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ORIGINAL RESEARCH

Comparison of Phacoemulsification Grooving Efficiency in Longitudinal vs Transversal Handpieces

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Purpose: To determine the difference, if any, in grooving efficiency at various settings on the Whitestar Signature Pro phacoemulsification (phaco) system.

Methods: Cataractous lenses were simulated by exposing porcine lenses to formalin for 2 hours. A total of 120 lenses were analyzed at various power settings on both longitudinal and transversal handpieces. Twenty trials each were performed with power set to 25%, 50%, and 75% on both handpieces. A Whitestar Phaco Handpiece System was used to provide longitudinal power, and a Whitestar Signature Ellipsis Handpiece provided transversal power. Lenses were placed within a plastic chamber and grooved by an investigator blinded to settings. A second investigator recorded times and adjusted settings. The Whitestar Signature Pro phaco system was used for grooving.

Results: There was no significant difference in grooving times between the longitudinal and transverse handpieces at any power setting ($P > 0.05$). There was a significant decrease in grooving times when comparing the 25% power setting with the 75% power setting for the transversal handpiece ($P=0.021$).

Conclusion: Both longitudinal and transversal handpieces on the Whitestar Signature Pro phaco system produce similar results to one another at each power setting. There is a general trend toward shorter grooving times, reflecting greater efficiency, at higher power settings. Grooving efficiency on the transversal handpiece may be more affected by changes in the power settings as compared with the longitudinal settings.

Keywords: phacoemulsification, cataract, phacoemulsification energy, transversal ultrasound, phacoemulsification efficiency

Plain Language Summary

Cataract surgery involves breaking up and removing the natural lens with a phacoemulsification (phaco) device, then replacing the natural lens with an artificial lens. Phaco handpieces and settings can be changed to achieve various goals. Although phaco is very safe, the process can put the cornea at risk of irreparable damage. One of the risk factors is the length of time and the energy used during phacoemulsification. Therefore, it is in the best interest of the surgeon to optimize settings for efficient removal of the natural lens.

In this study, we compared the efficiency of longitudinal and transversal handpieces. Pig lenses soaked in formalin were used to replicate a human natural lens with a cataract. This model was developed by our lab and described in other studies. Efficiency was measured by the time taken to separate the lenses into two pieces using a process called grooving.

Our findings in this study are important for determining which handpiece is most efficient for grooving.

Introduction

Cataracts are a common, correctable cause of vision loss worldwide. Modern cataract removal surgery is performed by the removal of the cataractous lens by phacoemulsification (phaco), and replacement with an artificial lens. One possible

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complication of cataract removal is that prolonged phaco can cause damage to other structures of the eye, including the cornea.[1,2] Optimization of phaco is therefore key to reduce the length of the procedure and minimize exposure of the eye to damage. Bottle height, vacuum, aspiration flow rate, power, and handpiece type (longitudinal vs transversal) are all variables that can be adjusted to improve phaco efficiency. The objective of this study is to measure grooving times at various power settings, in order to determine optimal power settings. It also compares longitudinal vs transversal handpieces. The tip of the longitudinal handpiece vibrates forward and backward, while the tip of the transversal handpiece vibrates in an elliptical pattern with some longitudinal movement. This study is one of our series of investigations concerning the Whitestar Signature Pro phaco system.[3,4]

Materials and Methods

Lenses were harvested from whole pig eyes purchased from Visiontech, Inc. (Sunnyvale, Texas, USA) and shipped to the John A. Moran Eye Center. Once harvested, they were immediately immersed in a 10 mL solution of 10% formalin where they remained for 2 hours (measured from the addition of the final lens to the solution). After treatment with formalin, the lenses were rinsed with balanced saline solution (BSS) and placed in a BSS bath for 24 hours. Once this preparation was complete, lenses were selected at random and individually placed in the grooving chamber.

A Whitestar Signature Pro phaco system (Abbott Medical Optics, Inc. Johnson & Johnson Vision [J&J], Santa Ana, California, USA) was used for grooving. A Whitestar Phaco Handpiece System was used to provide longitudinal power, and a Whitestar Signature Ellips Handpiece provided transversal power.

The grooving chamber was developed by our lab to simulate the environment of the lens at the time of surgery. It is composed of a plastic base with a clear plastic lid. The chamber's interior is a 16 mm diameter hemisphere (Figure 1).[5] Each lens was placed inside the chamber, which was then filled with BSS before grooving. Grooving proceeded by bisecting the lens at its widest point. Groove times were measured by handheld stopwatch and recorded by a second investigator, without being shown to the first investigator. This process was repeated, with power settings being adjusted between each lens in a semi-random pattern by the second investigator, who was blinded to these changes. Twenty lenses were grooved at power settings of 25%, 50%, and 75% with a longitudinal handpiece. The process was then repeated with the transversal handpiece. Vacuum was set at 300 (peristaltic), aspiration flow rate at 30, and bottle height of 90 throughout all trials.

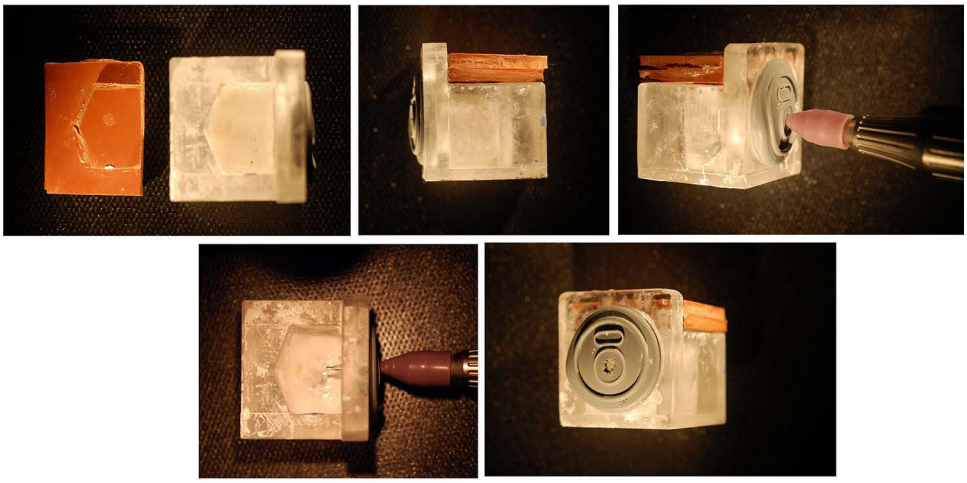

Figure 1 Aerial view of the groover with lid removed (upper left), front view of the groover (middle left), side view of the groover with the handpiece in (upper right), aerial view of the groover with the handpiece in (lower left), and side view of the groover (lower right). The interior of the chamber measures 16 mm in width, 16 mm in length (from the front to the pentagon's point, which is the back of the chamber), and 16 mm tall.
Note: Reproduced with permission from Dove Medical Press. Thomson RS, Bird BA, Stutz LA, et al. The effect of increasing power when grooving using phacoemulsification. *Clin Ophthalmol*. 2019;13:611–615.[5]

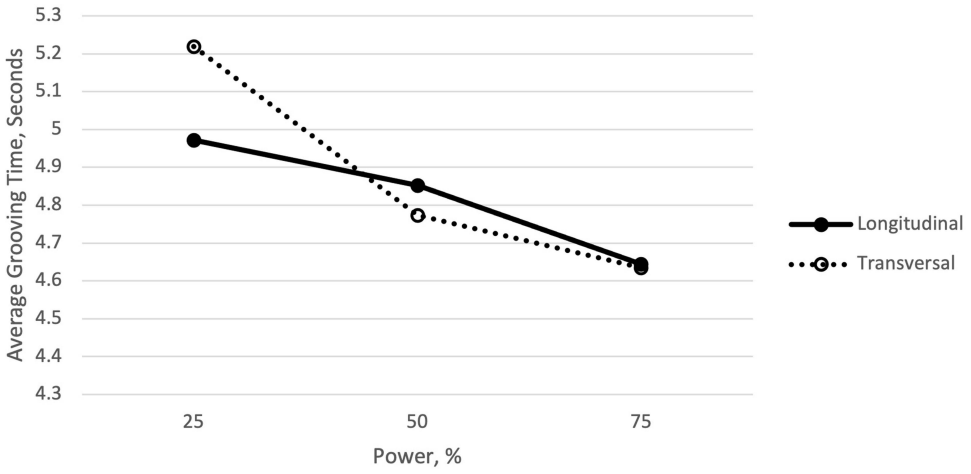

Figure 2 Average grooving times for longitudinal and transversal settings.

Statistical Analysis

Single-factor ANOVA from the Data Analysis plug-in for Microsoft Excel was used to compare the average, mean, variance, and groups.

Results

The average grooving time for the longitudinal setting was 4.972 ± 0.84, 4.8525± 0.5715, and 4.645 ± 0.989 seconds for 25%, 50% and 75% power, respectively. The average grooving time for the transversal setting was 5.22 ± 0.758, 4.77 ± 0.83, and 4.63 ± 0/69 seconds for 25%, 50%, and 75% power, respectively (Figure 2). The difference in grooving times between longitudinal and transversal setting at 25%, 50%, and 75% power was insignificant (P>0.05). Between the longitudinal settings tested, there was no difference in the grooving times (P>0.05). Between the transversal settings, the grooving times were statistically different as the power increased (P=0.035).

Discussion

At each power setting, the longitudinal and transversal handpieces on the Whitestar Signature Pro phaco system produced similar results. For each respective handpiece, there is a trend in decreased grooving times for higher power settings, which demonstrates increased efficiency. The transversal handpiece had a statistically significant decrease in grooving times at increasing power settings. Thus, the transversal handpiece may be more affected by changes in power than the longitudinal handpiece.

Grooving efficiency is an important attribute during phaco. The duration of phaco and the amount of dissipated energy during phaco increase the likelihood of damage to the corneal endothelium. More power typically increases efficiency; however, increased power may also increase adverse effects caused by chatter and excess delivered energy. Therefore, the goal of phaco settings should be to find an optimal power setting with sufficient power to minimize duration of phaco without increasing power to the point of excessive chatter that may nullify the benefits of the higher power.

The porcine model of cataractous lens is most similar to human cataracts rated at 3+ and 4+ when comparing data from DeMill et al and Oakey et al.[6,7]

Dewan et al found higher frequency phaco to be associated with decreased phaco time in hard cataracts.[8] They compared two frequencies: 28 kHz and 42 kHz, in patients with grade 4.0 to 6.9 senile cataracts. Their power was set to 40%. In our system, the longitudinal handpiece had a frequency of 29kHz and the transversal handpiece had a frequency of 38kHz. Our findings did not show a significant difference between the two ultrasound modalities. The most likely explanation is that the differences in the two modality designs are more important than the frequencies used.

Christakis et al conducted a comparative study evaluating longitudinal, transversal, and torsional in patient cases.[9] Similar to our findings, they did not find a statistically significant difference between longitudinal and transversal for phaco time.

When grooving a cataract, the lens is immobile. This is a very different scenario compared to a quadrant that is mobile within the anterior chamber. Removing quadrant lens pieces in transversal ultrasound has been shown to be more efficient compared to longitudinal ultrasound at least partially due to the increased chatter that happens in longitudinal mode.[6,10,11] Transversal ultrasound tends to hold the lens piece at the tip, allowing more efficient work to happen on the lens. With an immobile lens during grooving, the ultrasound needle is advanced into the cataract; and whether the needle is moving longitudinally or elliptically, the efficiency appears to be the same.

In conclusion, grooving time does not aid in selection between transversal and longitudinal phaco using the Whitestar Signature Pro system. Surgeon preference would appear to be more important in choosing the ultrasound mode used during the grooving step of cataract surgery.

Abbreviations

ANOVA, analysis of variance; BSS, balanced saline solution; phaco, phacoemulsification.

Ethics Approval and Informed Consent

Since no human subjects were involved, approval from the University of Utah Institutional Review Board was not obtained.

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Disclosure

Dr Olson is on the Board of Directors of Perceive Bio and the Scientific Advisory Board of Perfect Lens. Dr Jeff Pettey reports a Consulting agreement for Lensar, outside the submitted work. The other authors report no conflicts of interest in this work.

References

1. Beesley RD, Olson RJ, Brady SE. The effects of prolonged phacoemulsification time on the corneal endothelium. *Ann Ophthalmol*. 1986;18(6):216–219.
2. Takahashi H. Free radical development in phacoemulsification cataract surgery. *J Nippon Med Sch*. 2005;72(1):4–12. doi:10.1272/jnms.72.4
3. Bernhisel AA, Cahoon JM, Sella R, et al. Optimum on-time and off-time combinations for micropulse phacoemulsification in venturi vacuum mode. *J Cataract Refract Surg*. 2019;45(12):1797–1800. doi:10.1016/j.jcrs.2019.07.001
4. Ramshekar A, Heczko J, Bernhisel A, et al. Optimizing tip diameter in phacoemulsification of varying lens sizes: an in vitro study. *Clin Ophthalmol*. 2021;15:4475–4484. doi:10.2147/OPTH.S333903
5. Thomson RS, Bird BA, Stutz LA, et al. The effect of increasing power when grooving using phacoemulsification. *Clin Ophthalmol*. 2019;13:611–615. doi:10.2147/OPTH.S194731
6. DeMill DL, Zaugg BE, Pettey JH, et al. Objective comparison of 4 nonlongitudinal ultrasound modalities regarding efficiency and chatter. *J Cataract Refract Surg*. 2012;38(6):1065–1071. doi:10.1016/j.jcrs.2011.12.040
7. Oakey ZB, Jensen JD, Zaugg BE, Radmall BR, Pettey JH, Olson RJ. Porcine lens nuclei as a model for comparison of 3 ultrasound modalities regarding efficiency and chatter. *J Cataract Refract Surg*. 2013;39(8):1248–1253. doi:10.1016/j.jcrs.2013.01.049
8. Dewan T, Malik PK, Kumari R. Comparison of effective phacoemulsification time and corneal endothelial cell loss using 2 ultrasound frequencies. *J Cataract Refract Surg*. 2019;45(9):1285–1293. doi:10.1016/j.jcrs.2019.04.015

9. Christakis PG, Braga-Mele RM. Intraoperative performance and postoperative outcome comparison of longitudinal, torsional, and transversal phacoemulsification machines. *J Cataract Refract Surg*. 2012;38(2):234–241. doi:10.1016/j.jcrs.2011.08.035
10. Jensen JD, Shi DS, Robinson MS, et al. Torsional power study using CENTURION phacoemulsification technology. *Clin Exp Ophthalmol*. 2016;44(8):710–713. doi:10.1111/ceo.12748
11. Ronquillo CC Jr, Zaugg B, Stagg B, et al. Determining optimal torsional ultrasound power for cataract surgery with automatic longitudinal pulses at maximum vacuum ex vivo. *Am J Ophthalmol*. 2014;158:1262–1266.e1262. doi:10.1016/j.ajo.2014.08.034