Arch. Soc. Amer. Oftal. Optom. (1979)-13-193

VITRECTOMY BY ASPIRATION IRRIGATION AFTER ULTRASONIC FRAGMENTATION

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Formed vitreous cannot be aspirated through even a large cannula such as an 18 gauge needle. In 1972 the author discovered that formed vitreous could be fragmented by high speed vibrations such as those produced with an ultrasonic generator. Vibrations had to be between 20.000 and 40.000 vibrations per second. When the vitreous was fragmented in this way it was possible to aspirate formed vitreous through a 23 gauge cannula. An instrument was designed [1] to produce vibrations in a 23 gauge cannula. The technique was first reported by the author in 1973 and was used to perform vitrectomy as well as aspiration of cataracts (18-28). Since that time the technique has been tried in several conditions involving the vitreous. This report will review the technique briefly and report the results of the first 57 consecutive cases in which it was used.

Technique

In this technique two 23 gauge needles attached by plastic tubing to two 50 cc syringes are used to perform aspiration and irrigation. For ultrasonic fragmentation the aspiration needle is attached to an ultrasonic vibrator. Irrigation through the irrigating needle keeps the anterior chamber formed while aspiration is performed after ultrasonic fragmentation. This technique can be performed either through the anterior chamber or the pars plana.

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1 Girard Fragmentor, Manufactured by Sparta Instrument Company, Fairfield, New Jersey.

Anterior Chamber Approach. Indications are: 1) adherence of the vitreous to the cornea; 2) aphakic bullous keratopathy; 3) cystoid macular edema; 4) massive vitreous contraction and retinal detachment in aphakia.

In this technique two incisions are made in the superior nasal and superior temporal quadrants 1 mm inside the limbus. The incisions should be about 1 mm in width and should be beveled. A 23 gauge needle attached by a plastic tubing to a 50 cc syringe containing balanced salt solution is inserted into the anterior chamber and is held in place by the surgeon. An assistant keeps the anterior chamber formed. A second needle is inserted into the opposite incision. The needle is attached by a plastic tubing to an empty 50 cc syringe. The needle is held by a handle which is an ultrasonic vibrator (Figs. 1 a, b). Observing the two needles through the cornea, utilizing an operating room microscope with co-axial illumination, vitrectomy is performed by aspiration-irrigation with short bursts of ultrasonic vibration (Figs. 2 and 3 a-c).

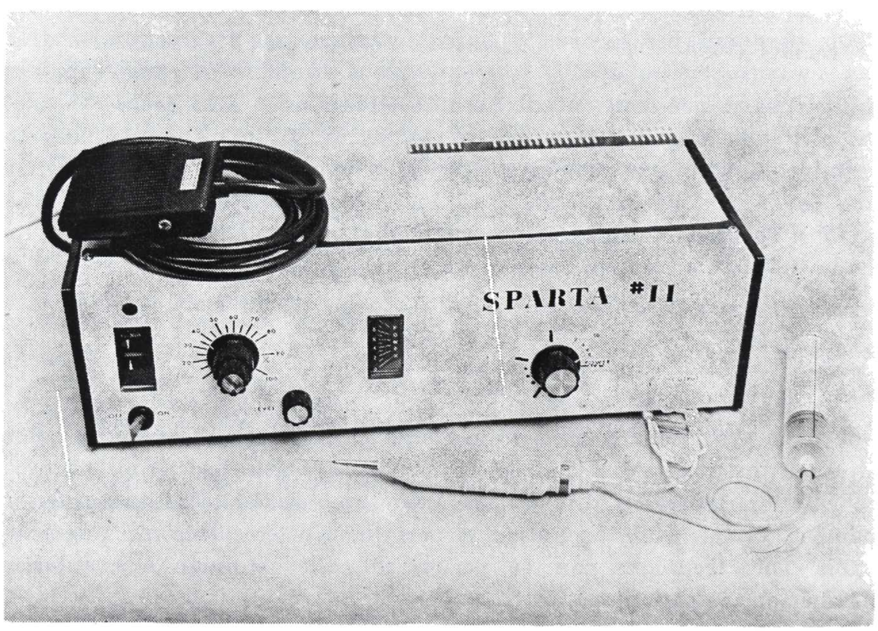

FIGURE 1 a
Instruments necessary for vitrectomy by ultrasonic aspiration and irrigation.

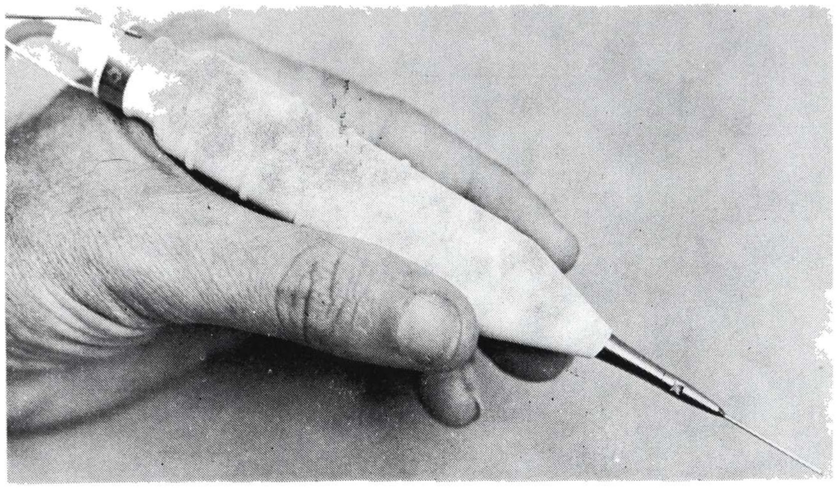

FIGURE 1 b
Ultrasonic probe with the aspiration needle attached.

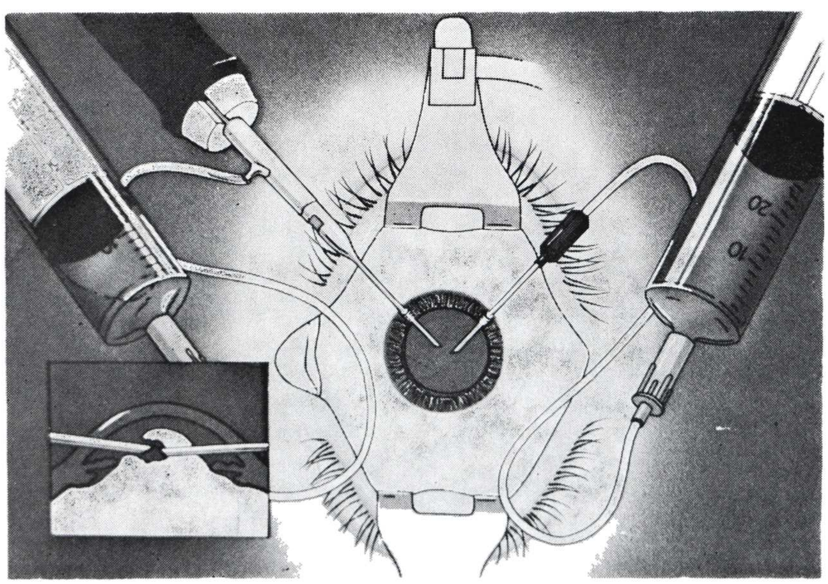

FIGURE 2
Vitrectomy by ultrasonic fragmentation. Anterior chamber approach.

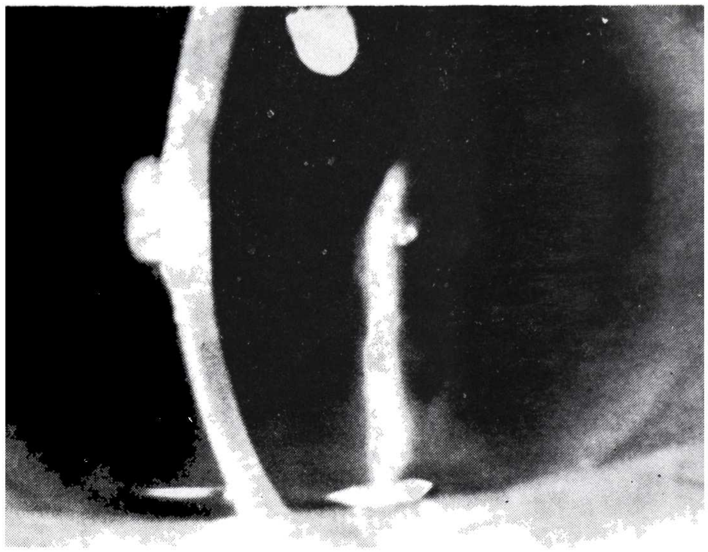

FIGURE 3 a
Aphakic bullous keratopathy from vitreous adherence.

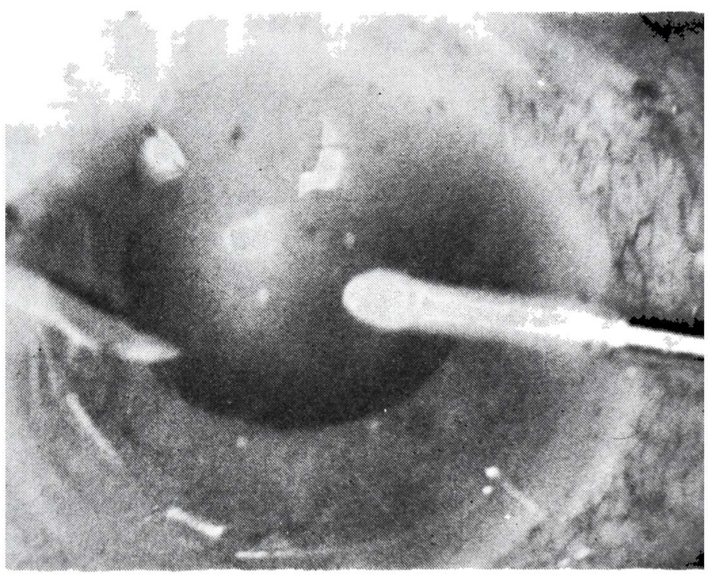

FIGURE 3 b
Vitrectomy by ultrasonic aspiration and irrigation.

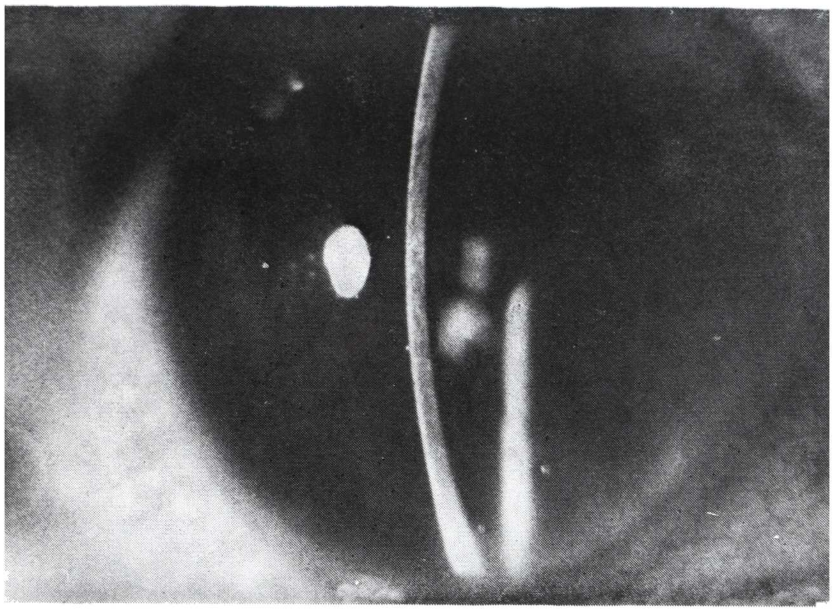

FIGURE 3 c
Postoperative appearance. Vision inproved from 20/400 to 20/40.

Should the epithelium be bullous it should be removed before beginning the procedure.

Vitrectomy should be carried out back through the pupil until there is no evidence of herniation of formed vitreous into the anterior chamber. At the end of the procedure the needles are withdrawn and air is instilled into the anterior chamber. No sutures are required. The patient should be treated with anti-inflammatory agents during the postoperative period.

Vitrectomy Through the Pars Plana. In the pars plana approach the conjunctiva is incised in the superior nasal and superior temporal quadrants, 7 mm back from the limbus and the sclera exposed. A caliper is used to mark four to five milimeters and a stab incision is made into the globe with a Ziegler knife. The irrigating and aspirating cannulas are inserted and observed through the pupil in the vitreous cavity (Fig. 4). Vitreous opacities are easily visualized when using co-axial illumination. Particular care must be taken not to touch the lens or a cataract can be produced. Ordinari it is not necessary to use a contact lens as the microscope can be focused a sufficient depth to observe the aspiration and irrigation, almost to tl retina. In all of the cases the vitreous is detached posteriorly and is in tl central or anterior portion of the vitreous cavity. However, when it necessary to view the retina a flat surfaced contact lens can be employ (Fig. 5 a-c).

Conditions for which vitrectomy through the pars plana have be used are: 1) in phakic eyes with opacification of the vitreous from massi vitreous hemorrhage, diabetes, amyloidosis, etc.; 2) pupillary block; 3) massive vitreous contraction and retinal detachment; 4) in massive vitreo hemorrhage and retinal detachment; 5) in massive vitreous hemorrhag retinal detachment and intraocular foreign bodies.

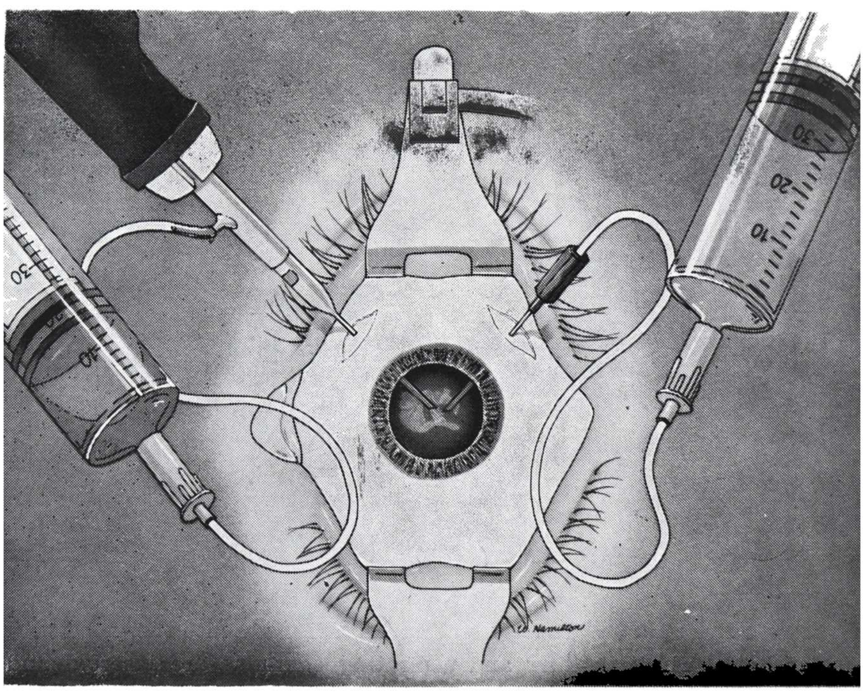

FIGURE 4

Vitrectomy by ultrasonic fragmentation. Pars plana approach.

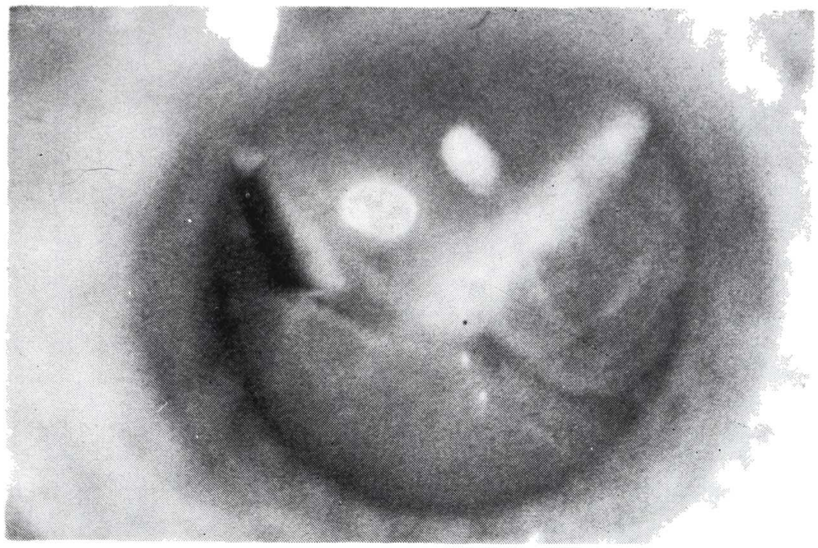

FIGURE 5 a

Vitrectomy by ultrasonic aspiration in a case of massive vitreous hemorrhage of 3 and a half years duration.

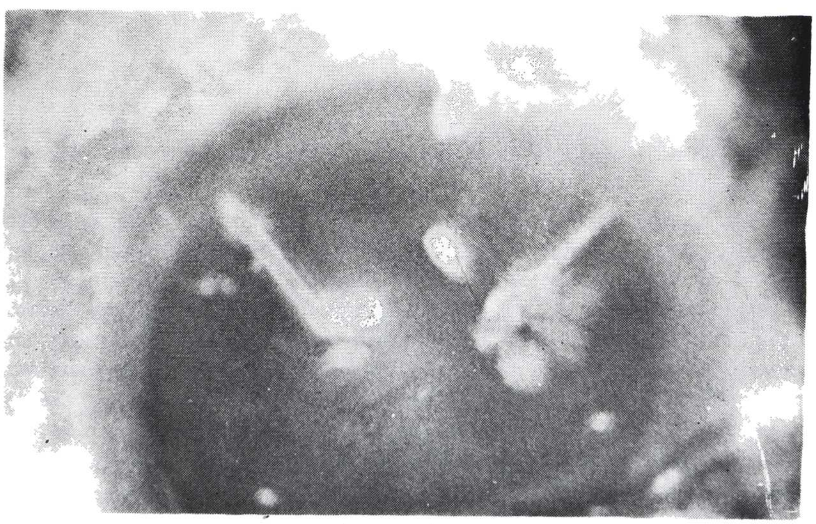

FIGURE 5 b

After partial vitrectomy.

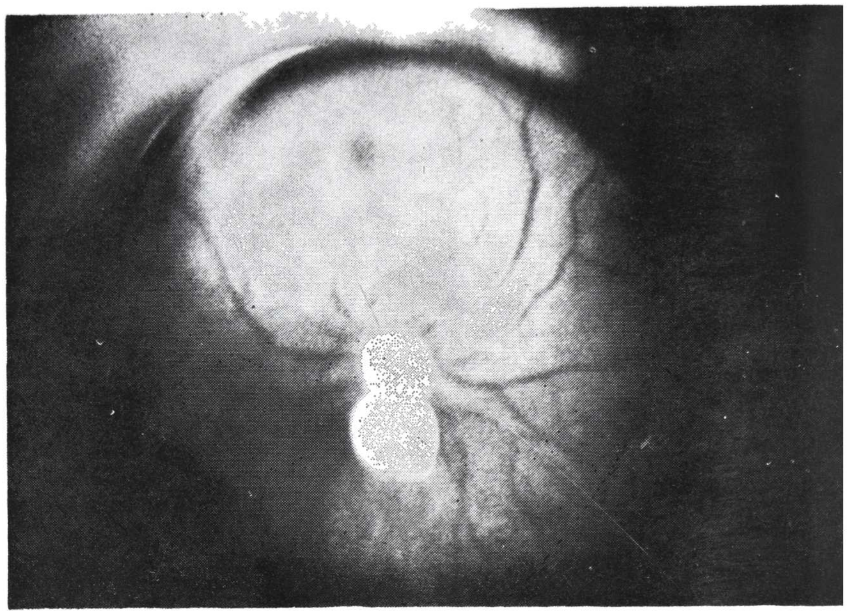

FIGURE 5 c

Appearance of fundus after cataract extraction and vitrectomy by ultraso aspiration. Vision with correction is 20/15

Results

Ultrasonic fragmentation and aspiration of the vitreous has been us in the conditions shown in Table 1.

Aphakic Bullous Keratopathy. The results in aphakic bullous kera pathy are shown in Tables 2 and 3. In all cases (100%) there was compl removal of vitreous from the anterior chamber. The cornea improved six of the seven cases (86%), in spite of the fact that the bullous kera pathy had been present from a few months to as long as eleven years. T vision improved in five of the seven cases (71%). In one case there v an initial improvement from 20/200 to 20/40, but the cornea later deco pensated and required a penetrating keratoplasty.

Pupillary Block. In pupillary block which has not responded to incis of the anterior hyaloid or a peripheral iridectomy, vitrectomy through t pars plana has been used in three cases. The glaucoma was relieved all the cases (100%) and there were no further complications (Table 4).

TABLE 1

CATEGORIES OF PATIENTS TREATED WITH VITRECTOMY BY ASPIRATION AFTER ULTRASONIC FRAGMENTATION

1.	Aphakic bullous keratopathy	7
2.	Pupillary block	3
3.	Cystoid macular edema	4
4.	Peaked pupil and vitreous adherence to the wound	2
5.	Vitreous opacification other than hemorrhage	6
6.	Massive vitreous hemorrhage	18
7.	Massive vitreous hemorrhage and retinal detachment	4
8.	Massive vitreous contraction and retinal detachment	4
9.	Massive vitreous membrane and retinal detachment	2
10.	Massive vitreous hemorrhage, intraocular foreign bodies and retinal detachment	7

TABLE 2

RESULTS IN APHAKIC BULLOUS KERATOPATHY TREATED BY ULTRASONIC FRAGMENTATION

Case		*Vision*			*Cornea*	*Length of time before treatment*
		Preop	*Best*	*Final*		
1.	AA	20/70		20/25	Clear	Unknown
2.	LL	20/200	20/40	4/200	Recurred	2 yrs.
3.	EB	20/60	20/20	20/50	Clear	1 yr.
4.	HC	20/300		20/80	Clear	3 mos.
5.	HC	HM		HM	Clear	11 yrs.
6.	CS	5/300		20/400	Hazy	6 yrs.
7.	JE	20/40		20/30	Clear	Unknown

TABLE 3

APHAKIC BULLOUS KERATOPATHY

Number of patientes	7	
Anatomical Results		
Improved	6	(86%)
Unimproved	1	
Visual Results		
Improved	5	(71%)
Unimproved	2	

TABLE 4

PUPILLARY BLOCK

Number of Patients	3	
Anatomical Results		
Improved	3	(100%)
Unimproved	0	

Persistent Cystoid Macular Edema. Five cases of persistent cystoid macular edema were treated by vitrectomy. All of these cases had been resistent to treatment with steroids and phenylbutazone, or had improved and then relapsed. In all cases there was vitreous attached to the wound. This was removed successfully in each case (100%). The vision improved in four of the five cases (80%) (Tables 5 and 6).

Peaked Pupil From Adherence To The Wound. In peaked pupil from vitreous adherence to the wound, single strands can be broken by the chopping block technique (26). Where there is extensive adherence of vitreous to the wound, the technique of vitrectomy by aspiration after ultrasonic fragmentation has been used in two cases. It has been possible to remove the vitreous in both cases (100%), releasing the pupil and without producing further complications (Table 7).

TABLE 5

CYSTOID MACULAR EDEMA

Case	*Vision*		*Anat/Res*
	Preop	*Postop*	
1. LT	20/200	20/100	Clear
2. EW	20/200	20/30	Clear
3. WW	20/70	20/40	Clear
4. PK	20/200	20/200	Clear
5. JFS	20/100	20/50	Clear

TABLE 6

CYSTOID MACULAR EDEMA

Number of Patiens	5	
Anatomical Results		
Improved	5	(100%)
Unimproved	0	
Visual Results		
Improved	4	(80%)
Unimproved	0	
Unchanged	1	

TABLE 7

PEAKED PUPIL FROM VITREOUS ADHERENCE TO THE WOUND

Number of Patiens	2	
Anatomical Results		
Improved	2	(100%)
Unimproved	0	

Vitreous Opacification Other Than From Hemorrhage. Six cases of vitreous opacification other than from vitreous hemorrhage were treated by vitrectomy. The vitreous cavity cleared in all cases (100%), and vision improved in four of the six cases (67%) (Tables 8 and 9).

TABLE 8

VITREOUS OPACIFICATION OTHER THAN HEMORRHAGE

Case		*Vision*		*Anat/Res*
		Preop	*Postop*	
1.	HCM	20/60	20/200	Clear
2.	HCM	20/80	20/40	Clear
3.	HH	3/200	20/400	Clear
4.	RC	1/200	20/40	Clear
5.	MR	LP	HM	Clear *
6.	JD	20/400	20/400	Clear

* Acid burn, severe glaucoma, and keratoprosthesis.

TABLE 9

VITREOUS OPACIFICATION

Number of Patients	6	
Anatomical Results		
Improved	6	(100%)
Unimproved	0	
Visual Results		
Improved	4	(67%)
Unimproved	1	
Unchanged	1	

Massive Vitreous Hemorrhage. Vitrectomy with the present technique was used in 18 cases of massive vitreous hemorrhage. The vitreous cavity remained clear in 14 (78%) of the cases (Table 10). In some cases the vitreous had been filled with blood for as long as three and a half years. In cases of diabetic retinopathy and vitreous hemorrhage there was recurrence of bleeding at times, but since the formed vitreous had been removed the blood absorbed rapidly. In many cases it was possible to perform photocoagulation within a week after the vitrectomy.

TABLE 10

MASSIVE VITREOUS HEMORRHAGE

Case	*Vision*		*Anat/Res*
	Preop	*Postop*	
1. LF	1/200	6/200	Clear
2. FS	NLP	NLP	Recurrent Bleeding
3. JOH	LP	LP	Clear
4. JR	LP	20/40	Clear
5. JH	NLP	NLP	Recurrent Bleeding
6. NH	4/200	5/200	Clear
7. JH	LP	20/20	Clear
8. MR	20/30	20/20	Clear
9. RK	HM	20/60	Clear
10. BB	2/200	1/200	Hazy
11. LN	LP	20/60	Clear
12. GN	LP	LP	Recurrent Bleeding
13. SL	5/200	5/200	Clear *
14. IMC	LP	LP	Recurrent Bleeding
15. ED	LP	LP	Clear
16. CG	20/200	20/60	Clear
17. LB	LP	6/200	Clear *
18. MH	LP	20/80	Clear +

* Diabetic.

\+ Cataract Extraction - Trauma.

Vitrectomy in cases of massive vitreous hemorrhage can be quite dramatic. Some patients improved from ligth perception to 20/20; 20/60; or 20/80 (Table 11). Anatomical improvement (clear vitreous cavity) occurred in 14 of the 18 cases. Vision improved in 10 of the 18 cases (56%).

Massive Vitreous Hemorrhage And Retinal Detachment. Four patients with massive vitreous hemorrhage and retinal detachment as shown by ultrasonography and faulty retinal function tests were treated with this technique. The anatomical results were excellent. Three of the four patients have clear vitreous cavities and the retina was re-attached by a scleral buckle (75%). The visual improvements in four cases was not impressive; however, it should be pointed out that these were cases with a poor prognosis, i.e., perforating injuries and one case of severe diabetic retinopathy (Table 12).

TABLE 11

MASSIVE VITREOUS HEMORRHAGE

Number of Patients	18	
Anatomical Results		
Improved	14	(78%)
Unimproved	4	
Visual Results		
Improved	10	(56%)
Unimproved	1	
Unchanged	7	

TABLE 12

MASSIVE VITREOUS HEMORRHAGE
AND RETINAL DETACHMENT

Number of Patients	4	
Anatomical Results		
Improved	3	(75%)
Unimproved	1	
Visual Results		
Improved	0	
Unimproved	0	
Unchanged	4	

Massive Vitreous Contraction And Retinal Detachment. Four cases of massive vitreous contraction and retinal detachment were treated by vitrectomy after ultrasonic fragmentation. In all four cases the contracted formed vitreous was successfully removed (100%). The retina was reattached in two of the cases by scleral buckling procedures (50%). Vision remained unimproved, however, in three of the cases, and was reduced in one case (Table 13).

TABLE 13

MASSIVE VITREOUS CONTRACTION AND RETINAL DETACHMENT

Number of Patients	4	
Anatomical Results		
Improved	4	(100%)
Unimproved	0	
Visual Results		
Improved	0	
Unimproved	1	
Unchanged	3	

Massive Vitreous Membrane And Retinal Detachment. Two cases of massive vitreous membrane and retinal detachment were treated. The membranes were removed in both cases and there was complete clearing of the vitreous cavity (100%); however, there was only slight improvement in vision in one case. Again, these were severely damaged eyes (Table 14).

TABLE 14

MASSIVE VITREOUS MEMBRANE AND RETINAL DETACHMENT

Number of Patients	2	
Anatomical Results		
Improved	2	(100%)
Unimproved	0	
Visual Results		
Improved	1	
Unimproved	0	
Unchanged	1	

Massive Vitreous Hemorrhage And Retinal Detachment Due To A: Intraocular Foreign Body. Seven cases were treated, and in five of the seve: cases the vitreous could be cleared (71%) and the retinal detachmen observed. After repair of the retinal detachment only one case showed a: improvement in visual acuity. Three cases remained unimproved and thre cases became worse, one case progressing to phthisis bulbi. Again, thes were desperate cases (Table 15).

TABLE 15

MASSIVE VITREOUS HEMORRHAGE
INTRAOCULAR FOREIGN BODIES
AND RETINAL DETACHMENT

Number of Patients	7	
Anatomical Results		
Improved	5	(71%)
Unimproved	2	
Visual Results		
Improved	1	
Unimproved	3	
Unchanged	3	

TABLE 16

RESULTS OF ULTRASONIC VITRECTOMY

Total Number of Patients	57	
Anatomical Results		
Improved	50	(88%)
Unimproved	7	(12%)

DISCUSSION

Vitreous surgery has become a common place ophthalmic procedure since 1968. Initially most procedures were done with the open sky technique (1-14). With the introduction of the vitreous suction cutter by Machemer (15, 16), various devices have been introduced to perform vitrectomies, such as the Douvas (17) rotary extractor, and Kloti's victretome. These devices all employ a mechanical means of cutting and aspirating the vitreous. The author was the first to introduce ultrasonic fragmentation as a means of cutting the vitreous. Also he was the first to be able to perform aspiration of formed vitreous through a very fine cannula (a 23 gauge needle has a diameter of 0.6 of a millimeter, and, therefore, the incision to insert the cannula needs to be only one millimeter in length).

It is important to understand that the mechanism of fragmentation, either of the vitreous or of cataracts is not being performed by ultrasonics, per se, such as a beam of ultrasound as is used for ultrasonagraphy or sonar. Fragmentation is produced by rapid vibration of the aspirating needle. An electrical current activates an oscillator which, in turn, sets up vibrations in a piezoelectric crystal which vibrates at approximately 40.000 vibrations per second (kiloherts). This is amplified by a resonance to the tip of the aspirating needle. The aspirating needle has been shown to vibrate in a longitudinal direction les than .001 inches at 40.000 cycles per second. It is the physical movement of the tip of the needle which produces the fragmentation of the cataract or the vitreous.

It is interesting that striate keratopathy and bullous keratopathy sometimes can be produced when utilizing ultrasonic fragmentation for cataract extraction (19, 23, 24), while no damage has been produced to the corneas in vitrectomies, even though the ultrasonically vibrating needle has been brought withing a fraction of a millimeter of the back of the cornea. Evidently it is the physical contact to the back of the cornea by a hard nucleus which produces the endothelial damage rather than the vibrating needle. There has been no evidence that the ultrasonic vibration has produced any damage to the cornea or to the retina, even though the instrument has been brought very close to these structures. It will, of course, produce damage if it is brought in direct contact with these tissues.

The results in aphakic bullous keratopathy are inexplicable at the present time. It is difficult to understand how removal of the vitreous can result in regeneration of the corneal endothelium. Yet it has occurred in patients who have had bullous keratopathy for as long as two years. Apparently, if there is some normal endothelium it is possible for the cornea endothelium to cover the denuded areas. It is the author's opinion tha this technique should be tried, preferably early, as soon as bullous keratopathy can be seen to be developing from a vitreous touch. The technique is simple and has not resulted in further complications. Certainly it should be tried before recommending a more extensive procedure like a penetrating keratoplasty.

Cystoid macular edema has been an enigma to ophthalmic surgeons The exact mechanism is unknown. It does seem to result from creation of an inflammatory process in the anterior segment which is somehow transmitted to the retina. Patients with vitreous adherence to the wound almost inevitably develop cystoid macular edema. In patients who do not respond to this conservative treatment, this technique should be considered since it is simple and has so few complications.

In pupillary block it should be understood that there are adhesions between the iris and the vitreous, not only at the pupillary area, but in some cases over the entire posterior surface of the iris. This is why many times conservative treatment (forced mydriasis, incision of the anterior hyaloid, etc.) is insufficient. Even a peripheral iridectomy may be insufficient because it may not create a passage, due to the vitreous blocking the peripheral iridectomy. When this occurs, a simple means of performing an anterior vitrectomy is with ultrasonic fragmentation.

When the formed vitreous becomes filled with blood it will not absorb even after a prolonged time unless there is great liquefaction of the vitreous. Vitrectomy with ultrasonic fragmentation is a simple matter and can be performed in a few minutes with very gratifying results. The surgery is directed towards the central core of the vitreous leaving the vitreous base intact. Many times, interestingly, the vitreous which remains at the base will clear with time, indicating that once the liquefaction process starts, it continues. The aspirated vitreous is replaced by balanced salt solution and then very shortly by the patient's aqueous. If additional bleeding occurs to a vitrectomized eye the aqueous may become turbid, but then clear very rapidly. In patients who have recurrent bleeding, such as diabetes, this has been observed. Photocoagulation can be carried out within a few days after a vitrectomy.

Where a retinal detachment is obscured by a hemorrhage it is possible to perform retinal surgery at the same time or within a few days of the vitrectomy, because in essence, there is a closed system. Even though experience is limited, there is evidence that this procedure will aid the retinal surgeon in being able to view the retinal holes and to reattach the retina.

When the retina is being held detached by vitreous bands, massive vitreous contraction, or vitreous membranes, vitrectomy by this technique offers the retinal surgeon a better opportunity for retinal re-attachment. As the vitrectomy is being performed it is possible in many cases to see the retina settle backwards. It may be that one day this will be a routine procedure in conjunction with retinal surgery.

SUMMARY

Vitrectomy by aspiration irrigation after ultrasonic fragmentation is a procedure first described by the author in 1973. The technique has been used in such conditions as: aphakic bullous keratopathy due to vitreous adhesions; pupillary block glaucoma; cystoid macular edema secondary to vitreous adhesions; peaked pupil from vitreous adherence to the wound; massive vitreous hemorrhage; massive vitreous hemorrhage and retinal detachment; massive vitreous contraction and retinal detachment; and massive vitreous hemorrhage, retinal detachment, and intraocular foreign bodies. The technique is described and the results reported.

SUMMARY

The author first described this procedure in 1973. The following routes are used:

a) Through the Anterior Chamber in cases of:
   1) Vitreous adherence to the cornea.
   2) Bullous keratopathy in aphakics.
   3) Cystic macular edema.
   4) Massive vitreous contraction with retinal detachment in aphakicks.

b) Through the Pars Plana in cases of:
   1) Vitreous opacity due to massive hemorrhage, diabetes, and amiloidoses.
   2) Pupillary block.

3) Massive contraction of the vitreous with retinal detachment.

4) Vitreous hemorrhage with retinal detachment.

5) Vitreous hemorrhage with retinal detachment and foreign body.

Basically, in this technique 2 incisions are performed in the nasal and temporal superior quadrants. These incisions are made 1 mm. from the limbus for the anterior route and 7 mm. from the limbus for the pars plana route. Two Nº 23 cannulas joined to a plastic tube are introduced through them; the first cannula is connected to a syringe with 50 cc of saline, and the second one is connected to the ultrasound vibrator and the aspiration system. The operation is performed with the aid of a microscope with coaxial illumination.

Fragmentation of the vitreous body is obtained through fast vibration discharges which oscillate between 20.000 - 40.000 vibrations per second with an oscillating movement of only 0.001 of an inch, rendering this technique harmless.

Irrigation is permanent to maintain a good chamber. When the pars plana route is used, the movement of the cannulas may be observed through the dilated pupil with the aid of coaxial illumination and contact lenses.

After performing the vitrectomy the cannulas are withdrawn.

Sutures are not necessary.

The author presents several cases of patients who have undergone this procedure with satisfactory results, especially in massive vitreous hemorrhages; bullous keratopathies, and pupillary block.

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