Clinical Assessment of the White Star® Power Control System for Phacoemulsification

Nobuhiko Chikamoto, M.D.

Department of Biomolecular Recognition and Ophthalmology, Yamaguchi University School of Medicine, 1-1-1, Minami-Kogushi, Ube, Yamaguchi, 755-8505, Japan
(Received April 1, 2004, accepted May 31, 2004)

Abstract

Purpose: To compare the clinical efficacy of phacoemulsification performed with or without the White Star® (Allergan) power control system.
Methods: The study population comprised 26 individuals (37 eyes) with cataract but without any general or ocular complications. Subjects were recruited between November 2001 and January 2002. According to the Emery-Little classification, 11 eyes were grade 2, 20 eyes were grade 3, and 6 eyes were grade 4. One group of patients (12 individuals, 18 eyes) underwent surgery with White Star, the other group (14 individuals, 19 eyes) underwent surgery with the conventional program. Phacoemulsification in all cases was performed by the same surgeon. Main Outcome measures were operation time, total effective phaco time, average phaco power, irrigation solution volume, flare value, corneal thickness, and corneal endothelial cell loss.
Results: Operation time was 19.9 ± 4.6 min with and 27.4 ± 8.8 min without the White Star power control system. Mean phaco power was 6.9 ± 2.8% with and 10.0 ± 3.5% without White Star. The postoperative increase in corneal thickness was 5.9 ± 4.2% with and 10.5 ± 7.6% without White Star.
Conclusions: These results suggest that the White Star power control system improves phaco efficiency and reduces both surgical stress and damage to the corneal endothelium.

Key words: phacoemulsification, White Star, corneal thickness, corneal endothelium

Introduction

Current surgical techniques for cataracts are safe and effective. However, there remains room for improvement in postoperative recovery of corneal function that might be achieved by reducing further the invasiveness of cataract surgery. Thus, although such surgery has benefited from the development of viscoelastic materials, intraocular irrigation solutions, fine surgical instruments, and intraocular lenses, corneal endothelial damage is still one of the most serious postoperative complications. Indeed, the number of patients who undergo corneal transplantation after cataract surgery has been increasing.[1] In addition to corneal endothelial damage, the phacoemulsification and aspiration technique currently performed can result in thermal burns at the wound site, postoperative astigmatism, and inflammation.[2] The energy generated by the ultrasound waves appears to be responsible for these complications,[3-7] with thermal burn leading to postsurgical astigmatism. Rupture of the posterior capsule and vitreous herniation are also possible complications of phacoemulsification. A reduction in the total ultrasound energy necessary for surgery might be expected to ame-

liorate these various side effects. Indeed, the extent of surgical complications depends largely on the ultrasound system used. A low phacoemulsification power allows better surgical control, increases wound stability, reduces the risk of pathogen entry into the anterior chamber, and, most importantly, accelerates visual rehabilitation.

Since Kelman[8] first introduced phacoemulsification for cataract surgery, the development of linear, pulse, and modulation burst modes of phacoemulsification machines has contributed greatly to the safety of this technique. The introduction of the divide-and-conquer approach also markedly reduced the ultrasound energy necessary for cataract emulsification. A new ultrasound power modulation program was recently developed, and the oscillation mode of Sovereign with White Star® (Allergan) is expected to reduce the total ultrasound energy required for phacoemulsification of cataracts. With the conventional program, 1 oscillation unit time in the pulse mode is 50 ms. In contrast, the pulse time of ultrasound wave oscillation with the White Star system is only 2 ms. Furthermore, opmization of the numbers of ON and OFF modes should allow minimization of the ultrasound energy required for complete phacoemulsification of cataracts. I have now compared the effectiveness of the White Star power control system with that of the conventional program for cataract emulsification.

Materials and Methods

The study was approved by the internal review committee for clinical research at Yamaguchi University School of Medicine and Yamaguchi University Hospital. The study population comprised 26 individuals (37 eyes) with cataract but without any general or ocular complications. They were recruited between November 2001 and January 2002. According to the Emery-Little classification, 11 eyes were grade 2, 20 eyes were grade 3, and 6 eyes were grade 4. The mean age of the subjects was 72.8 ± 7.9 years (range, 53 to 88 years). After obtaining informed consent from each patient, I assigned them to two groups nonrandomly. One group (12 individuals, 18 eyes) underwent cataract surgery with the use of Sovereign with White Star; the other group (14 individuals, 19 eyes) underwent cataract surgery with the use of Sovereign with the conventional program.

All surgeries were performed by the same surgeon (N.C.) with the patients under local anesthesia (2% lidocaine administered sub-Tenon's capsule). The surgical technique involved a 3.5-mm unsutured sclerocorneal tunnel, two side ports, injection of viscoelastic material (Healon®) without the soft-shell technique, continuous curvilinear capsulorhexis (CCC), aspiration of the cortex, and refilling of the capsular bag with viscoelastic solution. A foldable acrylic intraocular lens (Sensor®) was implanted into the capsular bag with the aid of an injector. Surgery was performed with the two-hand technique, and the phaco tip used was 15° and 19-gauge. First hemisect sculpting was achieved by the divide-and-conquer technique,[9][10] and emulsification was performed by the stop-and-chop technique.[11][12] The settings of the phacoemulsification machine, including phaco power, vacuum, and bottle height, were the same for both the White Star and conventional programs.

Operation time, total effective phaco time, average phaco power, irrigation solution volume, flare value, the increase in central corneal thickness (pachymetry), and central corneal endothelial cell loss were compared between the two approaches. All eyes were examined by noncontact specular microscopy (Noncon Robo-CA®, Konan) preoperatively and 1 week postoperatively. The endothelial cell density at the corneal center was measured. And central corneal thickness were examined by ultrasonic pachymetry (PACHYMETER SP-2000® TOMEY) preoperatively and 1 day postoperatively.

Data are presented as means ± SD. They were compared between the conventional group and the White Star group by the unpaired Student's t-test, and among the three groups of Emery-Little classification[13] by the Tukey-Kramer test. A P value of <0.05 was considered statistically significant.

Results

To evaluate the overall efficacy of the White Star power control system for cataract surgery,

I compared the operation time. Whereas the operation time with the conventional program was 27.4 ± 8.8 min, it was only 19.9 ± 4.6 min with White Star, a statistically significant reduction of 27.4% ($P < 0.05$). The total effective phaco time (total time of the ON mode) was 10.9 ± 11.1 sec with the conventional program and 7.6 ± 7.5 sec with White Star (Fig. 1), but this difference was not statistically significant.

Comparison of the total effective phaco time for each grade of hardness of the lens nucleus, however, revealed a significant difference for grade 4 between the conventional program (36.4 ± 16.6 sec) and White Star (22.1 ± 3.8 sec) (Fig. 1). Average phaco power was significantly reduced with White Star (6.9 ± 2.8%) compared with the conventional program (10.0 ± 3.5%) for all subjects (Fig. 2). Although
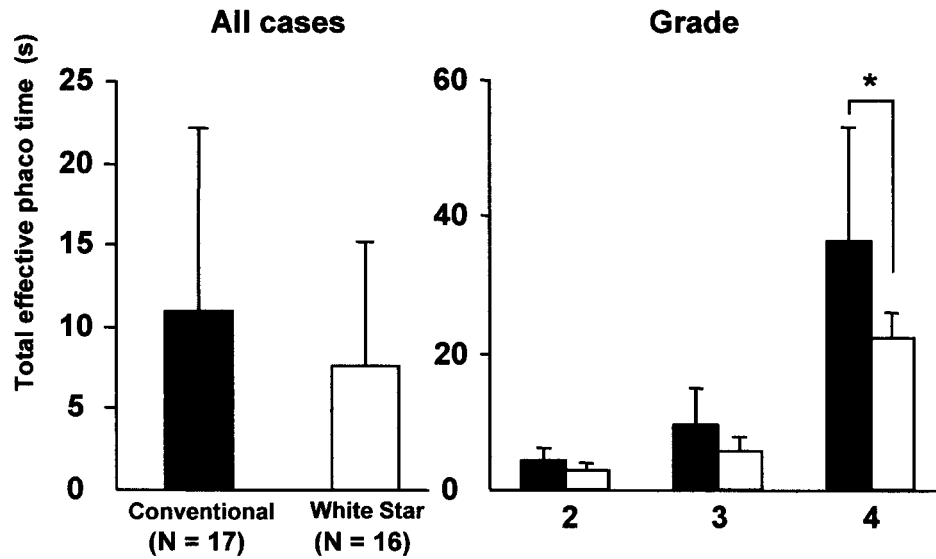

Fig. 1 Comparison of total effective phaco time between conventional and White Star programs. Data are shown for all cases (left panel) as well as for eyes classified according to Emery-Little grade. *$P < 0.05$ (Tukey-Kramer test).
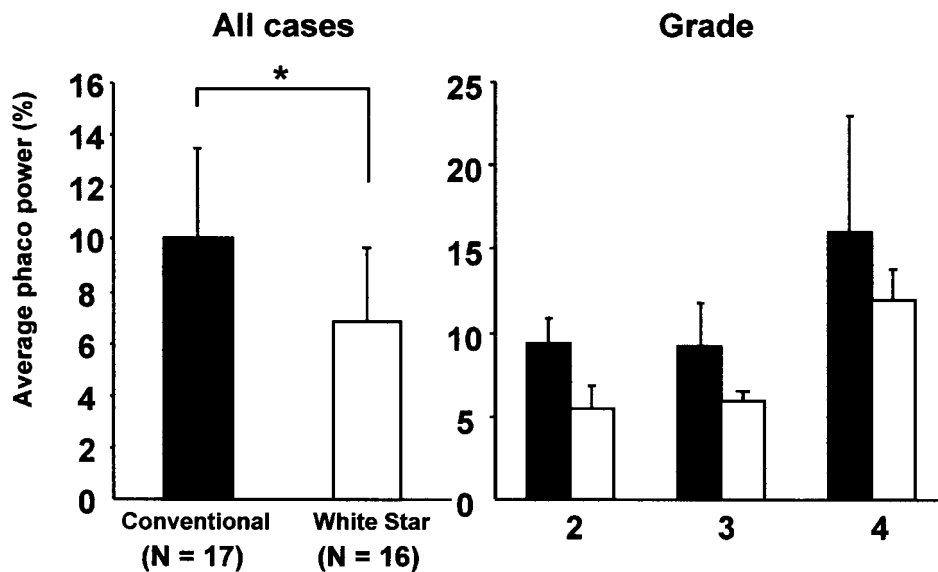

Fig. 2 Comparison of average phaco power between conventional and White Star programs. Data are shown for all cases (left panel) as well as for eyes classified according to Emery-Little grade. *$P < 0.05$ (unpaired Student's t test).

average phaco power was also reduced with White Star for each grade of cataracts, these differences were not statistically significant (Fig 2). The total amount of irrigation solution was also reduced to 162.7 ± 43.6 ml with White Star, compared with a value of 203.2 ± 63.0 ml for the conventional program, but again this difference was not significant.

The average endothelial cell loss 1 week after surgery was 22.2 ± 12.1% with the conventional program and 14.2 ± 9.7% with White Star, although this difference was not statistically significant. The increase in corneal thickness apparent 1 day after surgery was 10.5 ± 7.6% with the conventional program but only 5.9 ± 4.2% with White Star (Fig. 3). I further analysed the change in the corneal thickness based on the cataract grade. When convention-

al type used for the surgery, increase in the corneal thickness after the surgery was rather constant regardless the hardness of the cataract. Even after surgery to the grade 2 cataract (soft cataract), corneal thickness increased almost 15%. On the contrary, the increase in the corneal thickness depend on the grade of the cataract when White Star system was used. However, these changes were not statistically significant. This significant difference thus suggests that surgery with the White Star program resulted in less endothelial damage than did that performed with the conventional approach. Finally, I analyzed the anterior chamber reaction 1 day after surgery with a laser flare cell meter. The flare value was 8.8 ± 4.1 pc/ms with the conventional program and 10.7 ± 3.2 pc/ms with White Star.
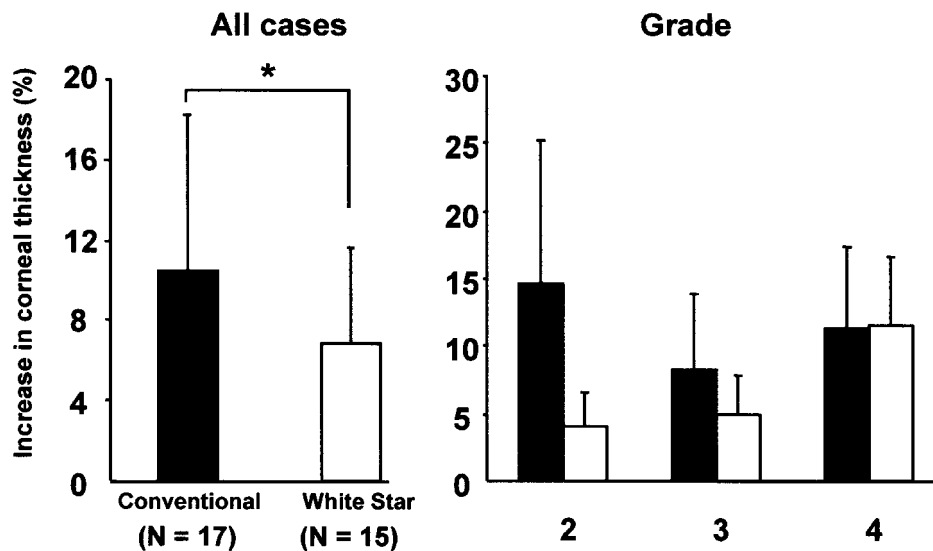

Fig. 3 Comparison of postoperative increase in corneal thickness between conventional and White Star programs. *P < 0.05 (unpaired Student's t test).

Discussion

The transparency and refractive surface of the cornea are important for vision and the postoperative condition of the cornea is one of the most important factors in determining the outcome of cataract surgery. Corneal transparency depends on the water content of the stroma, which accounts for 90% of the corneal thickness.[14] Changes in the thickness of the cornea reflect the overall function of the corneal endothelium. Influx of water into the corneal

stroma is regulated by the barrier function of the epithelium as well as the barrier function and water pump activity of corneal endothelial cells. The functions of the corneal endothelium are determined by both endothelial cell density and the activities of the individual cells. Whereas endothelial cell density can be mo-nitored by specular biomicroscopy, it is not possible to evaluate the activities of corneal endothelial cells clinically at this time. However, inflammation in the anterior chamber may reduce endothelial cell function as a re-

sult of the production of inflammatory cytokines. Endothelial damage results in an increase in corneal thickness and alters the normal morphometric pattern of the endothelium.[14] Corneal endothelial dysfunction and decompensation lead to loss of vision.

Cataract surgery may damage the corneal endothelium as a result of bubble or free radical formation during phacoemulsification, excess ultrasound energy, turbulence of the irrigation solution, mechanical trauma caused by instruments, or the presence of lens fragments or intraocular lenses. Endothelial cell loss and an increase in corneal thickness are thus complications of cataract surgery.[15-18] Although improvements in the technology of phacoemulsification machines and the development of surgical techniques such as phaco chop[19-22] and stop and chop have reduced the total ultrasound energy required for lens extraction, minimization of the energy applied remains an important goal.

I have now shown that application of White Star technology reduced the loss of corneal endothelial cells associated with phacoemulsification, indicating that the reduction in total ultrasound energy achieved with the use of 2-ms pulses, compared with the 50-ms pulse duration of the conventional approach, helps to reduce the adverse effects of ultrasound energy on the corneal endothelium. In grade 2 and 3 cataract, total effective phaco time and average phaco power were reduced with White Star. Accordingly the increase in corneal thickness was reduced. But in grade 4, the increase in corneal thickness was invariable. This result showed that White Star was effective to prevent endothelial damage for rather soft cataract. White Star was obviously reduced functional endothelial damage.

Cataract surgery has been rendered less invasive by reducing the size of the incision, altering the chemical components of the intraocular irrigation solution, and the introduction of the soft-shell technique. Incision affects corneal endothelial cell loss, with smaller incisions inducing smaller cell loss. The mean endothelial cell loss apparent 3 months after a 5.5-mm scleral tunnel phacoemulsification was found to be 11.8%.[23] A scleral tunnel incision is associated with less postoperative endothelial damage than is a clear corneal in-

cision, with the difference being statistically significant at the 12 o'clock position.[24] It remains necessary, however, to process the lens nucleus with an adequate oscillation time, with the excess energy causing potential complications. Improvements in viscoelastic materials have also been achieved.[25-27] The soft-shell technique was shown to reduce corneal endothelial cell damage during cataract surgery in patients with a hard lens nucleus (Emery-Little classification of grade 3 or higher).[28] BSS Plus® may also reduce corneal risk in eyes with compromised corneas or in cases of prolonged surgery.[29]

Tsuneoka et al.[30][31] and Soscia et al.[32][33] recently showed that two small (1.4 mm) incisions might be sufficient to insert the ultrasound tips in cataract surgery. One potential problem with such approach, however, is the heat generated by the ultrasound tips, which must be used unsleeved. I currently use a 3.5-mm incision to insert the ultrasound tip with sleeve. I have now shown that White Star technology reduced the total ultrasound energy by about one-third compared with the conventional program.

In conclusion, I have shown that sculpting was possible with lower ultrasound energy with the use of White Star technology for cataract surgery. With this approach, it was possible to position the ultrasound tip closer to the target tissue, thereby reducing the possibility of mechanical trauma caused by released lens fragments and yielding more working space for surgery. The shortened phaco time and reduced phaco power with White Star also resulted in a little increase in corneal thickness after surgery because of reduced endothelial damage.

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