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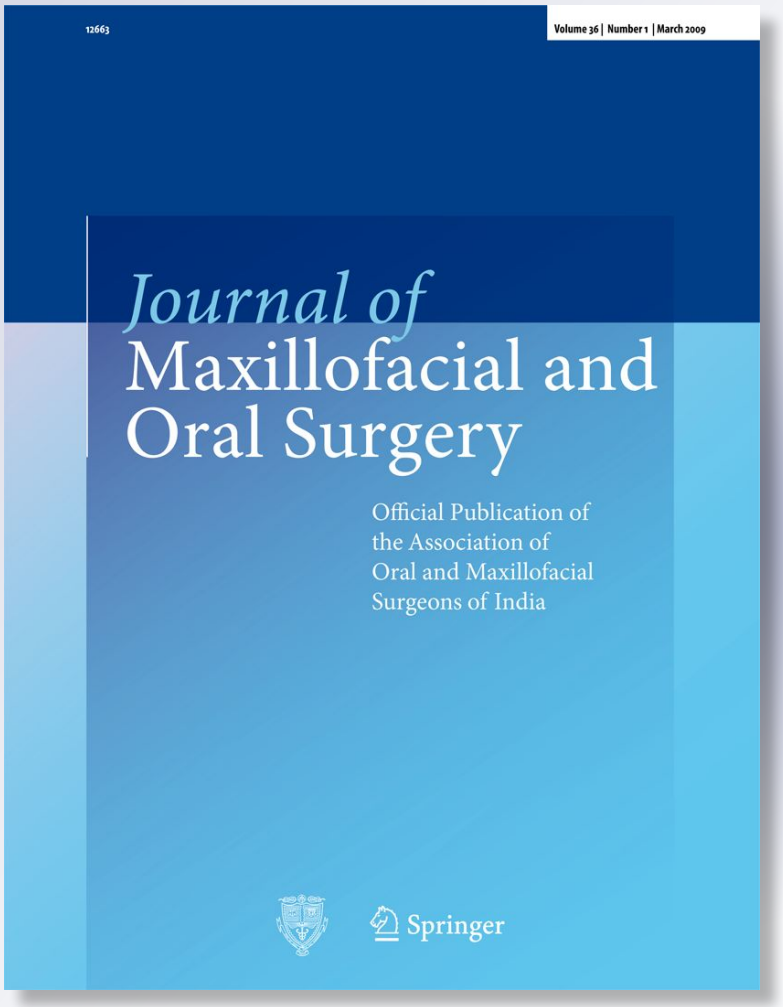

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CASE REPORT

Orbital Fracture in a Professional Diver: Issues and Management

Dennis Yu Kim Chua · Stephen Lo

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Abstract
Background We present a case report of a professional diver who sustained a fracture of the left orbital medial wall as well as floor exceeding 50% with orbital fat herniation blocking the maxillary sinus ostium. This may result in a closed cavity within the maxillary sinus that could potentially result in barotraumas during future diving. The aim of his surgery consists of repairing the orbital fracture and to aerating the sinus at the same sitting.
Method A transconjunctival approach was used combined with endoscopic sinus surgery approach to the maxillary sinus. The orbital floor fracture was repaired with a titanium plate. A wide middle meatal antrostomy was performed. A size eight Foley's catheter was inserted into the maxillary sinus and the balloon inflated to elevate and support the displaced inferior orbital floor bone fragment. The balloon was left in situ for 4 weeks to support the mobile inferior orbital fragment till adequate bone healing and stability.
Results Patient recovered well. At 3 months post-operatively, the maxillary antrostomy remained patent, and a hyperbaric oxygen challenge test was performed with success. A repeat orbital CT scan 1 day after hyperbaric challenge showed no signs of air leakage, and the bony inferior orbital floor fracture has healed completely with the titanium plate in situ.
Conclusion This is the first case report of repair of orbital floor fracture with simultaneous aeration of the maxillary sinus in a professional diver using a combined approach. The patient was able to resume his occupation as a professional diver following surgery.

Keywords Orbital fracture · Scuba diving · Sinus barotrauma

Introduction

Diving is a popular sport that is increasing in popularity. It is also a high risk sport which can result in various types of injuries. Nasal sinus barotraumas are the second most common site of barotraumas [1]. This occurs when there is a difference between the pressures of the nasal sinuses and hydrostatic pressure of the environment. Equalization of pressure between the cavities is crucial to the prevention of injuries. If a diver sustains an orbital wall fracture, this can result in a closed cavity within the nasal sinus that may potentially result in barotraumas to the nasal sinus during diving in future. Should there be a residual bony defect connecting the nasal sinus and orbit, the orbit may also be at risk, there has been a single case report in the literature that describes orbital fracture deterioration after scuba diving [2]. We present our experience in the repair of an orbital fracture in a professional diver and how we confirmed the safety of future dives via a hyperbaric oxygen chamber test before he resumed diving.

Methods

A 35-year-old Caucasian male who worked as a professional diver, presented to a tertiary institute after being punched on the left eye multiple times during an assault.

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Fig. 1 Pre-operative CT scan showing fracture of *left* inferior orbit

He complained of left eye pain and swelling. He was assessed by the ophthalmologist and was noted to have diplopia on left upper gaze. A Computed Tomographic (CT) scan of the orbits, showed a fracture of the inferior wall of the left orbit exceeding 50%, with the fracture fragment intruding into the left maxillary sinus. The orbital fat also herniated into the maxillary antrum blocking the ostium (Fig. 1).

There was also slight buckling of the left lamina papyracea (medial orbit wall) superiorly, but with no definite fracture line or blockage of anterior ethomoid sinus cells seen. No entrapment of either left medial or inferior rectus was noted.

In view of his occupation as a professional diver, he was planned for surgery that involved a combined approach (transconjunctival and endoscopic transnasal) to repair his orbital floor fracture and to aerate his maxillary sinus, with a view to prevent the potential complication of barotraumas to his maxillary sinus and orbit. The reduction of his lamina papyracea buckling was deemed unnecessary.

Operative Procedures

Endoscopic intra-nasal examination confirmed herniation of orbital content through the left maxillary ostium causing blockage. A left transconjunctival approach was employed to access the orbital floor fracture from above. The orbital contents were reduced, the fractured bone fragment elevated, and the floor was repaired by a titanium plate (Synthes). Endoscopic sinus surgery approach was then employed to create a wide middle meatal antrostomy. A size eight Foley's catheter was inserted via the antrostomy into the maxillary sinus and inflated with 7 ml of normal saline to prevent the unstable orbital floor fracture fragment from displacing inferiorly. The ballooned Foley's catheter was anchored with a silk suture to the nasal septum and left in situ for 4 weeks. This provided extra stability to maximise the chance of complete bone repair of the orbital floor defect. The patient was discharged on the next day with daily normal saline nasal irrigation and advised not to blow his nose.

Instituitional Board Review approval was obtained with appropriate patient consent prior to embarking on this project.

Results

Post-operatively, the patient recovered well and his diplopia resolved completely. At 3 months post-operatively, endoscopic nasal examination revealed a patent maxillary antrosomy with normal healthy sinus. He also underwent a Bounce Dive Test by immersion in a monoplace hyperbaric chamber at a maximum of 2 Absolute Atmospheric for 14 min. This is equivalent to a depth of 10 m below sea level and any problems in equalisation of pressure between the sinus and environment can be easily detected during this time. During this time he was perfectly asymptomatic with no opthalmological or sinus related symptoms. A repeat CT scan of the orbits performed at 1 day after hyperbaric challenge showed no signs of air leakage into the orbit under pressurised conditions, and the bony inferior orbital floor was continuous and intact with the titanium plate in situ (Fig. 2).

He subsequently resumed aggressive diving off the North coast of Borneo with no further complications at 4 months after his surgery.

Discussion

Diving is a popular risky sport that has the potential to result in serious injuries. Orbital fractures sustained can potentially worsen during diving especially if there is a closed cavity as a result of the fracture. Nakatani et al. [2] presented a case report of how orbital fracture deteriorated in a patient after diving. This patient was a 28-year-old

Fig. 2 Post-operative CT scan showing healed *left* orbital floor fracture with implant

female diagnosed with fractures of the orbital floor and medial wall with minimum bone displacement on CT scan, in the absence of symptoms or signs of eye complications. She scubadived 16 days after her initial injury, the patient experienced immediate epistaxis after she dived, and gradual worsening of her diplopia and enopthalmos a few weeks after her diving. Eventually a repeat CT scan at 3 months showed worsening of her orbital floor fracture. She was suspected to have edema of the maxillary sinus ostium that resulted in obstruction and converted the maxillary sinus into a closed cavity that resulted in the deterioration.

She had to undergo orbital floor repair with split thickness calvarial bone graft via a subciliary and gingivobuccal transmaxillary approach. She was found to have maxillary sinusitis intra-operatively. However, the maxillary sinus ostium that was obstructed thus resulting in the orbital fracture deterioration was not addressed, and the patient continued to complain of left cheek pain at 3 months after surgery with the CT scan showing persistent sinusitis. It was not described in their paper whether this patient continued diving, but the unaddressed maxillary sinus obstruction can potentially lead to problems with equalization of pressure between environmental and maxillary sinus pressure during episodes of diving in future.

In our patient, the floor of orbit fracture has obstructed the maxillary sinus ostium and resulted in the maxillary sinus becoming a closed cavity. In a rigid cavity such as the maxillary sinus, Boyle gas law relates pressure to volume changes. There are three main mechanisms of sinus barotraumas: squeezing, reverse squeezing and mixed [3]. Therefore, the pressure differential may result in displacement of the fracture fragments as well as surrounding vital structures such as orbital contents.

There is without doubt that the orbital floor fracture required fixation, firstly, to reduce and prevent worsening of prolapse of orbital contents into the maxillary sinus as the fragment involved more than 50% of the floor. Secondly, the herniated orbital contents were obstructing the maxillary sinus ostium, creating a closed air cavity next to the fractured orbit which may potentially result in barotrauma to the eye should the patient resume diving. Thirdly, an unrepaired bone defect in the orbit floor even in the presence of an aerated maxillary sinus may still cause barotraumas to the eye during diving.

Bolognini et al. [4] described a case of a breath holding diver with a well aerated maxillary sinus who sustained a barotraumatic orbital emphysema during a forced valsalva manoeuvre. The air was believed to have been forced into the orbit via pre-existing dehiscences in the lamina papyracea therefore resulting in orbital emphysema. In our case despite the mild fracture of the medial wall, the lamina papyracea was intact without defect and the ethmoid sinus was well aerated, and our conservative approach did not result in any adverse sequelae.

We subsequently proceeded to create a wide middle meatal antrostomy via a transnasal approach to ensure pressure equalization of the involved maxillary sinus and preventing a closed air cavity next to the orbit which has been weakened by fracture. The extra precaution of inserting a Foley's catheter to support the mobile large orbital floor bony fragment during its repair was to ensure maximal chance of complete bone healing. This was well tolerated by the patient, akin to a nasogastric tube in place but without the throat discomfort.

As this patient was a professional diver and would be exposed to frequent exposure to diving at great depths with high pressure within the involved maxillary sinus, we wanted to ascertain that the fracture fragments has healed and that the wide middle meatal antrostomy will allow ease of pressure equalisation between the maxillary sinus and environmental pressure. He underwent a Bounce Dive Test during which he was perfectly asymptomatic with no opthalmological or sinus related symptoms. He was then allowed to resume diving 4 months after injury when the fracture has healed with no sequelae.

Summary

We report a case of managing a professional diver with an orbital fracture with an obstructed maxillary sinus ostium. A wide middle meatal antrostomy was performed to prevent the risk of dive-related barotraumas of the involved sinus. The combination of a transantral balloon and orbital floor titanium plate minimise any chance of bone dehiscence. A confirmatory Bounce Dive Test was used to ascertain the success of this repair prior to the professional diver resuming his occupation.

Financial disclosures No financial disclosures with regards to this case report.

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