Effects of Different Ocular Viscoelastic Devices on Femtosecond Laser-Assisted Cataract Surgery: A Case Report

Teng-Chieh Yu¹, Hsin-An Chen², Tzu-En Wu¹,³,*

ABSTRACT

A 65-year-old woman with a previous history of acute angle-closure glaucoma received femtosecond laser-assisted cataract surgery (FLACS) at our hospital. The patient's pupil diameter was about 4mm and could not be dilated preceding the operation. We performed corneal microincision following pupil dilation with OVDs (Viscoat, Alcon Laboratories, Inc.). Lens fragmentation and capsulotomy were not able to be performed by FEMTO LDV Z8. We replaced the dispersive OVD--Viscoat, with an alternative cohesive OVD--Protectal-on. After replacement, lens fragmentation and capsulotomy were performed smoothly under the same femtosecond laser settings.

We propose the componential difference of the two OVDs, as well as lower laser pulse energy of FEMTO LDV Z8, might contribute to our reported complication. Our hypotheses require further studies with better study designs to validate. We hope this experience might reveal effects of different OVDs on FLACS and also help solve possible difficulties during FLACS on a very smaller pupil and shallow ACD cataract.

Keywords: femtosecond laser assisted cataract surgery (FLACS), ocular viscoelastic devices (OVDs)

INTRODUCTION

Femtosecond laser-assisted cataract surgery (FLACS) has now been a staple of modern ophthalmology. One of the common nuances that restrict FLACS prevalence is the small pupil diameter. Due to possible complications, some conservative surgeons hesitated to do operation on patients with smaller pupils. Other surgeons use OVDs to dilate pupils before the operation; however, as we discovered, different OVDs have different effects on femtosecond lasers. This case report is to record a case of possible differences of femtosecond laser-assisted lens frag-
mentation and capsulotomy due to different ocular viscoelastic devices (OVDs) in the anterior chamber.

CASE PRESENTATION

A 65-year-old woman had acute angle-closure glaucoma with intraocular pressure (IOP) of 30~40 mmHg first treated at a clinic but in vain. She then came to our hospital for further treatments on 2018/12/5. Pentacam showed a very shallow anterior chamber depth (ACD) of 0.92mm. We found the bulging of the lens might be the cause of refractory ocular hypertension and corneal edema (Figure 1). On 2018/12/6, laser iridotomy (OD) couldn’t be performed successfully due to the edema of cornea and iris. The risk of pupillary block glaucoma caused by an intumescent cataractous lens was discussed, this can cause intraoperative complications such as corneal endothelium injury and capsule rupture to be higher for conventional cataract surgery. Therefore, we performed femtosecond laser-assisted cataract surgery (FLACS) on 2018/12/18. The femtosecond laser machine we used was FEMTO LDV™ Z8 (Ziemer Ophthalmic Systems AG, Port, Switzerland), usually, this machine performs lens fragmentation first, followed by capsulotomy then corneal incisions. In this particular case, the patient's pupil diameter was only about 4 mm and could not be fully dilated before the operation. We decided to perform main corneal microincision followed by mechanical pupil dilatation with OVDs (Viscoat, Alcon Laboratories, Inc.) before the femtosecond laser-assisted lens fragmentation and capsulotomy instead of the regular procedure.

After the anterior chamber was filled with OVDs from Viscoat, the pupil was dilated to 5.4 mm. However, lens fragmentation and capsulotomy were initiated, but still not able to be performed by the femtosecond laser machine (FEMTO LDV Z8) despite the correct docking and settings. We suspected a possible change of the laser beam focus position or a change in the refractive index of the anterior chamber that caused inadequate laser distribution was the problem, in response, we replaced the dispersive OVD (Viscoat), with an alternative cohesive OVD (Protectalon). The anterior chamber was irrigated to remove Viscoat and the anterior chamber was re-filled with Protectalon 1.6% (VSY Biotechnology) instead. After replacement, lens fragmentation and capsulotomy were performed smoothly under the same femtosecond laser settings. One week after FLACS, the best-corrected visual acuity (OD) was 0.9 after the operation. The IOP (OD) was 11 mmHg without medication control. Pentacam also showed the ACD level has increased to 3.71mm (Figure 2).

DISCUSSION

Femtosecond laser capsulotomies are the inclined method of many surgeons when performing cataract surgeries. The femtosecond laser with near-infrared wavelength of 1040 nm and real-time optical coherence tomography are combined to perform a precise capsulotomy in size, circularity and centration. Previous studies showed femtosecond laser capsulorhexis provide the long-term predictable effective lens position (ELP). This uniformly capsulotomy reduces the posterior capsule opacity (PCO) rate due to improved capsule overlap in superior IOL positioning. The consistency in femtosecond laser capsulorhexis is becoming more and more reliable as more patients select premium and toric IOLs. Moreover, the femtosecond laser capsulorhexis has
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Figure 1. (A) Slit lamp exam found acute angle-closure glaucoma with iris bombe, mid-dilated pupil and corneal edema with Descemet membrane folds. (b) Scheimpflug cross-sectional images from the Pentacam® (Oculus, Lynwood, WA) showed very shallow anterior chamber, which was 0.92 mm in depth (red arrow). The central corneal thickness measured in the top right section was 637 μm (asterisk).

Figure 2. (a) The slit lamp picture after cataract operation showed the intraocular lens was in place with deepened anterior chamber depth. (b) After the operation, widened anterior chamber angles were noted by the cross-sectional images from the Pentacam® (Oculus, Lynwood, WA), and the anterior chamber depth increased to 3.71 mm (red arrow). The corneal thickness in the top right section showed the generally subsided corneal edema, and the central thickness decreased to 576 μm (asterisk).
been reported to be helpful in particularly complex cases such as white cataract, traumatic, intumescent cataracts or zonular dialysis.

In a study of 40 eyes, Conrad-Hengerer et al. have proposed an efficient and safe 3-step treatment before FLACS for patients with small preoperative pupils [2]. The first step of the 3-step treatment is intracameral epinephrine administration, this was sufficient for FLACS in 7% of the eyes; additional second step by viscomydriasis was necessary for 25% of the eyes, the remaining 68%, still needed the Malyugin ring pupil expander as the final resolution. The OVDs they used were Healon (cohesive OVDs), Healon GV (cohesive OVDs) and Healon 5 (cohesive and dispersive OVDs). The femtosecond laser machine they used was The Catalys Precision Laser System (Optomedica Corp.). No severe intraoperative complications occurred in their study.

Optical calculations done by de Freitas et al. had demonstrated the change in the refractive index after anterior chamber refilling with various OVDs did not sufficiently shift the laser beam focus position to cause the incomplete capsulotomy on the Gullstrand eye models [3]. However, the laser beam focus shift due to different OVDs have still been observed and noticed by Boris Malyugin, this shift might still cause complications in operations [1]. To the best of our knowledge, there were no previous human studies about different effects between cohesive and dispersive OVDs on FLACS.

We tried to propose some possible causes for our results. According to the official data, there are some differences between Viscoat and Protectal on, as shown in Table 1 [4, 5]. Protectal on with high molecular weight and high viscosity supply good cohesiveness for increased anterior chamber expansion and maintenance which facilitates manipulation inside the eye. Constituent wise, Viscoat contains chondroitin sulfate, which Protectal on lacks, to support intraocular dispersion. Intraocular tissue is positively charged meaning that negatively charged particles are attracted to it. Most OVDs contain hyaluronic acid (HA), which has one negative charge. Chondroitin Sulfate has two negative charges, giving Viscoat with Chondroitin Sulfate and HA a triple negative charge. The high-protection, low-weight dispersive Viscoat can offer exceptional safety in the corneal endothelium and other ocular tissues, but hypothetically the triple negative charge of Viscoat might be an obstacle for femtosecond laser. Besides the difference between OVDs, the FEMTO LDV™ Z8 we used claims to utilize a lower laser pulse energy (nanojoule, instead of the more commonplace microjoule) with much higher repetition rate compared with other femtosecond lasers [6]. The FEMTO LDV™ Z8 with 1053 nm near-infrared spectrum, 10−15 seconds, ultrafast pulses to create far smaller amounts of energy. Maybe the peculiarity mentioned above led to the difficulty in this case. Although further studies with stronger study designs are still needed to prove our hypotheses.

In our FLACS experiences, FLACS can be smoothly performed on some cataract of small pupils or narrow AC space without any OVD use. Meanwhile, in more difficult cases of constricted pupil (<4.8 mm) or shallow ACD (<1.25 mm), OVD and iris expansion device should be considered to provide more stable pupil dilatation space for manipulation. This case report of the FEMTO LDV™ Z8 FLACS performed on a very smaller pupil and shallow ACD cataract after an appropriate OVD to dilate the pupil. We hope this experience might reveal effects of different OVDs on FLACS and also help solve possible difficulties during FLACS in the future.
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REFERENCES


Table 1. Characters of Viscoat and Protectalon 1.6%

<table>
<thead>
<tr>
<th></th>
<th>Molecular Weight (Dalton)</th>
<th>Na Hy.</th>
<th>Chondroitin Sulfate</th>
<th>Viscosity (mPas)</th>
<th>Character</th>
</tr>
</thead>
<tbody>
<tr>
<td>Viscoat</td>
<td>$6 \times 10^5$</td>
<td>3.0%</td>
<td>4.0%</td>
<td>$7 \times 10^4$</td>
<td>Dispersive</td>
</tr>
<tr>
<td>Protectalon 1.6%</td>
<td>$3 \times 10^6$</td>
<td>1.6%</td>
<td></td>
<td>$4 \times 10^5$</td>
<td>Cohesive</td>
</tr>
</tbody>
</table>

Note: Na Hy: sodium hyaluronate
不同之眼科黏彈劑（OVD）
對飛秒雷射輔助白內障手術影響：病例報告

游登捷¹，陳信安²，吳慈恩¹,³

本論文報告一病例，因使用不同之眼科黏彈劑（OVD），對飛秒雷射輔助白內障手術所造成之影響。病患為65歲華裔女性，因急性隅角閉鎖性青光眼發作，高眼壓導致水晶體的蛋白質變性腫大，使原本的白內障更為嚴重，並造成前房嚴重狹窄，以藥物治療效果不彰，故建議接受飛秒雷射輔助白內障手術。雷射手術前因瞳孔無法充分散瞳而先行以眼科黏彈劑（Viscoat®, Alcon Laboratories, Inc.）注入眼前房輔助，但發現後續雷射手術失效，直至將眼前房中之眼科黏彈劑更換為Protectalon 1.6%（VSY Biotechnology），順利完成飛秒雷射輔助白內障手術。本文推測為眼科黏彈劑間之類型與成分差異所致，望此經驗能對遭遇類似問題之醫師有所助益。

關鍵字：眼科黏彈劑、飛秒雷射輔助白內障手術

¹ 新光吳火獅紀念醫院眼科
² 長庚大學醫學系
³ 輔仁大學醫學系