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What decides the nature of extraocular muscle injury? The probable mechanism of flap tear and rupture

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ABSTRACT

The assessment of nature and the extent of extraocular muscle injuries during initial visit in ocular emergencies is of paramount importance to avoid/minimize the subsequent need for strabismus surgery. Based on our experience in managing acute globe and orbital injuries and cases of strabismus, we propose the probable mechanism involved in the occurrence of extraocular muscle flap tear and a complete rupture of the muscle. During high-velocity injuries when the forces are equally transmitted along the orbital bony framework and the globe, then due to differential shearing forces created between the global and the orbital fibres leads to a flap tear. In the second scenario, if the forces are only directed along the bony framework, then the globe continues to be in continuous motion leading to increased tension between the muscles and the globe. Thus the weaker portions between these two structures are at risk of complete separation, that is along the insertion of muscle onto the globe or the musculotendinous portion.

Introduction

Post-traumatic extraocular muscle injury is a less commonly focused area in the emergency room as far as the ocular emergencies are concerned [1–3]. Assessment of the extent of muscle injury with the available history and skilful clinical assessment is vital to achieve optimal ocular alignment with an intent to minimize subsequent corrective surgeries on extraocular muscles. Here in this report, we discuss the probable mechanism involved in the muscle injuries of different types.

Mechanism of rectus muscle flap tear

During high-velocity injuries when the impact is transmitted equally along the superior orbital margin, inferior orbital margin and the open end of the orbital cavity, the net posterior displacement forces are transmitted along the globe as well as the orbital bones. As the bony framework is a relatively immobile structure it comes to a sudden halt but the forces are transmitted along the bony walls. In addition to this due to a sudden increase in the intraorbital pressures, the tension is either absorbed or may be dissipated by fracture along the weaker zones (inferior and medial orbital wall).

The posteriorly directed forces on the globe create a wave of backward displacement of the globe, thus leading to posterior movement of the globe within the orbit. Now on the surface of the globe along with the spiral of Tillaux, there is attachments/insertion of the muscles fibres. As clinically and histopathologically evident the rectus muscles are composed of orbital and global fibres and among these, the global fibres being the innermost or towards the muscle cone, they are directly inserted over the sclera at a certain defined anatomical locations. Whereas the orbital fibres occupy the outer compartment of the rectus muscle and are inserted on the outer surface of the global fibres. The orbital fibres do not have any contact with the globe but rather they have adhesions directed towards the periocular orbital soft tissues.

Thus during the process of posterior globe movements, there is a creation of strong separation forces directed in the opposite direction along the orbital and global fibres. This is due to differential insertion and relationship of the two muscle fibre types with the periocular soft tissues leading to the separation between the fibres or flap tear of the muscle (Fig. 1).

Mechanism of rectus muscle rupture

In the second scenario during high-velocity injuries, when the forces are only directed either along the superior or inferior orbital margins, then there is a transmission of the forces only along the orbital bones (Fig. 2). Under such circumstances, the bony framework will come to a sudden halt, whereas the globe continues to be in a forward motion. During this crucial period, there is an increasing tension created at the

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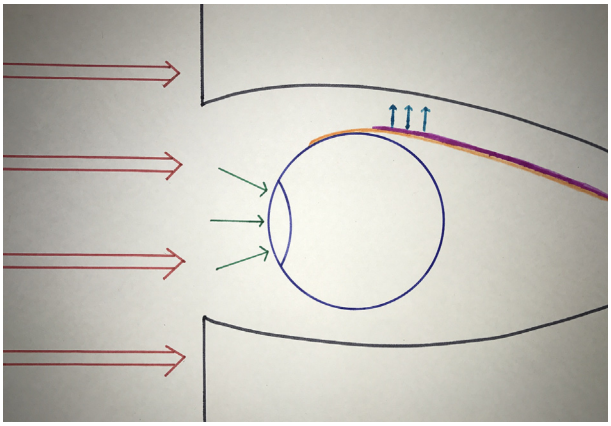

Fig. 1. Diagram shows, when the deforming forces (red arrows) are equally transmitted along the globe and the superior and inferior orbital margins. Then the globe tends to move posteriorly (green arrows) within the orbit. Because of which there is a creation of separation forces among the orbital (pink part of the extra ocular muscle) and global fibres (saffron part of the extra ocular muscle) due to the differential relation with the surrounding tissues leading to flap tear. (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article.)

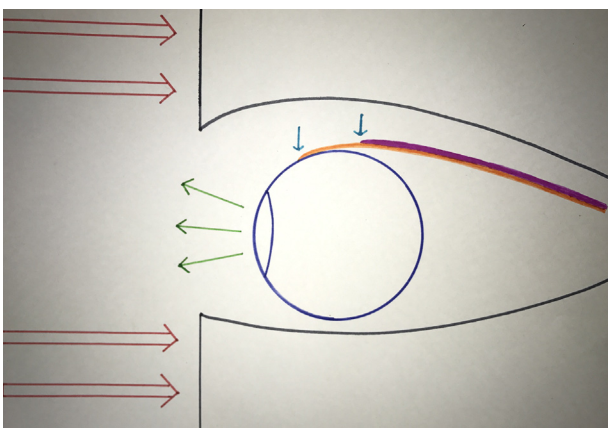

Fig. 2. In the second example, when the forces are only directed along the orbital bony framework (red arrows). The globe tends to be in continuous motion (green arrows), thus creating a stretching force along the weaker zone of extraocular muscles that is their tendinous insertion anterior light blue arrow) or belly-tendon (posterior light blue arrow) transition zone leading to a full thickness rupture. (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article.)

insertion site or along the muscle belly and tendinous transition zone. Thus depending upon the extent of tension created within the muscle or especially along the transition/weaker zones there is full thickness give away leading to rupture of the muscle (Figs. 2 and 3).

Discussion

In 2001 Ludwig et al., discussed the clinical profile of thirty-five patients with forty-two rectus muscle having flap tear [2]. Among these 35 patients, the orbital fracture was evident in 14 patients and it was doubtful in 15 patients. While sharing the intraoperative experience, the author described the three important findings to identify the rectus muscle and its lamellar tear. There will a thinning of the muscle along its insertion, and the injured muscle will usually have a disrupted capsule and a careful search may reveal the lost segment of the orbital muscle fibres in the vicinity surrounding orbital tissue [2]. Similarly, the same authors discussed again flap tear in 62 rectus muscles of 43 patients with the similar findings [3]. Thus a careful intra-operative exploration is necessary to avoid re-surgeries on the extraocular muscles.

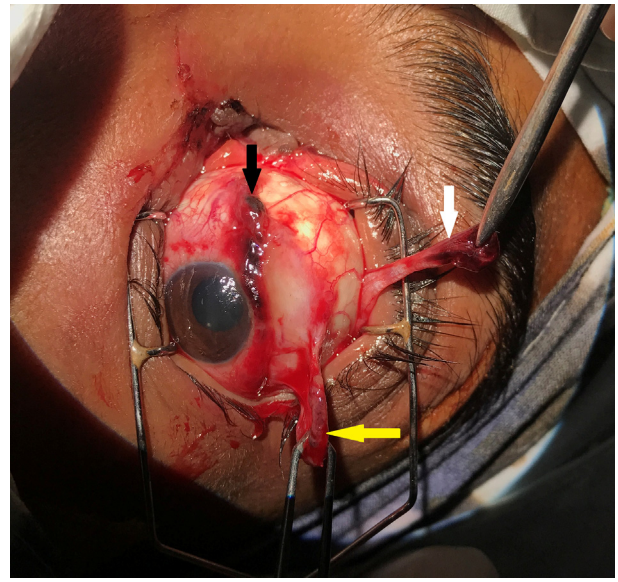

Fig. 3. Ruptured medial rectus at the muscle insertion (black arrow), superior rectus around 8–-10 mm from the insertion (yellow arrow) and the superior oblique tendon at the level of trochlea (white arrow).

Ludwig et al., hypothesised that the flap tear of the inferior rectus muscle is due to fracture along the floor of the orbit leading to a sudden traction along the outer layers of the muscle and thus manifesting as flap tear [2]. However, all the patients with flap tear may not possess significant orbital wall fracture to cause a traction, but rather it is likely to be due to complex interplay between the forces transmitted along the orbit and the globe.

Similarly, Saxena et al.. discussed a flap tear of the rectus muscle in three patients involving inferior rectus in two patients and medial rectus in one patient. All three patients were successfully managed and the authors found intraoperatively separated orbital and global fibres [4]. Likewise, there are other isolated reports describing the clinical course and management options for flap tear of rectus muscles [5,6]. Among all the extraocular muscles, the inferior rectus is more prone to such injuries likely to be due to reflex Bell's phenomenon during the event of trauma [2–4].

We reported a case of complete globe luxation following severe orbital trauma [7]. In our case, the direct impact was along the superior orbital margin in a high-velocity road traffic collision. As there was no direct impact on the globe, the globe remained in continuous motion whereas the orbital bony framework came to a sudden halt leading to a sudden increase in the tension along the all rectus muscle insertion and a complete muscle rupture of all horizontal recti along their insertion with a transected optic nerve [7].

In another case of high-velocity collision injury involving the forehead, the impact was directed along the medial aspect of the superior orbital rim. Because of which there a full thickness rupture of the medial rectus (at the insertion) and the superior rectus (at the tendon-belly junction). At the same time, the trochlea also suffered injury leading to rupture of the superior oblique tendon at the level of trochlea. However, the globe remained intact due to the lack of any damaging force on to it.

From the above explanations, it is clearly evident that the cases discussed by Ludwig and Saxena et al. were clearly explained by the flap tear mechanism and the other two examples (our cases) were explained by the mechanism involved in the full thickness rupture of the muscle.

Importance of this conclusion

To conclude, cases presenting to ocular emergencies with ocular/orbital trauma need a detailed evaluation regarding the nature of injury, velocity, site and the direction of forces to suspect the probable nature of extraocular muscle injury. Based on these observations careful exploration can be planned to identify the muscles more accurately so as to achieve a restrictive/limitation free binocular condition post-operatively.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.mehy.2019.01.011.

References

[1] Chen J, Kang Y, Deng D, Shen T, Yan J. Isolated total rupture of extraocular muscles. Medicine (Baltimore) 2015;94(39):e1351.
[2] Ludwig IH, Brown MS. Strabismus due to flap tear of a rectus muscle. Trans Am Ophthalmol Soc 2001;99:53–62. discussion 62-63.
[3] Ludwig IH, Brown MS. Flap tear of rectus muscles: an underlying cause of strabismus after orbital trauma. Ophthal Plast Reconstr Surg. 2002 Nov;18(6):443–9. discussion 450.
[4] Saxena R, Sharma M, Singh D, Sharma P. Managing flap tears of the rectus muscles. J Pediatr Ophthalmol Strabismus 2017;28(54):e23–6.
[5] Ameerally PJ, Ormiston IW, Avery C. Partial avulsion of the inferior rectus: an unusual cause of diplopia after blunt orbital trauma. Br J Oral Maxillofac Surg 2007 Apr;45(3):240–1.
[6] Raab EL, Ackert JM, Ostrovsky A. Rectus muscle flap tear as an independent cause of restricted motility. J AAPOS Off Publ Am Assoc Pediatr Ophthalmol Strabismus 2012 Aug;16(4):386–8.
[7] Pujari A. Post traumatic complete globe luxation Available from: Delhi J Ophthalmol 2017;28(2).