WP, Pruitt BA Jr. Vascular lesions in acute electric injuries. J Trauma 1974;14:461-73.
4. Huei TJ, Mohd Yussof SJ, Lip HT, Salina I. Case report of a high voltage electrical injury and review of the indications for early fasciotomy in limb salvage of an electrically injured limb. Ann Burns Fire Disasters 2017;30:150-3.
5. Lee RC, Zhang D, Hannig J. Biophysical injury mechanisms in electrical shock trauma. Annu Rev Biomed Eng 2000;2:477-509.
6. Lee RC. Injury by electrical forces: Pathophysiology, manifestations, and therapy. Curr Probl Surg 1997;34:677-764.
7. Skoog T. Electrical injuries. J Trauma 1970;10:816-30.
8. Lang W. Traumatic enophthalmos with retention of perfect acuity of vision. Trans Ophthalmol Soc UK 1889;6:41-5.
9. Resnick JJ, Kawamoto HK Jr. Facial fractures. In: Habal MB, Arlyan S, editors. Traumatic Enophthalmos. Philadelphia, PA: BC Decker Inc.; 1989. p. 155-69.
10. Clauser L, Galie M, Pagliaro F, Tieghi R. Post-traumatic enophthalmos: Etiology, principles of reconstruction, and correction. J Craniofac Surg 2008;19:351-9.
11. Nishi Y, Kiyokawa K, Watanabe K, Rikimaru H, Yamauchi T. A surgical treatment of severe late posttraumatic enophthalmos using sliced costal cartilage chip grafts. J Craniofac Surg 2006;17:673-9.
12. Chen H, Zhang Q, Qiu Q, Yang Z. Autologous fat graft for the treatment of sighted posttraumatic enophthalmos and sunken upper eyelid. Ophthalmic Plast Reconstr Surg 2018;34:381-6.
13. Buchanan AG, Holds JB, Vagefi MR, Bidar M, McCann JD, Anderson RL. Anterior filler displacement following injection of calcium hydroxylapatite gel (radiesse) for anophthalmic orbital volume augmentation. Ophthalmic Plast Reconstr Surg 2012;28:335-7.

Figure 2: Coronal sections of computed tomography orbits showing ill-defined soft-tissue lesion along the right medial and inferior orbit with mild enlargement of the right inferior and medial recti muscles