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Pathomechanism of iris sphincter tear

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A B S T R A C T

Traumatic iris sphincter tear has been thought to occur secondary to anteroposterior compression of the globe with defined forces lead to equatorial expansion and active pull along the corneoscleral junction and sphincter tear. However, here in this report, we elaborate the additional forces involved in the traumatic rupture of the sphincter pupillae muscle. During the anteroposterior compressive forces along the globe, the corneal deformation beyond certain limits leads to the development of sudden displacement forces within the anterior chamber. Aqueous within it which is in continuous circulation with a posterior narrow pupillary aperture as its entrance, find the path of least resistance that is along the pupillary orifices leading to an expulsive drive to displace the fluid through this small aperture. During this process, the horizontally oriented mechanical stretching forces appear to be the main cause of pupillary sphincter tear.

Introduction

Iris sphincter tear is a common examination finding following blunt trauma to the anterior segment structures. As the sphincter muscles are irreversibly damaged in this process, the mydriatic pupil causes significant visual disturbances to the patient. There are few described mechanisms of sphincter muscle tear, however, here in this report, we discuss the additional critical forces responsible for this kind of injury with the help of an experiment.

Mechanism

When there is an anteroposterior compressive force on to the globe during blunt trauma, the anterior surface of the globe is displaced and/or compressed within the orbit against its soft tissue contents. Thus, the sandwiched globe will have a sudden rise in the intraocular pressures, but this pressure will be dissipated by certain physiological changes along the ocular coats when the trauma is within the acceptable range of the tensile strength of the ocular tissues. When the exerted pressure exceeds the tissue tolerability, a sudden give away along the weaker zones of the eyeball is expected, leading tear or rupture.

As far as the anterior segment is concerned, it is a closed cavity with a continuously circulating aqueous humour within it. The aqueous enters this compartment via the pupillary aperture from the posterior chamber, following circulation; the fluid leaves the anterior segment via trabecular meshwork. Under normal conditions when there are compressive forces, the elastic layers such as the cornea, corneoscleral junction and the iris will have certain changes in their configuration to dissipate the tension created within them due to the deforming forces. However, this appears to hold good only formild forces, but in the case of high-velocity injuries, the manifestations will be more grievous in terms of severe discontinuity in the ocular coats.

In cases of moderate forces or when the deforming forces onto the anterior ocular coats are just sufficient to suddenly raise the intraocular pressures (Fig. 1A), so that along with the deformation of the corneal layer the anterior chamber contents needs to be displaced to counter the force and resist rupture (Fig. 1B). As the anterior chamber is filled with aqueous humour, it is displaced against the posterior soft tissue structures with a small opening that is pupillary aperture. The posteriorly oriented displacing forces find the path of least resistance that is along the pupillary opening after returning from the angles (Fig. 1C).

The pupillary orifice is around 2 mm wide during normal conditions, as previously suggested by some authors immediately the following trauma there is sudden pupillary constriction thus bringing the pupil to almost this level. Now through such narrowed pupil the aqueous is expulsed from the anterior chamber in presence of firm resistance (lens) at the exit. This creates an enormous horizontal mechanical force within the pupillary aperture which cannot be handled by the iris leading to sudden rupture of the pupillary marginal sphincter fibres (Fig. 1D).

This critical process is demonstrated here with the help of a balloon filled with tap water. An opening of 2*2 mm was made onto the surface of the deflated balloon (Fig. 2A), following this the balloon is filled with tap water. As the filling pressure raises within the balloon, the water

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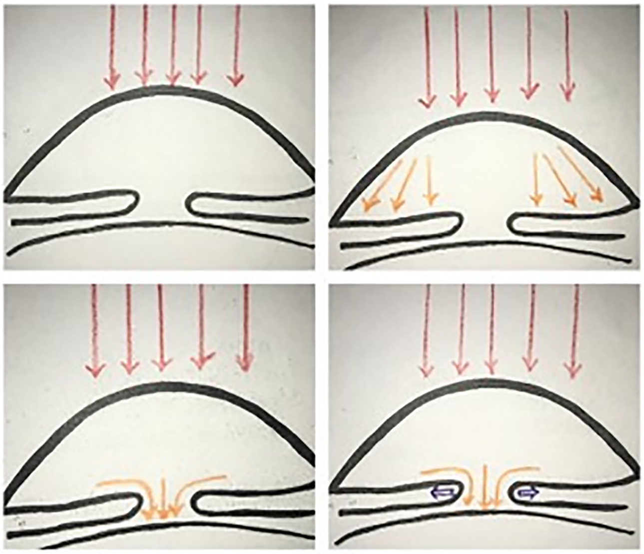

Fig. 1. A. External deforming forces acting evenly on to the cornea. B. The external forces subsequently generate, posteriorly oriented aqueous displacement currents along the angle and anterior surface of the iris. C. The aqueous currents find the path of least resistance, which is along the pupillary orifice. D. Through this small pupillary aperture a large amount of aqueous needs to be expulsed within a short span of time leading to the development of horizontally oriented mechanical forces along the pupillary margins and thus the pupillary sphincter tear.

Fig. 2. A. A small mechanical opening is made on the surface of the balloon. B. The balloon is now filled with water and this water finds the path of least resistance (that is the mechanically created opening) when the pressures within it try to rise. C. Now when sudden compressive forces are applied to the balloon filled with water, the water follows this path of least resistance, however, because of the development of large displacement tension within this opening there is an irregular tear along the original orifice corresponding with the sphincter tear.

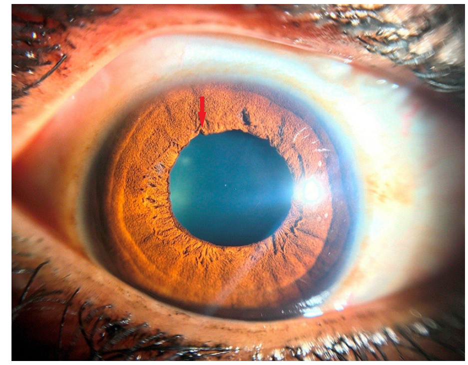

Fig. 3. Clinical picture of superior iris sphincter tear (red arrow). (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article.)

tries to escape from the closed cavity with a gradually increasing jet from it (Fig. 2B). Under these circumstances when sudden deforming/squeezing forces are applied to it, the large amount of water is forced to exit from the small aperture but with greater force, thus this enormous ejection force creates a horizontal stretching force along the small aperture leading to irregular tears along the original orifice (Fig. 2C).

What literature says?

Duke elder and Shingleton have hypothesized the natures of forces responsible for probable sphincter tear [1,2]. According to them, following anteroposterior compression of the globe there is an equatorial expansion with corneoscleral ring stretch, along with this there is a backward force created within the chamber which impinges on the anterior surface of the iris and then traversing laterally along the angles of the anterior chamber. During this, the relatively unsupported iris tissue or pupil, in particular, is going to constrict leading to aperture narrowing. Subsequently, due to strong opposition posed by the lens and the vitreous along with corneoscleral stretch will lead to sphincter tear.

Similarly, Chavan et al., studied iris and pupillary injuries in 79 eyes and they noted tears along the pupillary margin and other pupillary abnormalities in the majority of the cases. The traumatic iris damage can be focal or segmental depending on the extent of forces exerted and other noted injuries included pigment clumps on anterior iris surface, defect in the pigment layer of the iris and sector iris atrophy in long-standing cases [3]. These authors also supported the views of Duke elder. But these authors did not mention anything about the possible development of the horizontal stretching forces within the pupillary margins which is likely to be mainly involved the development of this complication.

Conclusions

Following trauma with anteroposterior compression of the globe with subsequent stretching along the corneoscleral ring, the sudden backward forces generated along the aqueous humour finds the path of least resistance (that is along the pupillary orifice) to displace the contents, so as to relieve the tension generated within this closed cavity. These combined forces acting in one direction with reflex pupillary constriction acting in opposite direction along with the strong posterior resistance due to lens creates enormous mechanical horizontal stretching forces within the pupillary margins leading to disruption/tear of sphincter muscles (Fig. 3).

Conflict of interest

None.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.mehy.2018.11.013.

References

[1] System of ophthalmology, mechanical injuries, volume 14; p. 101–2.
[2] Eye trauma, Iris trauma. Shingleton; 97.
[3] Canavan YM, Archer DB. Anterior segment consequences of blunt ocular injury. Br J Ophthalmol 1982;66(9):549–55.