

A New Classification of Vitreous Base Avulsion

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Abstract: *Objective:* Redefinition and classification of vitreous base avulsion (VBA) adapt to the clinical need for diagnosis and treatment of it. *Design:* A retrospective consecutive case observation. *Participants:* Ninety-eight consecutive patients (98 eyes) with VBA included 23 patients with closed-globe injury, 46 with open-globe injury, 17 with rhegmatogenous retinal detachment, 6 with proliferative diabetic retinopathy, 4 with vitreous hemorrhage caused by miscellaneous diseases, and 2 with acute retinal necrosis syndrome. *Methods:* The ora serrata and the pars plana were examined carefully using a slit-lamp biomicroscopy combining with depressing Goldmann three-mirror lens before operation and observed under the surgical microscope with scleral indentation during the scleral buckling or vitrectomy surgery. The samples obtained from the operations were examined histopathologically. *Main outcome measures:* The VBA was classified into the acute and the chronic according to the happening times and was subdivided into two subtypes of surgery and eye trauma based on the causes. The acute VBA was defined that the avulsion occurred at the same time of trauma and surgery, and the chronic that was occurred after one month of open-globe injury and surgery. *Results:* The VBA was acute traumatic in 24 cases, acute intraoperative in 64 cases, chronic posttraumatic in 8 cases and chronic postoperative in 2 cases. The histopathology presented that a sheet of the nonpigmented epithelium linked to the peripheral retina in all specimens of acute traumatic and intraoperative VBA, but that the pigmented epithelium was found in the some cases. The samples of chronic posttraumatic and postoperative VBA were similar in the morphology, in which the retina, ciliary epithelia and proliferative fibrous tissues could be detected. *Conclusions:* The clinical manifestations of VBA can be divided into two types as acuteness and chronicity and two subtypes as trauma and surgery. They are all attributed to an acute or chronic vitreous traction on the vitreous base. It is most common in the cases of eye trauma, vitreous surgery and cataract surgery with vitreous loss.

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1.Introduction

The conventional vitreous base avulsion (VBA) refers to the vitreous base lying free in vitreous cavity after ocular trauma.¹⁻³ The VBA is formed instantaneously at the time of the eye trauma. However, we always observe that the VBA is a gradual progress in the clinical practices.²⁻⁴ In order to conveniently understand the processes, we redefine the VBA as a break occurring, or a separation of the retina and the ciliary epithelium from the pigment epithelium at the areas of the vitreous base when the vitreous traction on the vitreous base under the effect of an external force. Though the VBA is a common entity clinically,¹⁻⁴ it is difficult to detect by conventional method, especially in the patients with the media opacity.³ Therefore, a detailed classification of the VBA has not been depicted yet. In this study, we bring forward a new classification of VBA based on our clinical and histopathological examination.

2.Materials and Methods

We reviewed the detailed medical records between July 1997 and January 2005. Among 1405 cases of vitreoretinal surgeries, 98 patients (98 eyes)

were diagnosed VBA and included in this study. IRB/Ethics Committee approval was not required for this study, but all patients had signed the informed consent. There were 87 males and 11 females, 52 right eyes and 46 left eyes. Mean age was 32 years old (from 3 to 66 years). The causal diseases include closed-globe injury (n = 23) and open-globe injury (n = 46),⁵ rhegmatogenous retinal detachment (n = 17), proliferative diabetic retinopathy (n = 6), vitreous hemorrhage caused by miscellaneous diseases (n = 4), acute retinal necrosis syndrome (n = 2). Fifty-five patients had previous operations, including vitrectomy in 15 cases, emergent management of globe wound in 26 cases and suturing of lid laceration in 6 cases, scleral buckling in 6 cases and single cataract removal in 2 cases. Eleven Of 55 patients had intraocular foreign body extraction through vitrectomy (n=4) or external electromagnet (n=7).

Methods of examining vitreous base

The ora serrata and the pars plana were carefully examined by slit-lamp biomicroscopy with depressing Goldmann three-mirror lens before operation and with scleral indentation during the operation of scleral buckling or pars plana vitrectomy (PPV).^{6,7}

Classification standard

The VBA was classified into acuteness and chronicity according to the happening times and was subdivided into two subtypes of trauma and surgery based on the causes. The acute VBA was defined that the avulsion concurred at the same time of trauma and surgery, and the chronic VBA that was occurred after one month of trauma and surgery.

Histopathological examination

During vitrectomy, the avulsed tissues or the materials prolapsed from sclerotomy sites were collected. The specimens were immediately immersed in 10% formalin solution and delivered to pathologic

department of Ophthalmic Institute, Zhongshan Ophthalmic Center, where the samples were embedded in paraffin, sectioned and examined under microscope after they were stained with hematoxylin-eosin (HE).

3.Results and Classification

The scleral buckling surgery was performed in 8 cases and vitrectomy in 89 cases. Among them, vitreous surgery for removal of intraocular foreign body was performed in 16 cases. Only one case was treated with Argon laser photocoagulation. The classification of the VBA was following (table 1).

Tab.1 Classification of Vitreous Base Avulsion

Types		Characteristics
I. Etiological classification		
1. Acuteness		
A. Trauma	Closed-globe injury	At least one or multiple signs of ocular contusion are found as follow: lid laceration, corneal abrasion and scarring, hyphema, iridodialysis, angle recession, cyclodialysis, lens dislocation, vitreous hemorrhage, festoon in vitreous cavity, commotio retinae, retinal breaks, choroidal rupture
B. Surgery	Vitreous surgery	Vitreous incarcerates in the sclerotomy sites and cutting suction tugs the vitreous base.
	Cataract surgery	An attempt to retrieve posteriorly dislocated fragments through a limbal incision has been made when the posterior lens capsule has been broken with vitreous loss. The vitreous incarcerates in the limbal incision.
2. Chronicity		
A. Trauma	Open-globe injury	Vitreous incarceration and proliferation in the wound of anterior segment draw vitreous base radially.
B. Surgery	Vitreous surgery and transscleral IOFB* extraction	Proliferative vitreous membrane fans outwards from the sclerotomy site to the vitreous base and causes the different types of vitreous base avulsion.
II. Clinical classification		
1. Vitreous base separation		A tenting-up of retina and epithelium of pars plana ciliaris forms ridges at posterior and anterior borders of vitreous base
2. Anterior border avulsion of vitreous base		Ciliary epithelial breaks form along the anterior border of the vitreous base, where the avulsed epithelium is curled on the retina
3. Posterior border avulsion of vitreous base		Retinal dialysis forms along the posterior border of the vitreous base, where the ciliary epithelium tilts or curls on the ciliary body
4. Complete avulsion of vitreous base		Anterior and posterior borders of the vitreous base are avulsed at the same time, the vitreous base is suspending the vitreous cavity like a festoon

* IOFB: intraocular foreign body

Acute traumatic avulsion of the vitreous base

Acute traumatic VBA was most commonly encountered in closed-globe injury (n=21) and rupture

(n=3). There were 4 types of clinical manifestations (table 1): (1) the separation of the vitreous base, where a tenting-up of retina and epithelium of pars plana

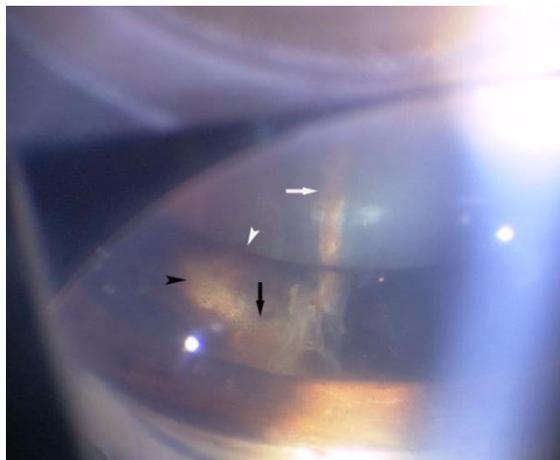


Fig. 1 Photograph of vitreous base avulsion(VBA) of a closed-globe injury. The patient have a angle cleavage, partial lens dislocation(white arrow head), complete VBA brown band(white arrow) and posterior border avulsion(black arrow). A white patch (black arrow head) may be seen behind the VBA because the ciliary pigmented epithelium has been avulsed.



Fig. 2 Photograph of complete VBA. It is the same patient as in figure one. The avulsed vitreous base floats in the vitreous cavity and contains pigment extending from 10:30 to 4 clock.

ciliaris formed ridges at posterior and anterior borders of the vitreous base (n=1); (2) ciliary epithelial breaks along the anterior border of the vitreous base, where the avulsed epithelium was curled on the retina (n=4); (3) retinal dialysis along the posterior border of the vitreous base, where the ciliary epithelium was tilted or curled on the ciliary body (n=4)(figure 1); (4) complete avulsion of the vitreous base, where the vitreous base was suspending the vitreous cavity like a festoon (n=6) (figure 1 and 2).¹Two or three types of them concurred concomitantly in 9 patients although these four types were seldom emerged in the same patient.

The ciliary muscle was exposed when the non-pigmented and the pigmented epithelia were



Fig. 3 Photograph of complete VBA. It is the same patient as in Fig. 1. The naked ciliary muscle exhibits a white patch with a couple of radial choroidal vessels, that look like zebrine striations(arrow).

avulsed together. The naked ciliary muscle exhibited a white patch with a couple of radial uveal vessels, which looked like a zebrine striation (figure 3). Rhegmatogenous retinal detachment might occur immediately or not, afterwards it developed a retinal dialysis.

One or multiple clinical signs of ocular contusion might also be found, such as lid laceration, abrasion or laceration of the cornea, conjunctival or superficial sclera laceration, hyphema, angle recession, iridodialysis, cyclodialysis, lens dislocation or subluxation, vitreous hemorrhage, commotio retinae, retinal breaks, choroidal rupture.

Acute intraoperative avulsion of the vitreous base

Acute intraoperative VBA was attributed to both vitreous incarceration of sclerotomy sites and a great cutting suction tugging on the vitreous base. During the vitrectomy, because the pressure of infusion solution forced the intraocular fluid outflow through the superior sclerotomy sites, the vitreous incarcerated in the incisions prolapsed outwards. With the repeated insertion and withdrawal of the surgical instruments, the prolapsed vitreous fibril was gradually drawing the vitreous base tightly and tore the basal posterior border or caused complete VBA at last.⁴ If the avulsed vitreous base blocked up the inner orifice of sclerotomy, the water outflow from the sclerotomy was not smooth or the pigmented gel-like content was prolapsed. If the ciliary pigmented epithelium was avulsed together, the zebrine striation could be seen. At the pars plana adjacent to the sclerotomy, a triangle area of the ciliary epithelial loss were also formed, in which the incarcerated vitreous fanned from the incision to the two ends of retinal dialysis. If the traction on the vitreous base was not loosened, the avulsed areas must be expanded with persistent prolapsing of the

intraocular contents. This case occurred in 42 eyes of 98 patients. Another intraoperative VBA happened in removal of intraocular foreign bodies. The vitreous base accompanied by removal of the intraocular foreign body was prolapsed through the extended incision at 10 o'clock (n = 11). While the anterior vitreous was being excised, too great cutting suction tugged the vitreous base causing the tenting of the ciliary epithelium and avulsion of the posterior border in 8 cases.

During the cataract surgery, the acute intraoperative VBA might be also created by attempts to retrieve posteriorly dislocated fragments through a limbal incision when the posterior lens capsule had been broken with vitreous loss. Generally, the avulsed type was the break at the posterior border of the vitreous base. The vitreous drew the anterior flap of the tear towards the limbal incision. The size of the tears was changed from one clock hour to giant tear (n = 3). These features are easily differentiated from other types of iatrogenic retinal breaks.

Chronic posttraumatic avulsion of the vitreous base

The diagnosis of chronic posttraumatic VBA was based on the vitreous incarceration at the wound of the anterior segment, in which the proliferative fibrous tissue fanned outward from it to the avulsed vitreous base. These wounds were resulted from either open-globe injury or scleral incision for intraocular foreign body extraction. The avulsed areas might be located at the opposite side, but also adjacent to the side of the wound. All types of the VBA described above might occur.² The complete avulsed vitreous base, however, crossed the vitreous cavity. It was fixed by contracting membrane tissues. The VBA created retinal dialysis leading to retinal detachment. This type of VBA was found in 8 patients.

Chronic postoperative avulsion of the vitreous base

Chronic postoperative VBA was also related to vitreous incarceration in sclerotomy sites. The VBA did not occur during the operation, but the incarcerated vitreous proliferated and produced fibrosis leading to traction VBA afterwards (n=2). Fibrovascular ingrowth and pigmentation were commonly detected at the incision sites,³ furthermore, a radial incarcerated vitreous, triangular epithelial loss and retinal dialysis might be detected at the inner aspect of sclerotomy sites (figure 4). The complete avulsed vitreous base might cross the vitreous cavity. No chronic postoperative VBA was found after cataract surgery in this study.

Seventeen specimens of VBA were collected from vitrectomy, including the acute traumatic VBA in 2 cases, acute intraoperative VBA in 13 cases, chronic posttraumatic VBA in 1 case and chronic postoperative VBA in 1 case. These samples had a common characteristic, i.e. they contained a sheet of the ciliary

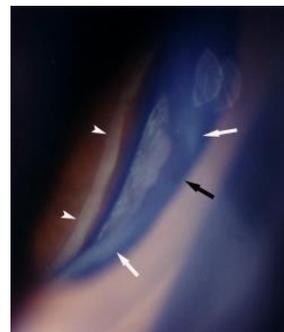


Fig. 4 Photograph of chronic VBA after surgery. The vitreous (white arrow) which radially incarcerated in sclerotomy site at 10 o'clock (black arrow). The avulsed vitreous base leading to an oral dialysis (arrow head) two months after the initial vitrectomy. The ciliary muscle is naked between the vitreous (white arrow) and the oral dialysis (arrow head). The oral dialysis was not found during intraoperative examination through a scleral indentation.

Histopathological results

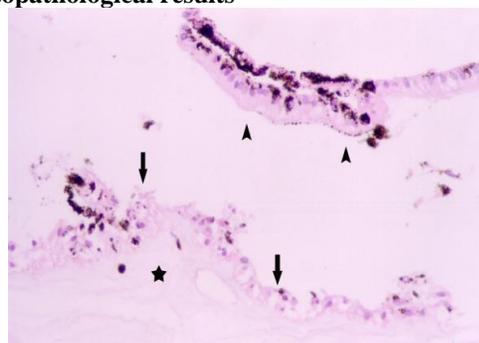


Fig. 5 Photograph of pathological examination. The biopsy of acute traumatic BVA demonstrates a sheet of ciliary nonpigmented attached by pieces of the pigment epithelium (arrow head) combining with peripheral neuroretina (arrow). The vitreous is clear (star) HE X 20



Fig. 6 The prolapsed tissue intraoperatively collected from sclerotomy site shows a sheet of the ciliary nonpigmented epithelium (black arrow head) connecting with neuroretina (black arrow) at the ora serrata (white arrow head). The brown layer is the

retinal pigment epithelium(white arrow) HE ×20

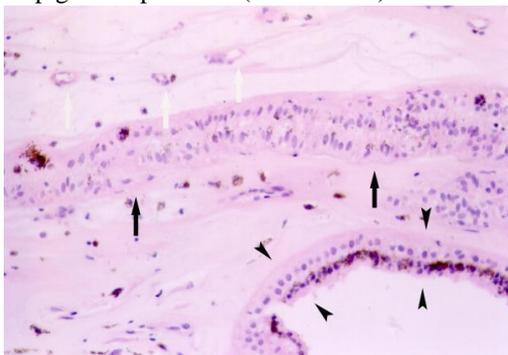


Fig. 7 Photograph of pathological examination. The biopsy of chronic traumatic VBA reveals multi-sheet of intraocular tissues, including the pigmented layer and nonpigmented layer of the ciliary body (black arrow head), retinal tissues(black arrow) and neovascular tissues in proliferative vitreous gel (white arrow) HE ×20

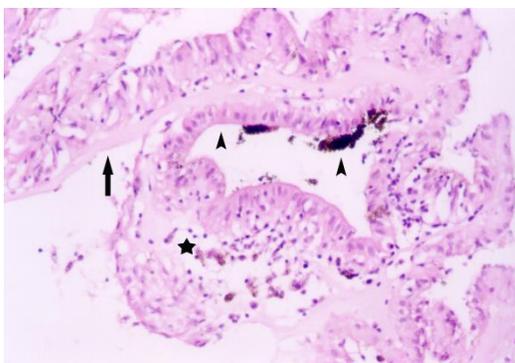


Fig. 8 Photograph of pathological examination. The patient with acute retinal necrosis syndrome had a vitreous surgery three months ago. An extensive vitreous proliferation occurred at the vitreous base. A complete vitreous base avulsion crossed the vitreous cavity between 2 o'clock and 8 o'clock. The specimen of the VBA comprises the ciliary nonpigmented and pigmented epithelia(arrow head), the neuroretina (arrow) and the proliferative tissues(star) HE ×20

nonpigmented epithelium and peripheral neuroretina (figure 5-8). The linking point of the ciliary epithelium and the retina could be easily identified. Some specimens also comprised pieces of the pigment epithelium adherent to the nonpigmented epithelium or the retina. The features were similar in acute traumatic and acute intraoperative samples, and the vitreous gel did not include the proliferative tissues (figure 5 and 6). But, in the chronic posttraumatic and chronic postoperative samples, proliferative fiber tissues or neovascularization were found in the vitreous gel (figure 7 and 8).

4. Discussion

According to our definition of the VBA mentioned at the first paragraph, the strike of external force is a prerequisite for diagnosis of the VBA. The ocular trauma and surgeries are the severe strike to the eye, especially when they interfere in the vitreous. The chronic posttraumatic and postoperative VBAs are actually sustaining circumstances after the strikes. The definition is differentiated from the other intraocular breaks created spontaneously. In addition, the VBA is a gradual progress except acute traumatic case. When the vitreous base is suffered from a tug, the separation of the vitreous base occurs at first. The strong tugging force just as tearing the thing results in the avulsion at the anterior or posterior border of which are the weakest places of the vitreous base. At last, the complete VBA produces with the increasing traction. The classification is perfectly combined with the processes and results of the VBA.

The clinical manifestations of the VBA have been classified into four types.¹ They are tenting of vitreous base, the avulsed breaks at anterior border, posterior border and both borders (complete avulsion). The traumatic VBA had been simulated and was associated with a high speed deformation of the cornea and sclera.⁸ The impact initiated so violent sclera expands and oscillates that the vitreous base and attached ciliary epithelium were pulled away from the pigment epithelium of the pars plana ciliaris. Clinically, the same mechanism caused the VBA both in closed- and open-globe ocular injuries.^{1,2} In this study, after 98 patients with the VBA were meticulously studied on their clinical characteristics and partial histopathologic samples, we found that the surgeries itself could also cause different types of the VBAs and that they could be subdivided into the acute and the chronic. The acute intraoperative VBA had been described in detail in our previous study.⁴ They were attributed to the traction on the vitreous base when the vitreous incarceration in the sclerotomy sites,⁹ the large cutting suction to the vitreous base, intraocular foreign body extraction through expanded sclerotomy or cataract removal with vitreous loss.¹⁰ Kreiger described the clinical manifestations of chronic VBA after PPV, which was caused by vitreous incarceration and proliferation at scleral incisions.³ But he did not recognize it as the VBA. The clinical features of the chronic posttraumatic VBA were also discussed in prior study and related to vitreous incarceration in wound and fibrosis contraction.² To our best knowledge, this study is the first time to classify the VBA systemically according to their onset time and etiology.

We found a fact that the tears were located at the anterior and posterior border of the vitreous base in the present study. No matter what pathogeneses caused the VBA, we did not observe the real retinal dialysis that is

defined as the separation of the neurosensory retina from the nonpigmented ciliary epithelium at the ora serrata.¹¹ It appears to be in conflict with the current conception.^{12,13} However, it is well known that the vitreous fibrils are firmly inserted into the epithelium and the retina at the vitreous base and very resistant to separation.¹⁴ The retinal dialysis occurs when the ora serrata is suffering from a developmental abnormality or a weakness.¹¹ Because the prerequisite was rare in our series, all the breaks were located at the anterior and posterior borders of the vitreous base, where is the weakest places of the vitreous base. The case has been supported by our histopathologic examination of the samples of the VBA, in which all of the specimens contain a sheet of ciliary epithelium and peripheral neuroretina (figure 5-8). This finding is similar to Cox and colleagues' observation.¹

The investigation of the classification and pathogenesis of VBA plays an important role in the precaution and treatment of this entity. For patients with closed-globe injury, especially with other signs of the ocular contusion, the vitreous base should be carefully examined so that the VBA can be treated as early as possible.¹⁵ For patients with penetrating trauma of anterior segment and with vitreous incarceration in the wound, the chronic VBA should be prevented and treated. When posterior lens capsule has been broken, one should avoid vitreous traction during attempts to remove posterior fragments by means of the limbal incision.¹⁰ During vitreous surgery, a complete vitrectomy of the superior vitreous base and the pars plana should be first performed before the cutter and the endoilluminator are withdrawn to avoid vitreous incarceration in the sclerotomy entry sites. A high cutting velocity (≥ 650 cuts/min) and low suction (< 20 mmHg) should be used when the vitreous shaving is near to the vitreous base. At the end of the surgery, the inner aspect of sclerotomy sites should be examined with scleral indentation to prevent and treat the sclerotomy-related complications.⁷ All of the measures are necessary for improving the successful rate of vitreous surgeries.

The new classification of the VBA is raised based on the authors' personal experience and the review of a great number of literatures. Though a great endeavor has been made to sum up a comprehensive description of the classification as in detail as possible, some of inaccurate depictions must be existed. Therefore, the authors appreciate the ophthalmologic experts participate in discussion and make it more perfect.

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