Aerial drone misadventure: A novel case of trauma resulting in ocular globe rupture

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\begin{abstract}
Purpose: The purpose of this case report is to present the novel findings of a drone causing such a traumatic ocular injury and provide recommendations for how it might be prevented.

Observations: We report on a recent case where a child presented to our Emergency Department after incurring a blow to the face by the propeller of a remote controlled drone. The patient suffered significant trauma including rupture of the right globe.

Conclusions: As drone sales continue to rise, it is important that physicians be prepared to treat the potential injuries that may result from using these devices. Furthermore, in an attempt to reduce the number of visits associated with remote controlled drones, physicians should be prepared to provide advice as to how patients can reduce the risks of injury.

Importance: We hope that the framework and recommendations below will help physicians decrease adverse outcomes related to this unusual injury pattern.
\end{abstract}

\section{1. Introduction}
Over the past year, the Federal Aviation Administration estimates that over 2.5 million drones have been sold and this number is expected to triple over the next few years.\textsuperscript{1} Many of these unmanned aircraft can travel up to 100 miles per hour (MPH)—and as such can deliver a significant force, strong enough to inflict serious bodily harm. Previous research has demonstrated that a 500-g drone traveling between 17 and 37 MPH can create forces between 14 and 69 J; which in cadaveric studies is significant enough to fracture the human skull.\textsuperscript{2} The rapid proliferation of inexpensive models has made these devices more readily available to consumers. As their use continues to become more prevalent, it seems inevitable that injuries from these devices are likely to rise as well. Our chart review demonstrated a dearth of reported cases in the literature relating to drone-related injuries. A single case of skull fracture following drone impact was reported earlier this year,\textsuperscript{3} however, there have been no reported cases of injuries to the face and/or eye as a result of drone aircraft reported to date. This article reviews the clinical presentation, implications, and management of facial trauma as a result of injury from a drone.

\section{2. Case report}
A nine year-old male presented to our Emergency Department (ED) after he was accidentally struck in the face by a drone propeller he was flying with his father. They lost control of the equipment, and he sustained lacerations to the right orbital region, left ear, nasal bridge and left lateral neck. The patient was brought to the ED by emergency medical service (EMS) who applied loose bandages over the bleeding areas. The patient denied loss of consciousness. Primary survey was intact. His vital signs were within normal limits taking into account his age. The patient complained of significant right periorbital pain. Secondary survey demonstrated a laceration to the right periorbital region. Examination revealed 20/20 visual acuity in the left eye with significant right-sided hemianopsia on the contralateral eye. Fundoscopic exam of the right eye revealed anterior chamber hyphema and neither the iris nor pupil could be visualized. There was partial avulsion of the right upper eyelid involving the margin that traverses superiorly and laterally forming an acute triangular tag of tissue that was attached at the base in the central upper lid. Additionally, a full thickness corneal laceration was present that traveled horizontally through the superior cornea (Fig. 1). No peripheral retinal findings...
were appreciated. Visualization of the orbit was difficult on exam due
to pain with retraction of the eyelid as well as blood.

A non-contrast CT demonstrated a ruptured right globe with sig-
nificant soft tissue swelling anterior to the right globe. No fractures of
the facial bones were visualized.

The patient was transferred to a pediatric trauma center for urgent
ocularoplast repair to close the globe as well as to prevent permanent
deformity of the margin and levator. Intraoperative findings included
ruptured globe with a 10mm corneal laceration and 11mm scleral la-
ceration temporally. The limbus was re-approximated with interrupted
9–0 nylon sutures. Subsequently, the corneal wound was re-
approximated with interrupted 10–0 nylon sutures. Thereafter, the
scleral laceration was further explored. Exposed uveal tissue was re-
moved. Interrupted 8–0 nylon sutures were then used to close the
scleral wound. Margin of the eyelid was closed with 6–0 vicryl sutures
and superficial lid laceration was closed with 6–0 plain gut sutures.
Patient was discharged home the next day.

Over the next few months the patient showed signi-
ificant improvement in his vision. He currently can differentiate shapes and faces, but
still has difficulty with finer focus. He has followed up with his
ophthalmologist closely. Six months after his injury, he underwent a
repeat examination under anesthesia and corneal suture removal.
Following his EUA, his vision was noted to be improved. At his most
recent follow-up examination, visual acuity was 20/400 with a +10
spherical equivalent and partial superior temporal visual
field deficit. There was no evidence of any traumatic cataract or an APD
at last follow up.

3. Discussion

The diagnosis of open globe injuries is typically made by visual
inspection of the eye, which often depicts obvious signs of a ruptured
globe. Classical findings that are highly suggestive of a globe rupture
include: eccentric/teardrop pupil, extrusion of vitreous humor, external
prolapse of the uvea, cornea or scleral tenting, and volume loss of the
eye. If the eye injury is more subtle, a Seidel test can be performed. This
test utilizes Fluorescin dye to identify either post-traumatic or post-
operative leaks from the cornea, sclera, or conjunctiva under a slit lamp
examination. A positive Seidel sign will help in diagnosing a globe in-
jury. Lastly, a peaked pupil with tissue prolapse through a sclera and/or
corneal wound is highly suggestive of a globe injury.\(^1\)

Once the diagnosis of an open globe has been made or when there is
high clinical suspicion, then certain precautions should be taken and an
ophthalmologic consultation is indicated. Until formal consultation is
obtained, no drops should be placed into the eye and a hard eye shield
should be used to cover the eye.\(^3\) Antiemetics and analgesics should be
employed as needed to control pain and nausea respectively, but also as
a means to prevent an increase in pressure from crying and Valsalva.
Lastly, it is recommended that prophylactic antibiotics be given to help
prevent post-operative endophthalmitis.\(^5\)

As drone sales continue to rise in the coming years, it is likely that
there will be an associated increase in the number of Emergency Room
visits secondary to these devices. As has been demonstrated by this
report, drone accidents involving the eye can easily cause devastating
injuries that place patients at risk for ophthalmologic emergencies
among other emergent treatment. It is necessary that emergency room
physicians and trauma surgeons be prepared for such mechanisms of
injury so that they can assess such patients in a timely and efficient
manner.

From a public health perspective, we felt that it is essential to pre-
sent this case report to warn the public of the dangers associated with
operating a remote controlled drone and to provide suggestions to help
prevent injury. The first recommendation to prevent future traumatic
injuries to the eye would be that anyone flying a drone should use
protective eyewear. The pilot of the drone would then be at a much
lower risk to incur damage both from a direct blow by the drone (or
propeller) as well as by flying debris. While a globe rupture appears to
be a rare outcome from trauma caused by aerial drones, lacerations are
a relatively common and can be equally dangerous. In recent articles,
there have been numerous lacerations caused by the propellers as a
result of their forced and sharp edges.\(^6\)\(^7\) Therefore, we also recommend
that individuals do not approach a drone until it has landed and the
propeller has come to a complete halt. Another means to aid in the
prevention of this type of injury would be the requirement of com-
pletely encasing the propellers in a protective screen—similar to
household fans. One group recommended adding bumpers, enclosed
rotors, and airbags to reduce the damage of a potential drone impact
and increase the safety of operating the drone.\(^8\) This would require
companies to acknowledge the risk that users encounter every time they
fly drones and a willingness to alter the design of future models. An-
other means by which injuries could be prevented would be to require
people to land their drone more than 100 feet away from individuals to
help prevent accidentally crashing the drones into individuals. Cur-
rently there are recommendations by the Academy of Model Aero-
nautics to maintain constant line of sight of aerial drones when flying
and to remain at least 25 feet away from individuals and vulnerable
property.\(^9\) The Federal Aviation Authority (FAA) has issued regulations
for commercial aircraft and has begun issuing regulations for the use
of drones by civilians.\(^10\)\(^11\) Specifically, flight over people is still explicitly
prohibited.\(^10\)\(^11\) We urge the FAA to educate civilians about the dangers
inherent in drone flight.

4. Conclusions

As drone sales continue to rise, it is important that physicians be
prepared to treat the potential injuries that may result from using these
devices. Furthermore, in an attempt to reduce the number of visits as-
associated with remote controlled drones, physicians should be prepared
to provide advice as to how patients can reduce the risks of injury. It is
our hope that some of the above framework will provide both physi-
cians as well as the drone industry with options to decrease these ad-
verse outcomes.

Patient consent

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Conflicts of interest

No conflicts of interest.

Authorship

All authors attest that they meet the current ICJME criteria for authorship.

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