Surgical Technique

Limited pars-plana vitrectomy for optimizing surgical outcome in subluxated cataracts undergoing femtosecond laser-assisted cataract surgery

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We propose a technique for combined femto laser-assisted cataract surgery (FLACS) and limited vitrectomy from the pars-plana site for optimization of surgical results in subluxated cataracts. FLACS creates a free-floating, customised capsulotomy, minimizes stress on compromised zonules, and prechops the nucleus, effectively reducing the ultrasonic power as well as the forces required to chop the nucleus. The area of zonular dehiscence creates a direct communication between the irrigation fluid and the anterior vitreous, leading to its hydration. Trans-limbal vitrectomy creates a continuum between the liquefied vitreous and the main wound, leading to further vitreous loss, and exaggeration of the zonular weakness, while pars-plana vitrectomy avoids this by cutting the liquefied vitreous, near its attachment, thereby preventing further hydration and causing lesser stress to the zonules. A combination of these procedures, along with a capsule support device, gives favorable surgical outcomes in moderate to severe subluxations.

Key words: Femtosecond laser-assisted cataract surgery, FLACS, pars-plana vitrectomy, subluxated cataract

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DOI:
10.4103/ijo.IJO_1636_21

Quick Response Code:

A subluxated cataractous lens is a challenging situation for an anterior segment surgeon. Modifications of surgical techniques such as low-fluidic phacoemulsification and capsular support devices may aid in the successful management of mild–moderate subluxation.[1] However, subluxations more than six clock hours can be challenging, given the higher chances of anterior herniation of vitreous. Moreover, this herniation is accentuated during phacoemulsification, leading to vitreous continually intruding the surgical field, making surgical maneuvers difficult. Intermittent vitrectomy through a pars-plana route prevents vitreous herniation into the anterior chamber (AC).[2] Femtosecond laser-assisted cataract surgery (FLACS) has been shown to provide optimal outcomes with preservation of the capsular bag have been reported in cases with varying degrees of subluxation.[3,4]

This paper highlights four cases managed successfully with combination of femto laser and limited pars-plana vitrectomy during phacoemulsification.

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The protocol was registered with the Ethics Committee of our Institute and adhered to the tenets of the Declaration of Helsinki, an informed consent was taken from all participants. Femtosecond laser was done under topical anesthesia using the Catalys (Optimedica, CA, USA) femto-second laser. We used custom center option to center the capsulotomy away from the site of subluxation, its diameter kept between 5.0 and 5.2 mm depending on the degree of lens displacement. Laser parameters for capsulotomy were pulse energy of 4.0 micro J with 50.0 mm per second speed. Four to eight radial cuts were used to fragment the lens nucleus, and the length of the nucleotomy incisions was reduced to 5.0 mm to maintain a safe pupillary edge clearance of 0.5 mm. No corneal incisions made with the laser except limbal relaxing incision in one case.

After the laser, peribulbar anesthesia was administered to the patient in the operating room. After cleaning and draping, a valved 23-gauge trocar was introduced at the pars-plana, 4 mm away from limbus adjacent to the area of maximum subluxation followed by vitrectomy to remove whatever vitreous prolapses through the cutter. Triamcinolone (40 mg/mL) was injected in the AC through the side port to highlight vitreous in AC, if any. Vitrectomy was done from the pars-plana sclerotomy, in the area just below the zonular dehiscence. For dry vitrectomy, the

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Received: 14-Jun-2021 Revision: 22-Aug-2021
Accepted: 03-Sep-2021 Published: 27-Jan-2022

Cite this article as: Sachdev MS, Gupta A, Gupta H, Sachdev GS, Malik R, Sachdev R. Limited pars-plana vitrectomy for optimizing surgical outcome in subluxated cataracts undergoing femtosecond laser-assisted cataract surgery. Indian J Ophthalmol 2022;70:658-61.

cut rate was kept at 5000–6000 cuts per second, with a suction of 200 mm Hg. Cutting was followed by suction.

Once the surgical area was clear of vitreous, phacoemulsification was begun. All cases were done on the Centurion Vision System (Alcon, USA). The femtosecond laser created free-floating capsulotomy. A minimal, or no hydro-dissection was done, with slow nudging movements on the nucleus to release any air bubbles trapped. A capsular tension ring (CTR) was placed within the capsular bag. In one case, with almost nine clock hours of subluxation, capsular hooks (CapsuleCare, Madhu Instruments, India) were also used to stabilize the capsular bag.

Once the bag was stabilized, prechopped fragments were phacoemulsified, using low parameters (Ultrasound Power – 40%, Vacuum – 350 mmHg, Flowrate – 32 mL/min), and a lowered infusion bottle height (50–60 cm). Active fluidics in the centurion system allow the surgeon to choose a target intraocular pressure (IOP). This system is designed to increase resistance to flow, and to prevent any tubing collapse, which can reduce postocclusion surge and thus increase AC stability. This technology is designed to allow the use of much higher fluidics parameters.

After phacoemulsification, aspiration of the cortex was started, using low parameters. With a CTR *in situ*, the direction of pull of the aspiration probe was always kept tangential, allowing for easier aspiration of the cortical matter entangled in the CTR. The irrigation fluid enters the patellar fossa/anterior vitreous through the zonular dehiscence. This leads to hydration of the vitreous, which herniates toward the AC. This upward herniation pushes the entire capsular-bag complex upwards, making aspiration of cortex extremely difficult, and further stressing the zonules.

To prevent this, we do not plug the trocar cannula. This leads to a continuous egress of fluid from the trocar, further avoiding vitreous hydration. The capsular bag is filled with viscoelastic, and three-piece intraocular lens (IOL) is inserted in the capsular bag.

At the end, remnant tags of vitreous in the AC were removed with conventional vitrectomy. The wound was hydrated and a single 10-0 prolene suture was applied to close main port in all cases [Video 1].

Results

We performed this technique of Limited pars-plana vitrectomy combined with FLACS in four eyes of four patients [Table 1]. All eyes had zonular dehiscence ranging from 120 to 210 degrees following history of blunt trauma. Fundus and IOP was within normal limits in all patients. In two patients, there was preexisting vitreous in AC coming from the area of zonular dehiscence and removed via limited pars-plana vitrectomy. We were able to implant three piece IOL within capsular bag in all four eyes.

There were no complications with the pars-plana vitrectomy or FLACS. All eyes had good vision postoperative.

Discussion

In the past decade, there have been several modifications of surgical techniques for the management of severely subluxation of crystalline lens. With the advent of femtosecond laser, machines with advanced fluidics and sutureless vitrectomy, it is possible to give excellent outcomes in severe subluxations.

Success of surgery depends on many factors, most important one being a well centered, adequate sized continuous capsulorhexis. Compromised zonular counter-traction hampers the initiation as well as completion of capsulorhexis. As femtosecond laser-assisted cataract surgery enables better-designed capsulotomies and nucleus fragmentation without the need of extensive maneuvers that could cause zonular damage.[5-7]

The femtosecond laser does not depend on zonular support to create a capsulotomy and thus is able to create a circular capsulotomy despite lens subluxation. Schultz *et al*.[8] demonstrated the successful use of femtosecond laser to perform the anterior capsulotomy in a subluxated lens of a pediatric patient with Marfan syndrome.

The presence of vitreous in the AC could also make capsulorhexis challenging. An added advantage of the femtosecond laser is that the size, as well as the centration of the capsulotomy, can be changed as desired.

FLACS gives a swift, effortless capsulotomy – and is hence the most important application for a subluxated cataract.

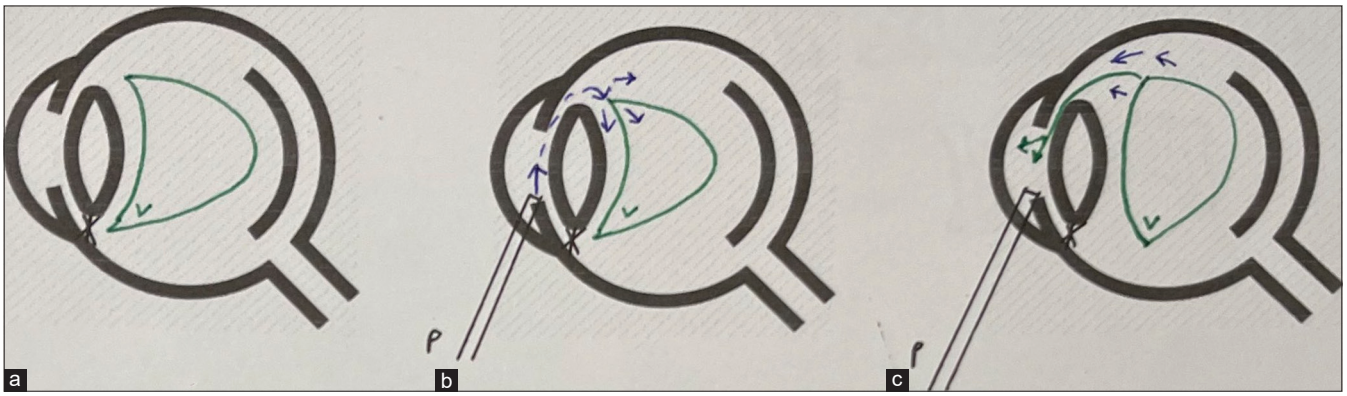

Figure 1: During phacoemulsification in a subluxated cataract, the hydration fluid (Blue arrows) from the phacoemulsification probe (p) enters the vitreous body (V; Green crescent), leading to its hydration (a and b). With further hydration, and aspiration, the liquefied vitreous herniates through the area of zonular weakness (c). This upthrust caused by the herniating liquefied vitreous further compromises the already weak zonules

Phacoemulsification of the nucleus is the next critical aspect of the surgery. Manipulation with the phacoemulsification and the I/A probe can transmit stress on the zonules. A thorough and complete viscodissection or hydrodissection is essential to make the nucleus mobile in the capsular bag. This allows for lesser stress to be transmitted to the zonules during nuclear manipulations. Lower aspiration and flow parameters will reduce turbulence, maintaining greater control over fragments of the lens.

Femtosecond laser fragmentation of the nucleus is another important step that contributes to sparing of zonules. The prechopped nucleus requires lesser amount of ultrasound energy, and much lesser nuclear manipulation. The nuclear fragments are readily mobilized without hydrodissection and rotation, owing to pneumodissection. Using the spider fragmentation pattern for softer nuclei, a cushion of thin epinucleus delineated by the limit of fragmentation posteriorly with the aid of aerodissection helps to protect the posterior capsule.[2,9]

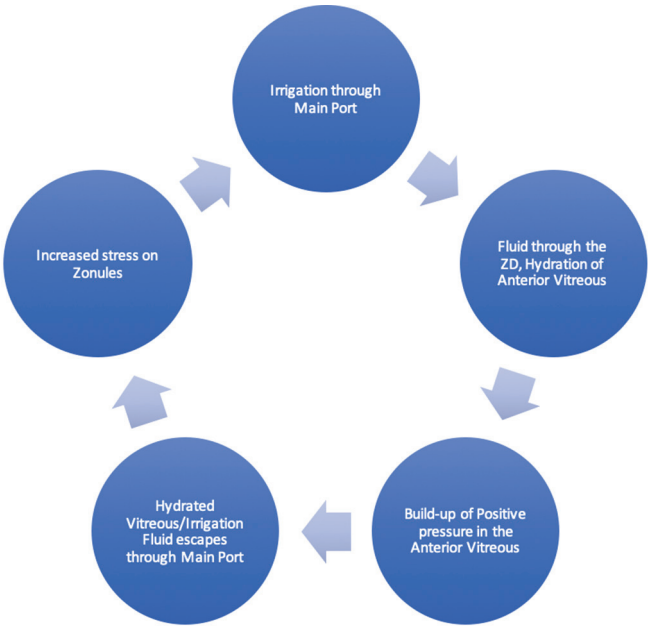

Figure 2: Irrigation/aspiration with trocar plugged. ZD: Zonular dehiscence

Aspiration of the cortical matter should be done in a tangential manner and in a direction away from the zonulopathy.

A very large subluxation of the natural lens essentially functions as a lenticular coloboma, forming a continuum between the anterior segment and the anterior hyaloid face. A small subluxation may have only a little amount of vitreous hydration that can be managed with tamponade with a dispersive ophthalmic viscosurgical device. However, performing a vitrectomy/phacoemulsification [Fig. 1] in the AC would lead to fluid seeping posteriorly to the anterior hyaloid face, through the area of zonular weakness, further hydrating the vitreous and leading to copious amounts of hydrated vitreous herniating anteriorly, thereby, setting up a vicious cycle.

Additionally, while performing cortical aspiration in such a setting, with the trocar plugged [Fig. 2], the only escape route for the fluid/hydrated vitreous is the main wound itself. This escaping fluid too would transmit mechanical turbulence and stress on the zonules.

With the trocar unplugged, the irrigation fluid/hydrated vitreous escapes through the pars-plana port, avoiding the zonular dehiscence. Thus, the removal of the plug essentially creates a continuum from the Main port, through the zonular dehiscence, the anterior vitreous, and ultimately to the exterior through the pars-plana port.

In eyes with a crowded anterior segment and positive pressure, a pars-plana vitreous tap with an automated vitrectomy has been suggested to facilitate phacoemulsification.[10]

Performing an intermittent vitrectomy prevents build-up of pressure in the posterior cavity due to vitreous hydration. The problems of vitreous herniation into the AC and subsequent extension of zonular dialysis are also avoided.[2]

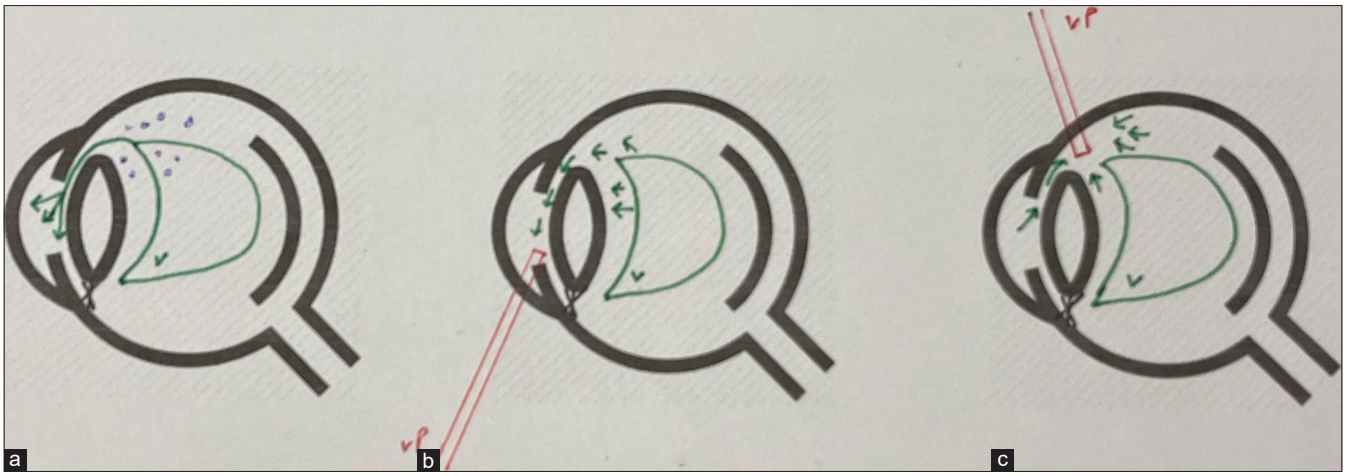

Figure 3: Herniating liquefied vitreous in the anterior chamber (a) obstructs phacoemulsification and must be cut from vitreous body to prevent further herniation. Conventional vitrectomy performed through the limbal paracentesis leads to the herniating vitreous being "pulled" into the vitrectomy probe (VP). This "pulling up" of the vitreous strand along with the bulkier vitreous body damages zonules further (b). Vitrectomy performed through a single pars-plana sclerotomy, close to the area of subluxation, leads to a "pulling back" of the herniated vitreous (c), imparting lesser damage to zonules

Table 1: Surgical results

Eye	Cause of subluxation	Nuclear sclerosis grade	Degree of subluxation (in degrees)	Capsular support used	Pars-plana vitrectomy	IOL placed	BCVA
OD	Trauma	2	180	CTR	Performed	Multipiece in the Bag	6/6 p
OS	Trauma	2	180	Capsular hooks plus CTR	Performed	Multi piece, in the bag	6/6
OD	Trauma	3	120	CTR	Performed	Multipiece, in the Bag	6/6
OS	Trauma	3	160	CTR	Performed	Multipiece, in the Bag	6/6

The vitreous, in its undisturbed state, is essentially a uniform ball of gel-like substance. Any disturbance to this uniform ball, say due to a trauma, or during phacoemulsification in a subluxated cataract, would lead to a strand of vitreous herniating from this mass and would herniate through any gap, like a zonular dehiscence [Fig. 3].

Any pull on this herniated strand would also pull the vitreous body. Similarly, while performing a vitrectomy, with the vitrector in the AC, a pull is exerted on the herniated vitreous strand. While this strand is being cut, the larger mass of vitreous body attached to the strand is also pulled through the zonular dehiscence, essentially stressing zonules.

When the vitrectomy probe is inserted through the pars-plana port, the connection of the vitreous strand is cutoff from the vitreous body. Thus, any further herniation is halted. We thus postulate that performing vitrectomy from the anterior route leads to more vitreous being pulled up, causing more stress to the zonulopathy. However, a pars-plana vitrectomy would be less traumatic to the zonules and would restrict vitreous loss. Like any novel surgical technique, this technique too has its limitations. Good execution of this technique requires an experienced surgeon, besides being dependent on the femtosecond laser platform, which adds to the cost of the procedure.

Conclusion

In conclusion, a femtosecond laser-assisted cataract surgery combined with a single-port pars-plana vitrectomy would cause minimal stress to the zonules, accounting to better surgical results.

Financial support and sponsorship

Nil.

Conflicts of interest

There are no conflicts of interest.

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