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Efficacy and Wound Temperature Gradient of White Star Technology Phacoemulsification Through a 1.2-mm Incision

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ABSTRACT

Purpose: To investigate the efficacy and wound temperature gradients of WhiteStar micropulse technology using bimanual phacoemulsification without an irrigating sleeve (a 1.2-mm incision).

Setting: Island Eye Surgicenter, Carle Place, New York, USA

Methods: 10 patients underwent phacoemulsification using micropulse technology without an irrigation sleeve through a 1.2-mm clear corneal incision. A thermocouple consisting of a 30-gauge copper wire was inserted into clear cornea directly adjacent to the wound to digitally record temperature gradients at the wound. Endothelial cell counts were evaluated pre-operatively and post-operatively in two patients.

Results: All 10 patients maintained corneal clarity with no sign of thermal damage to the wound. Maximum corneal wound temperatures during phacoemulsification ranged from 24 to 34 degrees Centigrade; well below the temperature of collagen shrinkage.

Conclusion: Due to the decreased thermal effect achieved with WhiteStar technology the irrigation sleeve used over the phacoemulsification needle is superfluous when using this software. As a result, bimanual phacoemulsification can safely be performed through 1.2-mm incisions.

One of the greatest innovations in cataract surgery was the invention of phacoemulsification. With this technique, cataract surgery advanced from a macro-incision procedure to a micro-incision procedure, adding increased safety and control, as well as more rapid wound healing and visual rehabilitation[1, 2]. Unfortunately, polymethylmethacrylate intraocular lenses required a minimal incision cord length of 5.5-mm. While the cataractous lens could be removed through a 3.5-mm incision, the full advantage of phacoemulsification was not achieved because the incision needed to be enlarged to accommodate the intraocular lenses[3]. With the advent of foldable intraocular lenses, the incision size decreased further to the 3-mm range, approximately the size of the phacoemulsification needle with its irrigation sleeve. Further reduction in the incision size would be advantageous, as it would improve surgical control, maintenance of the anterior chamber, reduce the risk of endophthalmitis, and accelerate visual rehabilitation[4, 5]. The rate-limiting factor for incision size with the present phacoemulsification technology is the diameter of the phacoemulsification needle and the overlying irrigation sleeve.

Recently a micropulse technology has been developed that allows for rapid dispersion of heat and produces little thermal effect on the cornea[6]. With this technique, the phacoemulsification needle oscillates at a set rate, with brief on-and-off ultrasound cycles. The thermal energy produced with this technology is markedly decreased. During the off period the heat is dispersed, decreasing the maximal temperature of the phacoemulsification needle, resulting in fewer thermal complications during phacoemulsification. At the same time, efficacy of the procedure is maintained.

The purpose of this paper is to evaluate the efficacy and wound temperature gradient of

WhiteStar micropulse technology using bimanual phacoemulsification without an irrigating sleeve (a 1.2-mm incision).

Patients and Methods

Ten patients underwent phacoemulsification using micropulse technology without an irrigation sleeve through a 1.2-mm clear corneal incision. Prior to beginning the procedure, a 30-gauge needle was used to create a superior opening through the cornea at the limbus, and a Type-TP (Physitemp) copper-Constantan thermo-couple thermometer wire was placed into the clear cornea and attached to a thermal probe. The thermal probe displayed temperatures digitally, using measurements of very small DC electrical voltages. The Type-TP thermo-couple wire is Teflon-coated, and is active to 0.1 degree Centigrade at a range of 0 to 50 degrees. The 30 gauge thermo-couple wire was attached to an auto-correcting BAC-12 temperature monitoring system. Standardized temperature records were continually displayed on the BAC-12 system, and recorded every 30 seconds. The maximum temperature was taken at every stage of the phacoemulsification procedure. The BAC-12 thermo-couple is approved for medical usage (Figure 1).

All patients had a 1.2-mm MVR (Beaver) blade incision placed superiorly and at the 9 o’clock position on the cornea. Following the placement of the wire, the MVR blade was passed directly beneath the thermo-couple so that the thermo-couple was contiguous with the incision. The wound size was then checked with a newly devised Deacon-Steinert gauge and was confirmed to be 1.2-mm. Preservative free 1% Lidocaine was injected into the temporal incision and Duovisc™ (Alcon, Fortworth, Texas) viscoelastic was placed through the superior incision. An anterior capsulorrhexis was performed with a bent 25-gauge needle, followed by hydrodissection and hydro-delineation. A 20-gauge irrigating cannula/cyclodialysis spatula was placed in the temporal incision. The bottle height for irrigation was raised approximately 1 foot above the maximal bottle height by use of an extender with the Sovereign™ (Applied Medical Optics, Irvin, CA) phacoemulsification unit. The straight phacoemulsification needle was then placed through the superior incision without an irrigation sleeve.

The phacoemulsification tip was placed in the anterior chamber, and a conventional four-quadrant splitting technique was performed using a bimanual technique with the side irrigating cannula also serving as a cyclodialysis spatula. Phaco 1 settings consisted of a power setting of 50%, micropulse setting of 1:1, aspiration of 20-cc/min and vacuum of 40-mmHg. Phaco 2 settings consisted of the same power, micropulse, and aspiration settings with a vacuum of 300-mmHg. The lens was phacoemulsified, and digital readings of maximum temperature were recorded every 30 seconds.

At the conclusion of phacoemulsification, the wound was extended to 2.65-mm and a conventional irrigation-aspiration, followed by lens insertion with a foldable intraocular lens, was accomplished. All corneas were evaluated for corneal clarity and wound integrity. In two patients, endothelial cell counts were performed preoperatively and at three months postoperatively.

Results

All 10 patients maintained corneal clarity, with no signs of thermal damage to the wound. Temperatures were recorded during wire insertion, viscoelastic insertion, capsulorrhexis, hydrodissection, the insertion of irrigation, the insertion of the phacoemulsification probe, and during primary phacoemulsification. For all 10 cases, the maximum temperature at the time of wire insertion was 32.5 (range 22.5 to 32.5), with a mean of 26.5 degrees centigrade. The viscoelastic insertion maximum temperature recording was 29.7 (range 26.2 to 29.7), with a mean of 28.4 degrees centigrade. The maximum temperature during capsulorrhexis had a mean of 30.0 (range 29.1 to 30.5) with a maximum of 30.5 degrees centigrade. During the hydrodissection the maximum temperature recorded was 30.2 (range 24.6 to 30.2), with a maximum mean of 27.1 degrees centigrade. During the phaco 1 phase, the maximum temperature recorded was 34.1 (range 30.9 to 34.1) with a mean of 33.1 degrees centigrade, and during the phaco 2 settings, the maximum recorded temperature was 29.0 (range 24.1 to 29.0) with a mean of 27.1 degrees centigrade (Table 1). At no time during the procedure were there any signs of corneal clouding or wound disturbance. While performing phacoemulsification with WhiteStar technology and a bimanual technique, the anterior chamber remained stable and markedly improved followability of nuclear fragments was noted.

Endothelial cell counts were performed preoperatively and at 3 months postoperatively in 2 patients. The mean preoperative endothelial cell count was 1,968 and decreased to 1,889 at the 3-month postoperative visit (within the standard measurement error).

Discussion

Previous human eye-bank eye clinical experimentation using a bimanual small incision approach[6, 7] showed that the anterior chamber could be maintained with at least two large holes or an open-ended, thin-walled, irrigating cannula. Furthermore, with adequate leakage around the phacoemulsification tip, this approach was quite forgiving from a temperature standpoint. Additional work with WhiteStar micropulse technology[6] verified that this added a large margin of safety such that we could not produce a wound burn under any potential clinical situation. The present study has now confirmed these results in a clinical setting.

Due to the decreased thermal effect achieved with WhiteStar technology, the irrigation sleeve with the phacoemulsification needle is superfluous when using this system. In addition, by using a bimanual technique, the irrigation does not repel the nuclear fragments.

Furthermore, irrigation can now be used for more than chamber maintenance. It becomes a tool to safely move nuclear fragments from off the posterior capsule or out of the capsular fornix without having to chase them with the more dangerous phacoemulsification tip. With a moderately tight wound, the lens fragments move to the aspiration port as the single significant drain for fluid flow. We have also found that less irrigation is needed to do the same work because coaxial irrigation and aspiration effectively short-circuits a lot of the fluid.

The decreased energy expenditure of the WhiteStar technology with rapid on/off cycles further reduces the dispersive forces, which drive nuclear fragments away from the phacoemulsification tip. Ultrasound always pushes nuclear fragments away, however, WhiteStar pulses are so short, aspiration forces predominate. The result of the reduced hydro-dispersive flow and ultrasonic energy is an anterior chamber which is less turbulent resulting in increased followability and control in removing nuclear fragments. As a result, phacoemulsification can be performed safely, without temperature damage to the wound and minimal endothelial trauma, through a 1.2-mm incision.

Small wound bimanual cataract extraction is also well suited to laser lens removal. This has been shown to be very forgiving temperature-wise[8, 9] and is regularly performed with irrigation separated from aspiration. It works well later with softer cataracts, however, it has been slow and unpredictable with hard cataracts[10]. Such is not the case with WhiteStar ultrasound technology, which we have regularly used with both 20 and 21 gauge instruments on very hard cataracts. Efficiency, if anything, may be increased due to decreased chatter and increased followability.

Thermal damage to corneal collagen occurs at 60^0c[11, 12] well below the usual temperatures achieved with WhiteStar technology in this and the previous study. Further investigation of WhiteStar technology is required in that the variations of different cycles are almost endless and will lend to other clinical advantages. Already there are intraocular lens designs that can be placed through incisions as small as 1.5-mm[13]. The field of small incision intraocular lenses is just beginning so that taking full advantage of this new technology will continue to mature.

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Figure Legend

Figure 1: The temperature recording instrumentation in place for real-time wound temperature recording.

Table

Table 1: Temperature of wound as recorded at each step of the cataract surgical removal with the 1.2-mm incision (N=10)

Surgical Step	Maximum Temperature (^{0}c)	Minimum Temperature (^{0}c)
Recording wire insertion	32.5	22.5
Viscoelastic injection	29.7	26.2
Capsulorrhexis	30.5	29.1
Hydrodissection	30.2	24.6
Nucleus grooving	34.1	30.9
Nucleus segment removal	29.0	24.1

Figures