• Letter to the Editor •

Orbital compartment syndrome following the use of sinonasal oxidized cellulose and gelatin sponge hemostat: report of two cases and literature review

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Dear Editor,

Orbital compartment syndrome (OCS) is classified as an ophthalmic emergency, necessitating early diagnosis and immediate treatment to prevent irreversible damages to the vision and orbital structures[1]. It is usually associated with trauma, vascular lesions, and postoperative congestion. Oxidized regenerated cellulose (ORC) and gelatin sponges are commonly used hemostatic materials in surgical procedures for managing bleeding[2]. While they are generally regarded as safe, their application in the confined space of the orbit poses certain risks, especially due to their potential to expand and increase orbital pressure.

This study presents the clinical and radiological manifestations of two patients with thyroid orbital decompression and external dacryocystorhinostomy (DCR) who developed early postoperative OCS due to hemostatic materials.

CASE PRESENTATION

Ethical Approval This report followed the tenets of the Declaration of Helsinki, and informed consent was obtained from the patients. The ethic committee determined that their approval was not required for this study because it is a case report.

Case 1 A 67-year-old man presented with a 9-month history of Graves' disease. His current treatment regimen included methimazole (12.5 mg daily), mycophenolate mofetil (1000 mg daily), and atorvastatin (20 mg daily). The patient reported smoking 20 cigarettes daily and opium use three times per week. Three months prior, he had been treated with intravenous methylprednisolone (2 g total, administered as 0.5 g weekly for 4wk) for active thyroid eye disease (TED) at another medical center. His thyroid function tests were within normal limits at the time of this presentation. The patient reported bilateral eye pain at rest, tearing, and a burning sensation. Examination revealed a visual acuity (VA) of 20/70 on the right and 20/50 on the left side, color vision of 4/15 of both side, and negative relative afferent pupillary defect (RAPD), and generalized depression on perimetry with a mean deviation (MD) of -30 dB in each eye. Intraocular pressure measured 18 mm Hg bilaterally. Hertel exophthalmometry indicated 25 mm of proptosis in the right eye and 24 mm in the left. Extraocular motility was limited in supraduction and abduction bilaterally. Computed tomography (CT) imaging demonstrated significantly enlarged extraocular muscles and a crowded orbital apex in both orbits.

With a diagnosis of bilateral dysthyroid optic neuropathy, more severe on the right side, he (Figure 1A) underwent trans-medial, inferomedial, and lateral bone decompression following an unsuccessful intravenous steroid treatment. After ethmoidectomy and orbital bone opening, a significant bleeding was observed which could not be controlled with cauterization, sinus-nasal irrigation, and pressure. Therefore, four trimmed absorbable ORC sheets [3×3 cm each, about 0.8 g total (ChitoCell, ChitoTech, Eshtehrad, Iran)] and three hemostatic gelatin sponge cubes [1×1×1 cm each, about 1.5 g

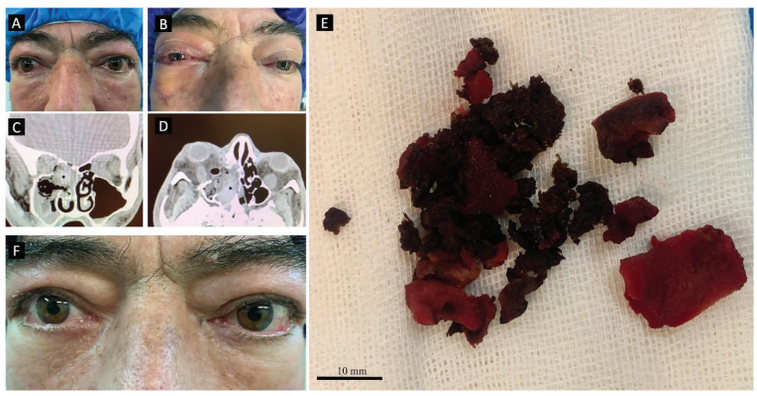

Figure 1 Orbital compartment syndrome in a patient after orbital decompression A 67-year-old patient before (A) thyroid orbital decompression and use of oxidized regenerated cellulose and gelatin sponges due to intraoperative bleeding. Development of orbital compartment syndrome (B) 10h after the procedure with a hyperdense intra-sinus lesion (asterisk) exerting compressive effects on the posterior orbital tissues on coronal (C) and axial (D) orbital CT scan. Patient was re-operated and expanded oxidized regenerated cellulose and gelatin sponges (E) were removed. In 3-week postoperative follow-up (F), the best corrected visual acuity was 20/70 with negative RAPD and 3-mm decreased proptosis. CT: Computed tomography; RAPD: Relative afferent pupillary defect.

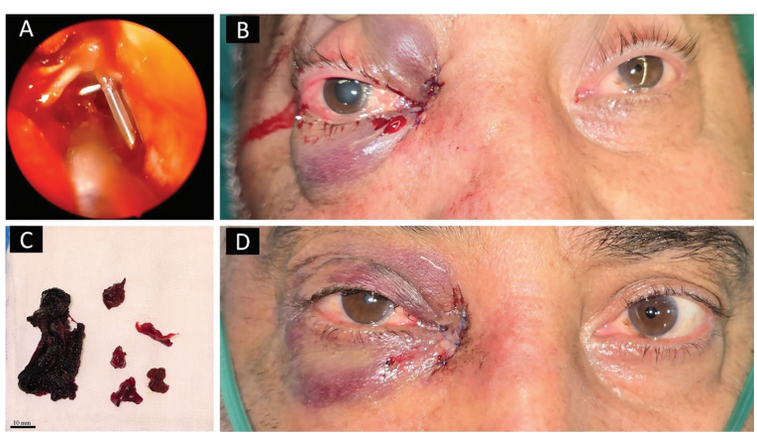

Figure 2 Orbital compartment syndrome in a patient after external dacryocystorhinostomy A 58-year-old patient with remained silicone tube (A) of a prior failed dacryocystorhinostomy (DCR) procedure who had revision external DCR procedure and use of oxidized regenerated cellulose and gelatin sponges due to intraoperative bleeding. He developed orbital compartment syndrome (B) 2h after the procedure, was re-operated and expanded oxidized regenerated cellulose and gelatin sponges (C) were removed, and had a full recovery on the postoperative day 1 (D).

total (CuraSpon, CuraMedical B.V., Amsterdam, Netherlands)] were put into the sinus-nasal cavity which let to cessation of the bleeding after 5min. Considering their bio-absorbability and safety, they were left in place to prevent rebleeding. After an uneventful recovery, early (3-hour) examination showed a negative RAPD and near VA of 20/70. As per protocol, he was planned to stay one night in the hospital. However, the patient reported a significant right-sided orbital pain and decreased vision approximately 10h after the surgery. Examination revealed a VA of counting fingers at 1 m, a positive RAPD, and increased proptosis (Figure 1B). An emergency orbital CT scan showed fullness of the ethmoid and maxillary sinuses as well as the orbital cavity (Figure 1C, 1D). Thus, the patient was immediately returned to the operating room in order to address the OCS. Intraoperatively, the hemostatic implants within the sinonasal cavity were found to be significantly swollen and enlarged which were removed in piecemeal (Figure 1E). The procedure was completed by irrigating (normal saline) the orbit, sinus, and nasal cavity with no intraoperative bleeding. In 3-week postoperative follow-up, the best corrected visual acuity was 20/70 with negative RAPD and 3-mm proptosis reduction (Figure 1F). Three months after surgery, the patient's visual function remained unchanged from the preoperative status.

Case 2 A 58-year-old man with previously (15 years ago) failed right external DCR with positive regurgitation test, VA of 20/200 on the right (significant cataract) and 20/25 on the left (prior cataract and lens implantation), and chronic renal failure (CKD) being on hemodialysis three times a week was scheduled for revision external DCR procedure. During the procedure, there was a remained neglected lacrimal silicone tube surrounded by fibrotic tissue at the obstructed ostium site (Figure 2A) and nasal septal-lateral wall adhesions. Intraoperative bleeding started by releasing the adhesions and

removing the fibrotic tissue including the silicone tube and continued to the stage of opening the lacrimal sac into the nasal cavity and silicone intubation despite continuous intranasal irrigation of normal saline with epinephrine (1/400 000), repeated nasal packing, and selected mucosal cauterization. Since blood loss was considered significant, anesthetic team ordered and the patient received five units of cryoprecipitate. We also put three trimmed absorbable ORC sheets [3×3 cm each, about 0.6 g total (ChitoCell, ChitoTech, Eshtehrad, Iran)] and three hemostatic gelatin sponge cubes [1×1×1 cm each, about 1.5 g total (CuraSpon, CuraMedical B.V., Amsterdam, Netherlands)] into the nasal cavity and exposed ethmoid sinus mucosa to control the bleeding. Bleeding stopped after 15min. Part of the nasal packing was removed and the rest was left in place at the end of the surgery. Approximately 2h after surgery, the patient reported significant right-sided orbital pain. On examination, his right eye vision was light perception (LP) with a positive RAPD, dilated pupil, and proptosis (Figure 2B). The patient was promptly taken back to the operating room and the surgical wound was opened. The hemostatic implants were found to be significantly enlarged, compressing the orbit from the medial side. They were completely removed (Figure 2C) which led to pupil constriction (Video 1 online supplementary) and resolution of RAPD. The wound was sutured after making sure of no active bleeding. On postoperative day one, the recovery was uneventful with right VA of 20/200 (Figure 2D). Three months after the surgery the visual function was same to pre-op.

DISCUSSION

OCS is rare with an incidence of approximately 0.088% in 18 093 craniomaxillofacial cases. In facial trauma, incidence ranges from 2%–3%, eyelid surgery around 0.055%, and retrobulbar anesthesia 0.44%–2%. Classic presentation includes acute vision loss, pain, proptosis, chemosis, tight eyelids, and RAPD[3]. Digital palpation reveals a firm globe with resistance to retropulsion[1,3]. Predisposing conditions include trauma, surgery (both orbital and sinus), coagulopathies, anticoagulant use (present in up to 50% of OCS cases), Graves' disease, and retrobulbar or peribulbar injections[4].

ChitoCell is an absorbable hemostatic pad made from ORC. The ORC first developed in 1942 and widely used across various surgical specialties, including orbital surgery[5]. This material functions by providing a barrier at the bleeding site, promoting clotting, and facilitating hemostasis, thereby reducing the need for its removal after surgery[5]. The production of ORC involves dissolving cellulose in an alkalinized organic solvent, then extruding it through spinnerets into an acid bath. This process regenerates the cellulose into continuous fibers, which are knitted into a gauze and oxidized[6]. The resulting material form a reddish-brown gelatinous mass that acts as an artificial clot[6]. It is bioabsorbable, designed to degrade within the body over a period of 4 to 8wk, thus often left in the surgical bed to maintain hemostasis[6]. The widespread use of ORC, including products like Surgicel, and Avitene, has been integral to advancements in neurosurgery and other fields where controlling bleeding is critical[5].

CuraSpon is a gelatin-based, absorbable hemostatic sponge designed to control surgical bleeding[7]. It is derived from denatured protein sourced from animal skin gelatin, commonly from bovine or porcine origins[7]. Upon contact with blood, CuraSpon swells, providing a physical barrier that promotes clotting and aids in rapid hemostasis[7]. Its expansile nature helps tamponade bleeding vessels, although its use is cautioned in tightly enclosed spaces due to potential compression issues. Over time, CuraSpon is metabolized and absorbed by the body within 4 to 6wk, negating the need for removal and minimizing long-term foreign body reactions[8]. It is particularly useful in various surgical settings including dental, otolaryngology, and general surgeries, where delicate or confined areas might make direct coagulation challenging[9].

Despite the benefits, reported complications are oxidized cellulose migration[10], radiological presentations that mimic hematomas[11], abscesses[12], or recurrent tumors[13], anaphylactic reactions[14], and pressure effect due to volume expansion. ORC can swell up to 7–10 times and gelatin-based foams 45 times[15]. Such an expansion could increase the pressure in the anatomically confined spaces such as intracranial space leading to intracranial complications[11] and/or vision loss[16].

Complications related to hemostatic materials following orbital/lacrimal procedures are exceedingly rare, with only two previous reports in the literature[6]. Arat *et al*[6] reported two patients with orbital tumor excision and fracture repair who experienced OCS (decreased vision, increased reduced extraocular motility, proptosis, and chemosis) within 24 to 48h after the orbital procedure. Swollen pieces of ORC with blood clots were removed which resulted in the restoration of counting fingers vision in one patient, while the other continued to have no LP.

We chose to retain the hemostatic materials rather than remove it entirely for two reasons. Both ORC and gelatin sponge are bioabsorbable and can remain *in situ* after achieving hemostasis[6,8]. Additionally, the compressive effect of the materials locally on the bleeding site is believed to be helpful in controlling hemorrhage. However, it is important to consider the potential expansion of these materials before absorption, particularly in the confined space of the orbit, to avoid complications.

The orbit can initially compensate for small increases in orbital volume through mechanisms such as the forward movement

of the globe and prolapse of orbital fat[17]. However, this compensation is typically followed by a rapid rise in orbital pressure, aligning with the pressure-volume dynamics that lead to OCS. Increased tissue pressures within an enclosed space are associated with decreased perfusion, which can lead to significant complications, including visual loss[17].

Although both procedures carry intrinsic risk of compartment syndrome, orbital decompression presents a larger anatomical field with potentially more insidious onset, whereas revision DCR involves a smaller yet less compliant space that predisposes to rapid pressure escalation. Recognizing these nuances informed our emphasized strategy for smaller, trimmed sponge use, meticulous hemostasis verification, and aggressive removal of hemostats before closure.

The majority of OCS cases occurred within the first 3h after surgery, and the risk significantly decreased after 24h[17]. Thus, it is important to vigilantly look for any signs and symptoms of OCS in the early postoperative period.

Intraoperative hemostasis could be achieved through ligation, direct compression of the bleeding site, electrical cauterization, and clipping. However, the application of hemostatic implants such as bone wax and gelatin sponges is sometime required, especially in patients with diffuse bleeding from nonspecific sources[8,18].

Patients with CKD especially those on long-term hemodialysis, are known to have a paradoxical tendency toward both bleeding and clotting[19]. Uremic platelet dysfunction, anticoagulation use during dialysis, and fluid compartment shifts contribute to a higher perioperative bleeding risk and tissue edema[20]. Meta-analysis shows CKD patients have significantly elevated odds of requiring transfusion and reoperation for bleeding compared to patients with normal renal function[20]. In our second case, the patient's CKD, dialysis-associated anticoagulation exposure, and edematous tissue from chronic periorbital fibrosis likely contributed to persistent intraoperative oozing, necessitating hemostatic packing. This, combined with the low compliance of the medial orbital compartment, created a physiological context highly susceptible to pressure build-up.

In summary, the presented patients highlight the significant risks associated with the use of hemostatic implants, such as ORC and gelatin sponges, in the orbital and lacrimal procedures. Therefore, the following considerations are recommended. Intraoperatively, utilize the smallest effective amount of hemostatic implants and after a good hemostasis, remove all. If there is a need to leave a fraction of the implants in the surgical site, closely monitor the patient within the first 24h for symptoms of OCS such as pain, vision loss, and swelling. If present, immediate decompression should be performed to avoid permanent visual impairment.

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Conflicts of Interest: Ghahvehchian H, None; **Kashkouli MB,** None; **Karimi N,** None; **Jamshidian Tehrani M,** None; **Aghai G,** None; **Manavishad A,** None.

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