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SURGICAL TECHNIQUE

Phacoemulsification outcomes with different illumination techniques

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ABSTRACT

Purpose: To compare surgeon experience and the outcomes of phacoemulsification using 2 different illumination techniques for cataract extraction.

Methods: A prospective interventional case series was performed on 20 consecutive patients (20 eyes) with senile cataract who underwent phacoemulsification enhanced with a 23-G endoillumination probe. The main outcome measures were the surgeon's perception of depth of field and quality of visibility of intraocular structures, ease of performance of the surgical procedure, effectiveness, and complications related to the procedure. A surgeon-specific questionnaire was administered at the end of the procedure.

Results: Surgery was successfully performed in all patients without any complications. The surgeon indicated that lateral endoillumination markedly enhanced the details of the lens structures, mainly the posterior capsule visualization, better than the coaxial lighting with the surgical microscope. Lateral endoillumination created an enhanced 3D effect and improved the depth perception of lens intraoperatively.

Conclusions: The lateral illumination technique with a 23-G endoilluminator probe placed in the anterior chamber through a paracentesis creates an enhanced 3D effect and improves depth perception of lens during phacoemulsification. These benefits increase the safety of the procedure.

Keywords: Coaxial illumination, Depth of field, Enhanced visualization, Increased quality, Phacoemulsification

Introduction

Phacoemulsification has been routinely performed for cataract removal since 1967, when Kelman first introduced the ultrasonic phacoemulsification technique. Currently, phacoemulsification remains the technique of choice for small-incision cataract surgery. Phacoemulsification requires good visualization of the anterior capsule, nucleus, cortex, and posterior capsule. Visualization of the red reflex using the operating microscope is essential for assessing the posterior capsule during surgery. Additionally, an adequate coaxial red reflex is required for performing a safe, well-centered capsulorhexis (1, 2). The use of an operating microscope for the red reflex is a longstanding practice. However, a novel side lighting technique presents some significant advantages for performing cataract surgery.

Endoilluminator-assisted Descemet membrane endothelial keratoplasty for identifying graft orientation and enhancing 3D perception of depth within the anterior chamber of the graft has been described recently (3). This technique uses an endoilluminator for oblique illumination for better visualization (3). The visualization is further enhanced by light reflexes from graft folds and edges (3). Endoilluminator-assisted lighting allows visualization of the entire graft even through a hazy cornea, allowing the surgeon better intraoperative assessment of graft dynamics, morphology, orientation, and positioning (3). This leads to easier and faster surgery, potentially decreasing graft damage due to excessive fluidics and unnecessary manipulation (3).

Surgeon-controlled intracameral illumination has been described for visualization during cataract surgery, combined cataract surgery, and 23-G vitrectomy (4, 5). The main outcome measures were causes of poor red reflex, value of the intracameral illuminator during specific steps in cataract surgery, and intraoperative and postoperative complications (5). Surgeon-controlled intracameral illumination provided excellent imaging and almost 360° visualization of the lens capsule structures (4, 5). This capability can be used for challenging cataract surgery combined with vitrectomy in eyes with poor red reflex (4).

The objective of this study is to compare outcomes and surgeon experience of lateral 23-G anterior chamber endoillumination to coaxial illumination with a surgical microscope during cataract surgery.

Methods

This prospective interventional case series enrolled 20 consecutive patients (20 eyes) with senile cataract who underwent phacoemulsification surgery using endoillumination with a

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23-G probe introduced into the anterior chamber through a paracentesis. The endoillumination technique was used to determine if it enhanced the details of the anterior chamber, and produced shadows for better 3D perception and depth of field of the anterior chamber structures, the lens fragments, and the posterior capsule.

Patient inclusion criteria were the diagnosis of significant or advanced senile cataract and absence of other comorbidities. Additionally, all patients had reported good light and color perception with positive light projection in all quadrants. Exclusion criteria were any significant corneal opacity and absence of or ambiguous perception of white light in primary gaze. All surgeries were performed by an experienced surgeon (J.B.Y.). This study adhered to the tenets of the Declaration of Helsinki. An adequate informed consent was signed by all patients included in this study.

Main outcome measures were comparison of the quality of vision through the microscope as perceived by the surgeon during the surgical procedure and at the end of the surgical procedure and efficacy of completing phacoemulsification surgery without complications using lateral illumination and coaxial illumination. A surgeon-specific questionnaire was administered at the end of the procedure. Data were collected on visual acuity preoperatively and postoperatively at 1 month, 2 months, and 3 months.

Surgical technique

A 2.5-mm clear corneal incision was created at the 11-o'clock position and a paracentesis was created at the 2 o'clock position with a 2.2-mm single bevel angled calibrated slit knife and a scleral 19-G V-Lance (Alcon Laboratories). Viscoelastic (Provisc; Alcon Laboratories) was injected into the anterior chamber and a continuous curvilinear capsulorhexis was performed with a 25-G needle cystotome and capsular forceps under direct light from the microscope. A 23-G endoilluminator probe (Constellation, 23-G Xenon endoilluminator; Alcon Laboratories) was then introduced through the paracentesis at the 2-o'clock position. The microscope light was switched off once endoillumination started. Cataract extraction was performed using a divide-and-conquer technique (Fig. 1, A-D), with the lateral endoillumination using the 23-G endoilluminator connected to the Constellation Vision System (Alcon Laboratories) at 22,500 lumens. The phacoemulsification tip was always placed at the 11-o'clock position. After cortex removal (Fig. 1, E and F), the capsular polishing was performed using irrigation/aspiration (I/A) under lateral/oblique illumination with the endoilluminator and the threaded I/A handpiece with a 0.3 small bore tip (Fig. 1, G and H). A foldable intraocular lens was implanted in the capsular bag.

The various stages of surgery, sculpted, fragmentation, phacoemulsification, and aspiration, are alternately performed with side lighting and coaxial illumination of the surgical microscope and the perception of structures, core, cortex, and posterior capsule were compared with each illumination technique.

Results

The mean age of the patients was 64.35 years (range 53-77 years). All cases of senile cataract were classified with at least NO (Nuclear Opalescence) III. (Lens Opacities Classification System III). The mean follow up period from diagnosis to surgery was 5.52 months (range 1 day-12 months). Surgery was successfully performed in all patients.

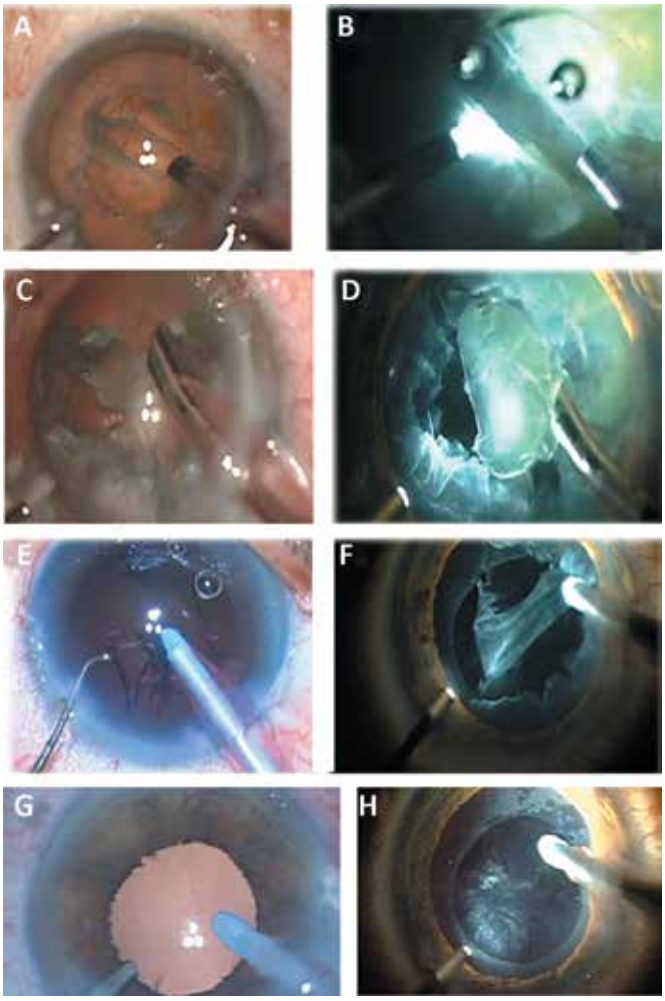

Fig. 1 - Cataract extraction using oblique endoillumination. (**A**) Sculpting of the nucleus using the divide and conquer technique. (**B**) Note the enhanced 3D quality of the images. (**C**) Nucleus extraction. (**D**) The lateral illumination facilitates surgery. (**E**) Placement of instrument and oblique endoillumination during cortex extraction. (**F**) Note the 3D effect of the release tissue during cortex extraction. (**G**) Placement of instruments and oblique endoillumination during capsule polishing. (**H**) Note the 3D effect during capsule polishing.

There were no cases of intraoperative complications such as capsular rupture or lens dropout. There were no postoperative complications. Postoperative visual acuity in operated eyes improved throughout follow-up (Tab. I).

Based on the surgeon-specific questionnaire results, the surgeon indicated that the endoillumination lighting markedly enhanced the perception of depth and caused a 3D effect and enhanced the details of the lens structures, especially the posterior capsule (Tab. II). Phacoemulsification was performed without difficulty under endoillumination. Excellent visualization with very good details of the posterior capsule were an advantage during cataract extraction. At 3 months

TABLE I - Postoperative visual acuity in eyes that underwent cataract surgery with endoilluminator-assisted lighting

Patient	Sex	Age, y	Preop VA	Postop VA	VA 3 months	VA 6 months	VA 12 months
1	Male	56	1.00	0.40	0.18	0.18	0.18
2	Female	63	0.90	0.60	0.60	0.40	0.40
3	Female	57	0.88	1.00	0.70	0.60	0.60
4	Male	65	1.00	0.70	0.70	0.54	0.60
5	Female	58	0.88	0.88	0.70	0.60	0.54
6	Male	53	1.00	0.88	0.88	0.88	0.70
7	Male	70	1.00	0.70	0.60	0.54	0.54
8	Male	68	0.88	0.60	0.60	0.54	0.40
9	Female	71	1.00	1.00	0.88	0.60	0.40
10	Male	54	0.90	0.70	0.54	0.54	0.18
11	Male	63	1.00	0.70	0.40	0.40	0.40
12	Male	59	0.80	0.60	0.60	0.60	0.60
13	Female	72	1.00	0.80	0.80	0.80	0.80
14	Male	77	1.00	0.88	0.70	0.60	0.54
15	Female	68	0.90	0.70	0.70	0.54	0.60
16	Male	75	0.90	0.88	0.50	0.50	0.50
17	Female	62	1.00	1.00	0.88	0.60	0.40
18	Female	59	1.00	0.70	0.70	0.54	0.60
19	Male	66	0.90	0.60	0.60	0.40	0.40
20	Male	71	0.90	0.60	0.60	0.54	0.40

VA = visual acuity.

postoperatively, the posterior capsule remained intact and the intraocular lens was stable in the bag in all patients.

Discussion

This study presents a technique to enhance the 3D view produced by coaxial illumination by increasing the depth of field during cataract surgery with oblique endoillumination. In this technique, a laterally placed 23-G endoilluminator probe is inserted into the anterior chamber through a paracentesis. To our knowledge, this is the first report of a comparison of this technique to conventional microscope coaxial illumination.

Anterior chamber endoillumination is used to introduce the concept of enhanced 3D perception and increase the depth of field intraoperatively to enhance visualization and resolution of the structures and details of the crystalline lens. Jung et al (5) used a surgeon-controlled intracameral illumination for visualization during combined cataract surgery and 23-G vitrectomy. They realized that oblique intracameral illumination minimized the amount of corneal scatter and reflection of the illuminating light and provided high-quality intraoperative lens images for the majority of the surgical steps (5). However, Jung et al (5) did not mention the 3D quality of images and increased depth of field as we reported in the current study.

Coaxial illumination during traditional cataract phacoemulsification surgery uses light reflected from the lens structure, producing images with somewhat limited perception of depth, which can be improved. This technique results in a loss of detail of the nucleus trench. More importantly, without the sense of depth, there is greater risk of posterior capsule rupture during surgery. Lateral illumination has the property of showing depth and texture, which is advantageous during surgery. In the current study, coaxial illumination from the microscope did not allow 3D perception of the intraocular anatomy. On the other hand, the surgeon subjectively perceived that the depth of field increased with lateral illumination. Some authors have suggested that the 3D effect can only be obtained by lateral illumination outside the anterior chamber (6). However, our study indicates that oblique endoillumination by entering the anterior chamber allows depth perception and excellent observation of the lens fragments and posterior capsule. Additionally, there is the perception of depth during sculpting, fragmentation, and posterior capsule polishing, lowering the risk of complications. This is notable, because we are proposing the quality of the surgical field as an advantage in routine cases, not only in cases with a poor red reflex or hazy media as previously proposed (4, 7-9).

TABLE II - Comparison of the perception of the surgeon in the different phases of the surgery with the use of coaxial lighting and lateral endoillumination

	Coaxial illumination	Lateral illumination
Capsulorhexis	++	+
Nucleus fragmentation	+	+++
Cortex aspiration	+	+++
Posterior capsule visualization	+	+++

Mean gradings are based on a surgeon-specific questionnaire.
+ = Average; ++ = good; +++ = excellent.

The endoilluminator-assisted technique was first described in a patient with an intumescent cataract (10). Subsequently it has been described in a patient with a corneal opacity (11). Oshima et al (12, 13) and Jang et al (14) invented a 27-G and 23-G chandelier endoilluminator, respectively, and described

a technique using a 25-G transconjunctival chandelier endoilluminator through the pars plana for cataract surgery in patients with severe bullous keratopathy. A disadvantage of this technique is the additional endoilluminator exposure that is required may have a phototoxic effect on the retina (15).

Nichamin (16) designed an infusion cannula to enhance visualization when performing a bimanual anterior chamber vitrectomy. Kim et al (17) used endoillumination to enhance the red reflex during posterior capsule polishing. In contrast, we used the endoilluminator as a chopper as well as an image quality and depth perception enhancer during surgery, improving the cataract extraction technique.

Cataract extraction techniques have been performed using microscopes with coaxial light sources taking advantage of good red reflex, producing images with limited depth perception, making phacoemulsification more difficult. In most cases, a good red reflex is present only prior to hydrodissection. Following hydrodissection, hydrodelineation, and nucleus rotation, the red reflex is typically lost. At this point, it becomes very difficult to perceive depth and the contours of nuclear fragments with only a coaxial beam (18). Lateral illumination can dramatically increase contrast of and within the lens compared to coaxial illumination. During phacoemulsification with conventional coaxial illumination, the relief of lens structure is not visible and the details are very difficult to distinguish using a red reflex. However, contrast is dramatically enhanced with lateral illumination with a 23-G endoilluminator, allowing depth perception and greater resolution of lens details.

The advantage of lateral illumination is that the images are realistic and the sense of depth allows the surgeon to easily appreciate the distance within the lens. Additionally, in the current study, the surgeon indicated that oblique illumination facilitated better posterior capsule polishing compared to coaxial illumination. For example, it was much easier to appreciate any remaining cortex and the posterior capsule with oblique illumination. The surgeon also noted that the details in the posterior capsule and the vitreous that were not visible with coaxial illumination are resolved with oblique illumination.

To our knowledge, there is no comparison in the English-language peer-reviewed literature of coaxial microscope lighting to oblique/lateral lighting with an endoilluminator during phacoemulsification surgery. Here we documented the advantages and superiority of oblique lighting with an endoilluminator during the various steps of cataract surgery. The loss of depth perception with coaxial microscope illumination makes for a more challenging surgery than oblique illumination within the anterior chamber.

In conclusion, the lateral illumination technique with a 23-G endoilluminator probe located in the anterior chamber through a paracentesis creates 3D image quality and increases depth of field during phacoemulsification surgery that effectively assists the surgical maneuvers, especially removal of the nucleus and cortex, improving surgical control to preserve the integrity of the posterior capsule during phacoemulsification. The lateral light source improves resolution of depth perception of the lens structures, reducing the technical challenges and decreasing the risk of intraoperative complications during phacoemulsification cataract surgery.

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References

1. Bhattacharjee K, Bhattacharjee H, Goswami BJ, Sarma P. Capsulorhexis in intumescent cataract. J Cataract Refract Surg. 1999;25(8):1045-1047.
2. Kelman CD. Phaco-emulsification and aspiration. A new technique of cataract removal. A preliminary report. Am J Ophthalmol. 1967;64(1):23-35.
3. Jacob S, Agarwal A, Agarwal A, Narasimhan S, Kumar DA, Sivagnanam S. Endoilluminator-assisted transcorneal illumination for Descemet membrane endothelial keratoplasty: enhanced intraoperative visualization of the graft in corneal decompensation secondary to pseudophakic bullous keratopathy. J Cataract Refract Surg. 2014;40(8):1332-1336.
4. Nishimura A, Kobayashi A, PhD, et al. Endoillumination-assisted cataract surgery in a patient with corneal opacity. J Cataract Refract Surg. 2003;29(12):2277-2280.
5. Jung Y, Kim IN, Yoon J, et al. Intracameral illuminator-assisted advanced cataract surgery combined with 23-gauge vitrectomy in eyes with poor red reflex. J Cataract Refract Surg. 2013;39(6): 845-850.
6. Habeeb SY, Varma DK, Ahmed II. Oblique illumination and trypan blue to enhance visualization through corneal scars in cataract surgery. Can J Ophthalmol. 2011;46(6):555-556.
7. Farjo AA, Meyer RF, Farjo QA. Phacoemulsification in eyes with corneal opacification. J Cataract Refract Surg. 2003;29(2): 242-245.
8. Kuhn F, Morris R, Massey M. Photic retinal injury from endoillumination during vitrectomy. Am J Ophthalmol. 1991;111(1): 42-46.
9. Lee VY, Kwok AK. Multiport-illumination-system-assisted phacoemulsification in eyes with dense vitreous hemorrhage during combined cataract and vitreous surgery. J Cataract Refract Surg. 2003;29(7):1252-1255.
10. Mansour AM. Anterior capsulorhexis in hypermature cataracts. J Cataract Refract Surg. 1993;19(1):116-117.
11. Michels M, Lewis H, Abrams GW, Han DP, Mieler WF, Neitz J. Macular phototoxicity caused by fiberoptic endoillumination during pars plana vitrectomy. Am J Ophthalmol. 1992;114(3): 287-296.
12. Oshima Y, Awh CC, Tano Y. Self-retaining 27-gauge transconjunctival chandelier endoillumination for panoramic viewing during vitreous surgery. Am J Ophthalmol. 2007;143(1):166-167.
13. Oshima Y, Shima C, Maeda N, Tano Y. Chandelier retroillumination-assisted torsional oscillation for cataract surgery in patients with severe corneal opacity. J Cataract Refract Surg. 2007; 33(12):2018-2022.
14. Jang SY, Choi KS, Lee SJ. Chandelier retroillumination-assisted cataract extraction in eyes with vitreous hemorrhage. Arch Ophthalmol. 2010;128(7):911-914.
15. Fuller D, Machemer R, Knighton RW. Retinal damage produced by intraocular fiber optic light. Am J Ophthalmol. 1978; 85(4):519-537.
16. Nichamin LD. Endoilluminated infusion cannula for anterior segment surgery. J Cataract Refract Surg. 2012;38(8):1322-1324.
17. Kim KH, Sohn HJ, Song HJ, Lee DY, Nam DH. Surgeon-controlled-endoillumination-guided irrigation and aspiration during combined 23-gauge sutureless vitrectomy and cataract surgery in eyes with poor fundus reflex. J Cataract Refract Surg. 2010;36(12):2028-2031.
18. Chang D. Improving the red reflex and surgical outcomes with the Lumera Microscope. Cataract & Refractive Surgery Today. 2009;27-30.