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Post traumatic retinal injuries: Does the ocular protective reflex play a crucial role?

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ABSTRACT

Traumatic retinal injuries are commonly encountered in most retinal subspecialty clinics. Retinal dialysis, detachment and other complications consequent to blunt trauma are often thought to be due to equatorial expansion of the globe following an antero-posterior compressive force. However, stretching of the globe along the primary anatomical equator may not hold true for the adjusted globe position as a consequence of the protective Bell's phenomenon which gets activated before impact. The upward and outward rolling of the globe likely creates a new equator, with the compressive forces acting along this new plane, thereby leading to stretching along the ocular coats closer to the retinal periphery. Additionally, the coup and countercoup mechanisms with increased vulnerability of temporal sclera predisposes to retinal complications more commonly along the temporal and the nasal retina. Further, retinal complications involving other quadrants can also be explained through understanding of the Bell's phenomenon.

Introduction

Traumatic ocular complications have a huge bearing on the patient's long term visual outcomes and are of important concerns to any ophthalmologist [1–3]. Consequent to blunt ocular trauma, the widely known seven crucial vulnerable injuries are -iris sphincter tear, iridodialysis, angle recession, trabecular mesh work disruption, cyclodialysis, zonular dialysis and retinal dialysis. Retinal dialysis is characterized by a separation of the retina along the ora serrata. The separation can be anterior to the ora along the posterior ciliary epithelium or posterior to the ora along the peripheral retina [1]. These retinal injuries can be located in any quadrant of the eye, but are more commonly seen along the infero-temporal quadrant and along the superonasal quadrant. However, the simple concept of antero-posterior globe compression with equatorial expansion does not sufficiently explain the occurrence of dialysis at the ora. Therefore, here in this observation we elaborate the probable crucial role of protective ocular reflex in the causation of such complications.

What literature says

Retinal complications following trauma can either be due to blunt trauma or penetrating trauma; here we have considered the scenario of blunt trauma only. Since their description, traumatic retinal detachments have been studied extensively to understand the pathomechanisms, and, clinical implications and outcomes [1–7].

In an observation by Hagler et al involving a total of 523 eyes with retinal dialysis, blunt ocular trauma was found to be a significant factor in the causation of retinal dialysis. They also noted that these injuries were more common in young males and this observation has been shown to be true till date [1]. Similarly, in an another observation by William H. Ross, the author stated that virtually all cases of retinal dialysis are due to blunt trauma [3]. However, some authors suggest, that patients are likely to forget the event of trauma or it may not have been noticed by them, thus, subjective verification with the objective findings is of utmost importance to reach a definitive diagnosis of a traumatic retinal detachment [1,3,5].

In the event of a blunt trauma, as the forces are transmitted along the globe, they intend to displace the globe into the orbit, however, the orbit being full of other soft tissues, provides only a minimal space for any posterior displacement of the globe, thereby leading to the phase of compression/sandwich. As the globe is an elastic structure, in order to dissipate the tension due to the compressive phase, it expands in an axis perpendicular to the original forces, i.e. along the equator. This equatorial stretch puts a significant traction over the retinal periphery, and the temporal part of the globe being more exposed, receives the added

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major brunt of coup or direct injury impact. In addition, this area is inherently weaker due to many other pathological changes such as microcystoid degeneration, progressive enlargement of intra retinal cysts, and congenital weakness of retinal periphery. Therefore, all these factors combined together, increase the risk of retinal complications along the temporal quadrant [8].

However, it is not universal for the complications to be restricted to only the temporal retina, the clinically defined quadrants, that is, supero-temporal, infero-temporal, supero-nasal and the infero-nasal quadrants do manifest such complications but at a variable rate. The percentage of traumatic retinal dialysis according to the recent edition of the Retina textbook by Ryan is, 66% along the infero-temporal quadrant, 14% along the supero-nasal quadrant, 10% along supero-temporal quadrant and 4% along the infero-nasal quadrant [9]. Therefore, in addition to any inherent or other pathological predisposition of the temporal retina to trauma, the transmission of forces along the other quadrants and the position of the globe during the impact along with some other factors appear to play a key role in the causation of retinal complications.

The likely role of protective ocular reflex in the transmission of forces and causation of retinal complications

Bell's phenomenon is a protective ocular reflex described by Sir Charles Bell [10]. The normal phenomenon consists of an upward and outward rolling of the eyeball during forceful eye closure. This reflex is intended to protect the anterior ocular surface from an impending threat approaching the eye; it is commonly seen in up to 90% of normal individuals and it may be absent in remaining 10% of the normal population, which, however, is not abnormal. In addition to this, a downward movement of the eyeball has also been noted in some individuals and is commonly termed as inverse Bells phenomenon. This downward movement can be noted in normal individuals as well as following a large levator muscle resection for blepharoptosis. The neurological pathway for this reflex involves a complex co-ordination between the third and the fifth cranial nerves. This phenomenon of upward rolling of the eyeball is more pronounced in cases of seventh cranial nerve palsy due to an over exposure of the palpebral fissure, in addition, it can also be elicited in normal individuals while opening the eyelid forcibly, however, this reflex is absent in cases of regular blinks. Therefore, it is likely that this protective reflex needs an active threat from outside in order to reposition the globe into a relatively safer place within the orbit, thus ensuring minimal damage to the anterior eyeball structures. The nature of forces exerted on the exposed sclera can be a direct coup injury or a compressive injury, but as the sclera and rest of the globe being elastic in nature, an exact understanding regarding the extent of compression and causation of coup and counter coup consequences are difficult to decipher at any given point of time.

During the event of an acute trauma, it has been thought that, this protective reflex may come into action and because of this; certain other ocular structures may be more commonly prone for injury. During post traumatic extra ocular muscle injuries, due to Bell's phenomenon the inferior rectus muscle has been thought to be more commonly injured as compared to rest of the extra ocular muscles [11]. Similarly, during optic nerve avulsion and indirect choroidal rupture, the role of Bells phenomenon has been highlighted [12].

The normal eyeball possesses an anatomical equator and in primary orthophoric position if the antero-posterior compressive pressures are exerted, the equatorial portion of the globe will distend. Objects with different dimensions are likely to impose compressive forces with different magnitude and hence the equatorial expansion is likely to vary.

If we take the Bell's reflex into consideration then the position of globe's equator would change from that in the primary position and hence the compressive forces are going to act in a different manner resulting in the compressive and expansive changes in entirely different axes.

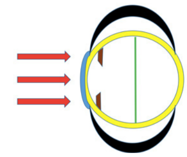

Fig. 1. Figure shows the direction of antero-posterior compressive forces (red arrows) acting along the anterior corneal surface when the globe (in a sagittal plane) is in its primary position. Subsequently the normal ocular coats (yellow circle) dissipate the compressive energy by assuming an equatorial (green line represents the primary anatomical equator) expansion (black semicircles along the ocular coats).

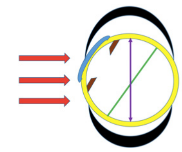

Fig. 2. When the protective Bell's phenomenon is in action (globe turned up and out), the antero-posterior compressive forces (red arrows) are likely to cause the stretching of ocular coats along the newly assumed equator that is purple bidirectional arrow. Thus, the stretch induced tensions are transmitted along the ora serrata and the post equatorial region.

Fig. 1 depicts the globe position in the primary gaze with its normal equator. In this position if antero-posterior compressive forces are exerted, then the actual equatorial portions would be distended. In presence of an up and out rolled eye, the anatomical equator (green dashed line) is also rotated with respect to the axial plane, therefore in this new position; a new equatorial position is assumed (yellow dashed line) (Fig. 2). Compressive forces in this position will lead to an expansion along the new equator that is the ocular coats near the ora serrata of supero-nasal quadrants. Thus, these areas receive the maximum brunt of the stretching forces. On the other hand, the ocular coats along the new inferior equator are of more posterior pole structures thus they may not be that vulnerable to stretch damage as compared to the other peripheral structures.

In a second scenario, if the globe position is in an inferior gaze due to inverse Bells, then the inferior ora structures or the superior post equatorial structures will receive the maximum brunt of stretch and related tension.

Therefore, during the event of acute blunt trauma with normal Bells phenomenon in place, the rotated globe positions the infero-temporal retina along the inferior dependent position, and the supero-nasal retina along the superior most position. Thus, the relative globe orientation during the impact of trauma is likely to be the crucial factor responsible for transmission of stretching forces. In addition to this, two other factors which are likely to exaggerate the findings in the superonasal and inferotemporal quadrant are, 1) coup and counter coup mechanism and the 2) increased vulnerability of temporal sclera. In addition, the inherently weaker temporal retina and the degenerative changes along its periphery may further exaggerate the predisposition to tearing of the temporal retina. These events were also experimented in goat's eye (Fig. 3A–D), however due to the avulsed nature of retinal tissue, only the exertion of forces in adjusted globe position can be elicited.

Conclusions

To conclude, the ocular protective reflex with its tendency to place the globe in a safer zone predisposes other areas at risk of excessive stretching and tension. Therefore, forces acting along these newly defined planes are likely to predispose the retinal complications along the superonasal and inferotemporal quadrants.

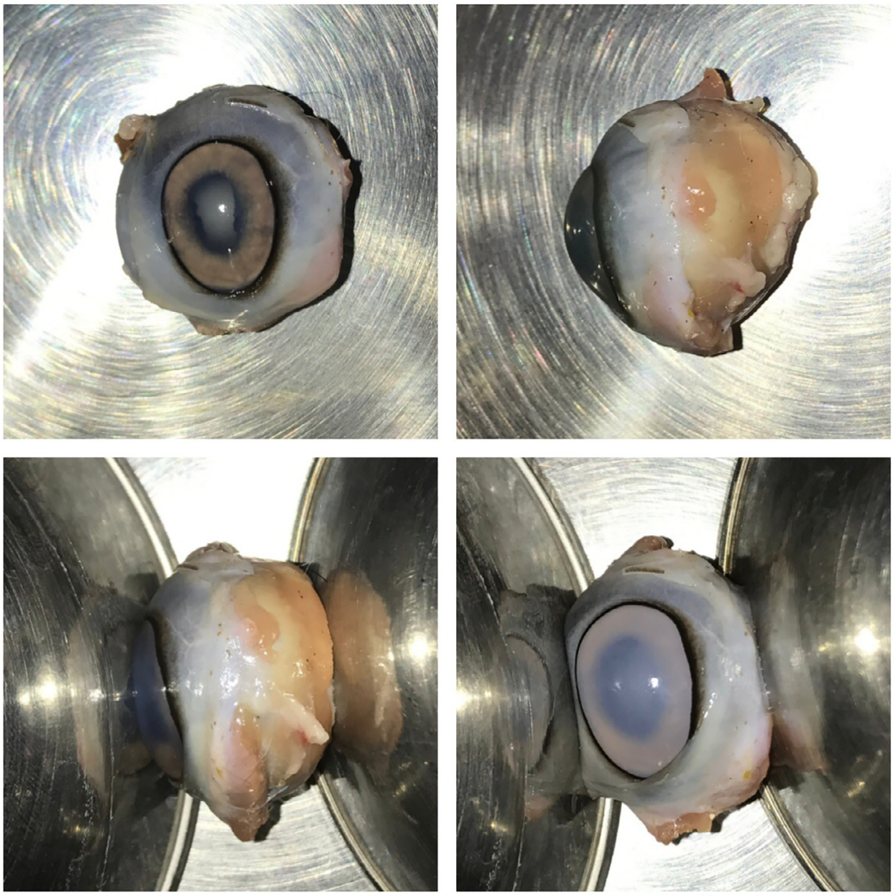

Fig. 3. (A) An intact goat's eye was considered for the demonstration purpose. Fig. 3B, C: The goat's eye is rolled in an anterior posterior direction. In this position when antero-posterior compressive forces are applied, the ocular coats are stretched along the normal equator region. Fig. 3D: However, when the globe is under the influence of Bells phenomenon (up and out), the energies are dissipated along the newly assumed equator, that is supero-nasal ora serrata and infero-temporal post equatorial region. In addition, the direct coup injury along the infero-temporal retina and counter coup injury along the superonsal retina are likely to add on the brunt of trauma.

Limitations

Our hypothesis is based on the consistent observation of retinal complications following blunt trauma, and do not involve the actual simulation of injuries on human eyes. In addition, the forces depicted along the new anatomical landmarks needs to be studied further in future observations.

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Declaration of Competing Interest

None.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.mehy.2019.109286.

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