Original Article - Retrospective Study

Residual diplopia in treated orbital bone fractures

Access this article online
Website:
www.amsjournal.com
DOI:
10.4103/2231-0746.110078
Quick Response Code:

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ABSTRACT

Background: Residual diplopia (RD) is the main post-treatment complication of orbital bone fracture (OBF) reduction. The cause of RD is varied and often related to the degree of inflammation, surgical timing, graft requirement, and trauma to orbital musculature, fat, as well as nerves. The exact prevalence of these and the influence of these factors on RD is not widely reported in literature. **Materials and Methods:** This retrospective study was conducted from January 1, 2000 through December 31, 2011. Sixty nine patients fulfilling inclusion and exclusion criteria were enrolled in this study. The nature of the defect causing RD was identified. Demographics, nature of initial OBF, extent and type of treatment, and grafts were noted. Corrective surgeries were performed. Data entry and analysis were performed using SPSS. Descriptive statistics and Chi square tests were employed. P value ≤ 0.05 was taken as significant. **Results:** Inferior rectus muscle (71%) and other periorbital musculature (56.5%) was entrapped, leading to RD. Globe position abnormalities was observed in 52.1% of cases. Degree of inflammation, types of grafts (P = 0.000) were significantly related. **Discussion:** Preoperative swelling, musculature inflammation, and graft placement significantly influenced the surgical outcome of OBF. RD is related to these factors. Adequate control with OBF healing and remodeling needs to be considered while timing OBF. Author's modification with mesh and cartilage in secondary corrective surgery for RD provided an effective solution for immediate intervention.

Keywords: Corrective surgeries, maxillofacial fractures, orbital bone fractures, residual diplopia, India

INTRODUCTION

Orbital bone fractures (OBF) are one of the commonest mid-facial injuries accounting up to 40% of all trauma injuries in the region. This trauma most often occurs in conjunction with other type of fractures including maxillomandibular, zygomatic, and frontal bones. Trauma involving the orbital bone and its adjoining soft tissue often results in serious, subsequent events including diplopia, ocular muscle entrapment, and enophthalmos.[1,2] Several causes of enophthalmos have been suggested including increase of the bony orbital volume, soft tissue contracture, fibrosis of musculature, and orbital fat atrophy.[2,3] Most of these have a potential to cause late, residual, or persistent enophthalmos. In spite of the numerous causes, the main locoregional change is the increase in the orbital volume accompanying a change in the shape of the posterior segment of the orbit from cone to round owing to anatomical changes.[3]

Diplopia is observed up to 86% of all OBF.[4] Most of the diplopia spontaneously disappears within 1–4 weeks of surgery. Persistence of diplopia after surgical intervention for OBF are common and reported in up to 20% of treated cases.[5] The cause of this residual diplopia (RD) is often caused by missed diagnosis or incorrect reconstruction.[3] For an ideal rehabilitation, the correct cause of the RD has to be assessed even before the secondary surgery. The treatment for these patients must focus on the repair of the anatomical size and correct positioning of the orbit. In the delayed repair of orbital trauma, it is, however, extremely difficult to reconstruct the original size of the orbit because of bone remodeling and scarring. Fine adjustments that must be performed intraoperatively remain a major challenge to virtually any surgeon. There have been varying reports on factors that lead to RD in such cases.[4,6]

The aim of the present study was to study the cause of the RD in surgically attempted post-traumatic OBF cases. An attempt has been made to identify the preoperative factors that predisposed to such RD.

MATERIALS AND METHODS

From the archives of the institute, cases with complaints of all post-traumatic diplopia were identified. In a period of 12 years (January 2000 to December 2011), 324 cases were identified. From these, only those cases that reported RD after complex craniofacial fractures reporting for secondary corrective surgeries with identifiable cause were included in this study. All such cases have been investigated using various imaging modalities to identify the defect. Patients with preexisting ophthalmic abnormalities, and with no adequate records were excluded from the study. All such details and other clinical details of age, gender, type of surgery (Emergency within 48 hours of trauma; delayed later that 48 hours), place of OBF (medial, floor, both), inflammation of muscle as shown in imaging, nature of primary surgery, and graft placement (autogenous/allogenous) in primary surgery were noted. From the investigations performed, entrapment of inferior rectus, periorbital musculature (POM), and level placement were identified. During secondary surgery, equator abnormalities and standard transduction test were done and results were noted down. Results of secondary surgery were also presented.

Secondary surgery

Initial assessment of the cause of RD was performed. Through a trans-conjunctival [Figure 1] or subciliary incision [Figure 2], the floor of the orbit was reached, and lateral canthotomy was performed when and where necessary. After reaching the floor of orbit, careful manipulation of globe was done. Entrapment of inferior rectus muscle (IRM), periorbital fat, and musculature, if any, were carefully released. Spicules of bone or other grafts from previous surgery were carefully trimmed or manipulated so as not to be a cause of RD.

In situations where grafting was required, the recipient site was properly prepared. The titanium mesh was placed subperiosteally and screwed in position. This ensured that the graft stays in position and does not interfere with globe position with later remodeling of the orbital volume. To prevent adhesion of the mesh to POM, a thin sheet of cartilage (as thin as possible) obtained from the patient's rib was placed and secured with the mesh. Care was taken, that during the preparation of cartilage, warpage does not set in. This cartilage reduces the adhesion of the orbital musculature to titanium mesh that would lead to RD [Figures 3-10].

Globe was carefully placed with respect to the equator and level at straight gaze. The layers were closed. No suture was placed for trans-conjunctival approach. For the subciliary incision, layered closures were performed using vicryl, and skin incision was closed by 6-0 Ethilon. Routine postoperative instructions for orbital surgeries, antibiotics, and non-steroidal anti-inflammatory drugs were given as required to the patients. Patients were followed-up weekly for initial 4 weeks and at least 12 weeks after the operation.

Statistics

All data were entered in Statistical Package for Social Services (SPSS, IBM, IL, USA, version 17.0) and analyzed. Descriptive statistics and Chi square statistics were presented. Yates correction was applied whenever needed. A P value less than 0.05 was taken as significant.

RESULTS

Sixty nine patients fulfilled the inclusion and exclusion criteria. Of the 69 patients, 60 (87%) were males. The mean age of patients was 35.15 $\pm$ 10.36 years (18–54 years). The trauma was sustained by blunt force with majority of them acquired in road traffic accidents and fall. The time difference between the trauma and primary surgery ranged from immediate surgery to 21 days after the trauma with a mean of 7.94 $\pm$ 6.73 days (0–21 days). Among all cases, floor was involved in 55 (79.7%) cases and medial wall was involved in 11.6% of cases. The primary repair required graft in 58 (84.1%) of cases. For these 43 cases (74.14%), titanium meshes and similar materials were used, while in other instances autogenous bone grafts were employed. In one-third of cases, indication of inflammation in the area preoperatively (during primary surgery) was noted in primary surgery imaging modalities. On examination using imaging modalities, inferior rectus and other POM entrapment was identified in 49 (71%) and 39 (56.5%) of cases, respectively, indicating that a group of patients had multiple issues. Abnormal positioning of globe equator was observed in 30.4% of cases, while, in 21.7% of cases, level of eyes was not in the same plane. In 4 cases, there was a negative transduction indicating neuronal abnormality [Table 1].

Entrapment of IRM was more commonly associated when the primary surgery was done in emergency. The difference was statistically significant ($P = 0.009$). Similarly, use of resorbable graft was associated with IRM entrapment ($P = 0.007$). Preoperative inflammation during primary surgery was also observed in association with IRM entrapment ($P = 0.034$) [Table 2]. Similarly, POM entrapment was significantly associated with the type of surgery ($P = 0.000$), type of graft ($P = 0.000$), and pre-operative inflammation during primary surgery ($P = 0.000$) [Table 3]. Equator abnormality and eye level abnormalities was not significantly associated with any other factors [Tables 4 and 5].

Of the 69 RD cases (after a primary surgery) surgically intervened in this study, 8 cases (11.6%) had RD even after the secondary surgery. Of these, 5.56% resolved spontaneously within 8 weeks, while there was a mild persistence of RD in other cases that required prisms for complete corrections. These cases had a negative transduction test during the secondary corrective surgery itself.

DISCUSSION

The only know prognostic factor for RD that could be assessed preoperatively with statistically significant correlation is the swelling of extraocular muscles, identified by imaging techniques and persistent postoperative RD.[7] The potential causes of persistent RD after primary surgery have been discussed by several authors.[8,9] Though several factors have been implicated for RD including timing of surgical repair, none of them have been proved. The effect of malpositioning of the globe on RD has not yet been investigated in detail.[3] It is unquestionable that normal anatomical positioning of the globe is a prerequisite for

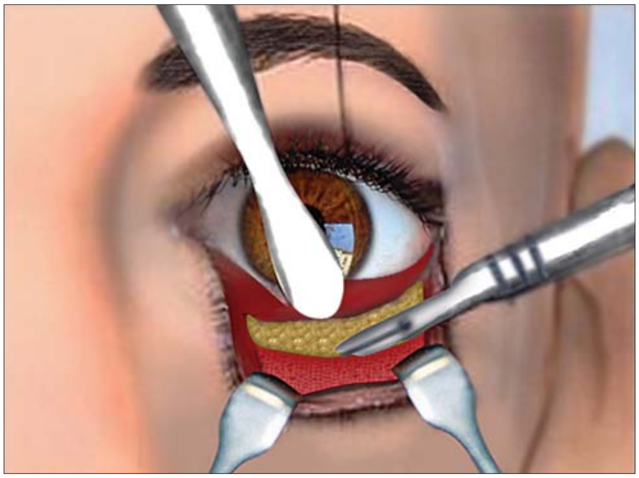

Figure 1: Illustration of transconjunctival (preseptal) approach

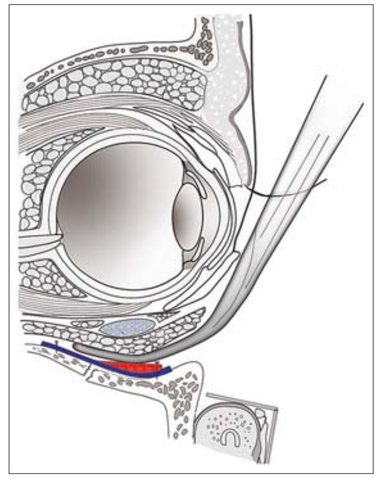

Figure 2: Illustration of orbital floor reconstruction via transconjunctival (preseptal) approach

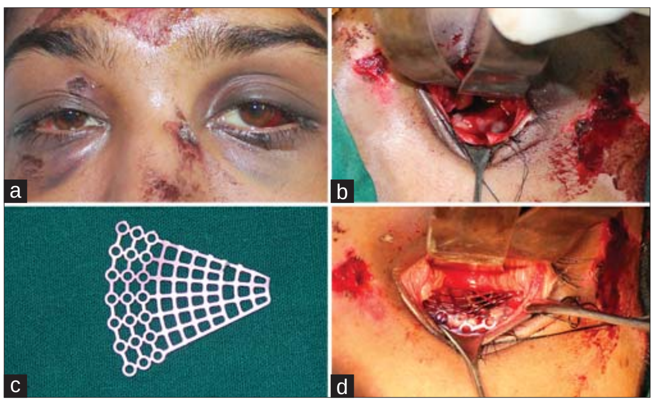

Figure 3: (a) Preoperative view showing left eye hypoglobus, pseudoptosis with supratarsal hooding indicative of enophthalmos, (b) Intraoperative view: Exposure of orbital floor disruption via transconjunctival approach, (c) Prefabricated titanium mesh, (d) Orbital floor reconstruction using titanium mesh

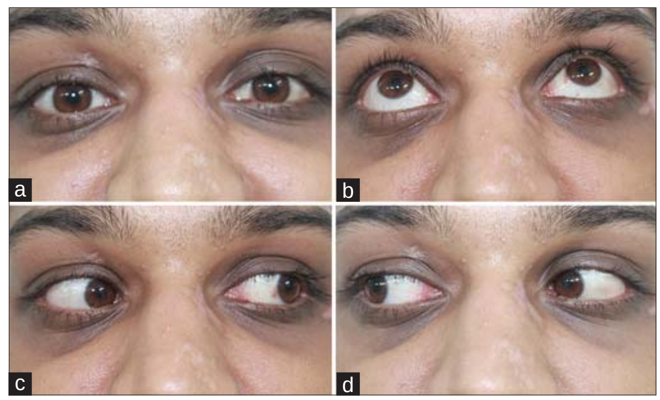

Figure 4: Postoperative view after 3 months – resolved subconjuctival hemorrhage and enophthalmos. Corrected globe position with no restriction in eyeball movement and correction of diplopia was noted

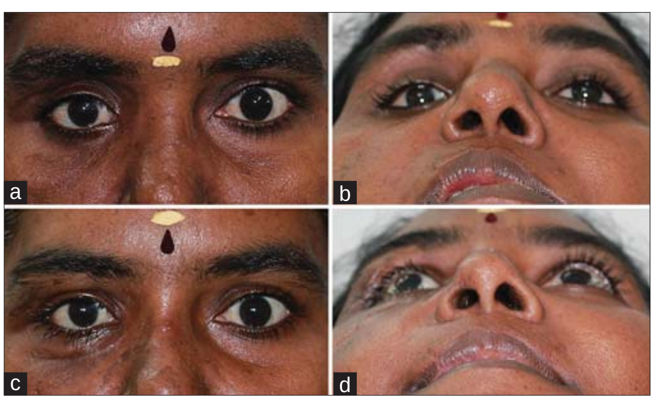

Figure 5: Comparision of pre- and postoperative appearance of a patient with post-traumatic right eye enophthalmos and diplopia corrected by orbital floor reconstruction using rib graft and titanium mesh

Figure 6: Subcilliary approach to orbital floor fracture. Orbital floor reconstructed using rib graft harvested from right sixth rib and titanium mesh. Note that the right enophthalmos was a secondary deformity with severe volume loss requiring augmentation with rib graft in addition to the mesh

normal functional ocular mobility.[3,6] Alteration in the orbital connective tissue system in OBF particularly interferes with the normal system of fine connective tissue ligaments that connects all orbital soft tissue structures.[6] Alterations in this system lead to tethering, thereby restricting the range of excursion of an extraocular muscle.[3,6] Harris *et al*. suggested that trauma to the inferior fibrofatty–muscular complex may heal by intrinsic fibrosis,

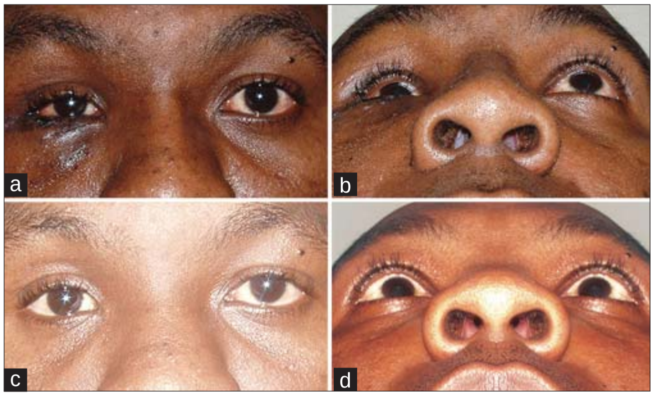

Figure 7: Comparison of pre- and postoperative view of a patient with post-traumatic right eye enophthalmos treated using titanium mesh. Note the improvement in pseudoptosis and scleral show after surgery

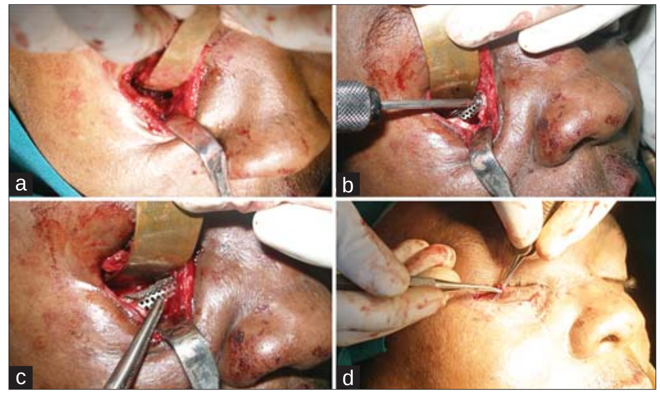

Figure 8: Transconjunctival approach with lateral canthotomy for orbital floor reconstruction using titanium mesh

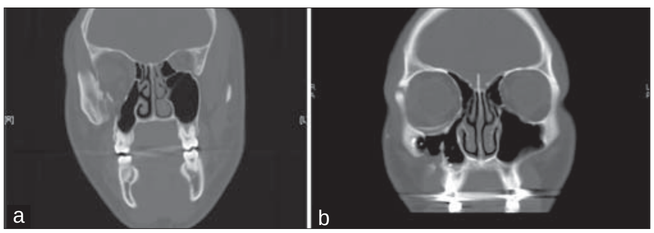

Figure 9: The diagnostic CT image showing the herniation of orbital fat and the postoperative CT showing the volume change in orbit. This volume change indicates altered orbital volume and thereby residual diplopia

leading to contraction and impeding normal globe movement, despite complete surgical reduction of the herniated tissue.[8] The other possible reasons for RD include direct damage to extraocular muscles,[10] local injury to a motor nerve,[11] or both.[3]

It has been pointed out in literature that persistence of RD even after secondary surgery is not related to the surgical technique, but that it is due to intraorbital changes that have occurred over time in the traumatized globe.[10] Reduction of the orbital volume to normal functional volume and effective mobilization of periorbital tissue often remains the goal of the secondary surgeries for RD.[3]

IRM entrapment is often the cause of RD in about 71% of study population and POM entrapment in 55% of cases. IRM and POM was significantly associated with clinical parameters such as emergency surgery, type of graft, and preoperative inflammation. With the case of emergency surgery, inflammation is a critical factor that upon resolution would drastically alter the orbital volume and placement of muscle structures. Positioning of orbit with inflammation may prove erroneous. Upon inflammation subsiding, the IRM may be observed to be entrapped within the graft [Tables 2 and 3]. Similar effect was observed in eye level placement. Owing to inflammation in emergency situations in the orbital content, checking of eye level would be often erroneous and could lead to RD as identified. Similarly, rate of remodeling of bone would alter the floor of the orbit, leading to alteration of orbit level after OBF. This significantly influences the outcome of the RD [Table 4]. No effect of factors have been identified with equator placement, indicating that this is often a stable

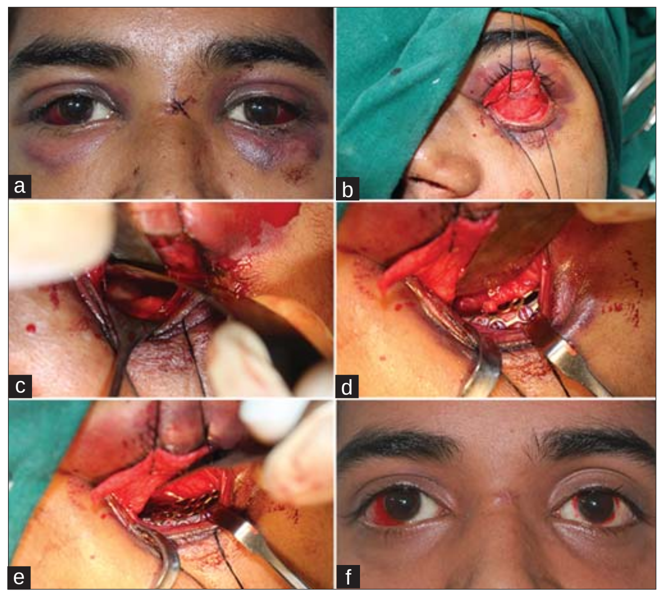

Figure 10: (a) Preoperative view - bilateral periorbital edema, subconjuctival hemorrhage, with binocular diplopia, (b) Intraoperative view – transconjunctival preseptal approach, (c) Surgical exposure of orbit floor disruption and rim fracture with no displacement, (d) Infra orbital rim fracture reduction and fixation with miniplate, (e) Orbital floor reconstruction with titanium mesh only, (f) Postoperative view

placement owing to its regional anatomical positioning [Table 3]. Edema and hemorrhage have been reported to cause proptosis of the involved orbit along with inflammation. In literature, a time period of 2-week observation is usually recommended for the resolution of proptosis before surgery can be planned. If urgent surgical indications such as necrosis exists, immediate surgery is advised.[12] In the present study, RD was associated more commonly in those cases where emergency surgeries have been done. Potential complications of OBF including blindness, infection of implanted material, implant migration, postoperative mydriasis, epiphora, and worsening of diplopia have been reported.[13]

The author's modification of secondary surgery using a cartilaginous graft on a titanium mesh to create orbital floor

Table 1: Demographic details of the study population (n=69) and the preoperative findings

Parameters	Frequency	Percent
Gender		
Male	60	87.0
Female	9	13.0
Nature of earlier surgery		
Emergency	16	23.2
Delayed	53	76.8
Wall		
Floor	55	79.7
Medial	8	11.6
Both	6	8.7
Graft		
No graft	11	15.9
With graft	58	84.1
Graft type		
Resorbable	15	25.86
Non-resorbable	43	74.14
Inflammation in musculature before surgery		
Yes	23	33.3
No	46	66.7
Inferior rectus entrapment		
Not involved	20	29.0
Involved	49	71.0
Periorbital musculature entrapment		
Yes	39	56.5
No	30	43.5
Equator abnormalities		
Yes	21	30.4
No	48	69.6
Eye level abnormalities		
Yes	15	21.7
No	54	78.3
Presence of negative transduction		
Yes	65	94.2
No	4	5.8

Table 3: Role of periorbital muscle entrapment as reason for residual diplopia

Parameters	Periorbital musculature entrapment		*P* value
	Yes	No	
Emergency surgery			
Emergency	16 (41)	0	0.000** (Y)
Delayed	23 (59)	30 (100)	
Use of graft			
No graft	7 (17.9)	4 (13.3)	0.43
With graft	32 (82.1)	26 (86.7)	
Type of graft used			
Resorbable	15 (46.9)	-	0.000** (Y)
Non-resorbable	17 (53.1)	26 (100)	
Preoperative inflammation in muscle			
Yes	20 (51.3)	3 (10)	0.000*
No	19 (48.7)	27 (90)	

*$P\leq0.05$ = Statistically significant; **$P\leq0.005$ = Highly statistically significant; Y = Yates correction

produces effective solution to problems such as graft collapse or structural alterations of graft. Through the holes in the mesh, the cartilage acts as good scaffold upon which new bone is formed making sure that it does not alter the position of IRM or the POM. The mesh gives much needed mechanical stability to the graft ensuring that the contents do not herniate. Absence of

Table 2: Role of inferior rectus muscle entrapment as reason for residual diplopia

Parameters	Inferior rectus muscle entrapment		*P* value
	Not involved	Involved	
Emergency surgery			
Emergency	0	16 (32.7)	0.009** (Y)
Delayed	20 (100)	33 (67.3)	
Use of graft			
No graft	2 (10)	9 (18.4)	0.320
With graft	18 (90)	40 (81.6)	
Type of graft used			
Resorbable	0	15 (37.5)	0.007** (Y)
Non-resorbable	18 (100)	25 (62.5)	
Preoperative inflammation in muscles			
Yes	3 (15)	20 (40.8)	0.034*
No	17 (85)	29 (59.2)	

*$P\leq0.05$ = Statistically significant; **$P\leq0.005$ = High satistically significant; Y = Yates correction

Table 4: Role of equator abnormality as a cause of residual diplopia

Parameters	Equator abnormality		*P* value
	Yes	No	
Emergency surgery			
Emergency	3 (14.3)	13 (27.1)	0.2
Delayed	18 (85.7)	35 (72.9)	
Use of graft			
No graft	2 (9.5)	9 (18.8)	0.281
With graft	19 (90.5)	39 (81.3)	
Type of graft used			
Resorbable	5 (26.3)	10 (25.6)	0.597
Non-resorbable	14 (73.7)	29 (74.4)	
Preoperative inflammation in muscle			
Yes	3 (14.3)	8 (16.67)	0.281
No	18 (85.7)	38 (79.17)	

Table 5: Role of eye level abnormalities as a cause of residual diplopia

Parameters	Eye level abnormality		*P* value
	Yes	No	
Emergency surgery			
Emergency	13 (86.7)	3 (5.6)	0.000**
Delayed	2 (13.3)	51 (94.4)	
Use of graft			
No graft	0	11 (20.4)	0.132 (Y)
With graft	15 (100)	43 (79.6)	
Type of graft used			
Resorbable	15 (0)	0	0.000** (Y)
Non-resorbable	0	43 (100)	
Preoperative inflammation in muscle			
Yes	15 (100)	8 (14.8)	0.000**(Y)
No	-	46 (85.2)	

**$P\leq0.005$ = Highly statistically significant; Y = Yates correction

inflammation in secondary surgery ensures proper placement of globe in functional position so that RD is rectified. Persistence of RD even after secondary correction in 11.6% of cases is a cause of concern, although in half of the cases, it spontaneously resolved and, in the rest, it was solvable by prisms. The neurological deficits and forced duction test failure in these cases indicate that the local anatomy has been altered with the trauma or the surgery that the globe did not adapt well, leading to functional impairment. Preoperative assessment has enabled to forewarn about such a possibility of RD.

CONCLUSION

Inflammation of orbital muscle and emergency surgeries has been shown as a major cause for postoperative RD. Use of combination graft of cartilaginous graft with titanium mesh has been shown as a wonderful tool for prevention of graft collapse. Identification of the problem preoperatively drastically decreases the incidence of RD.

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Cite this article as: Balaji SM. Residual diplopia in treated orbital bone fractures. Ann Maxillofac Surg 2013;3:40-5.

Source of Support: Nil, **Conflict of Interest**: No.