LABORATORY SCIENCE

Effect of chamber stabilization software on efficiency and chatter in a porcine lens model

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Purpose: To evaluate the effects of the use of programmable chamber stabilization software (Chamber Stabilization Environment) settings on efficiency and chatter in a porcine lens model.

Setting: John A. Moran Eye Center Laboratory, University of Utah, Salt Lake City, Utah, USA.

Design: Experimental study.

Methods: Porcine eyes were dissected and the lenses extracted. The lenses were then hardened and processed for the experiment. Phacoemulsification of the lens fragments was performed with the Whitestar Signature Pro with the Whitestar handpiece and a 0.9 mm straight Dewey tip with a 30-degree bevel. All arms of the study were run in peristaltic mode with 50 mL/minute aspiration, 100 cm bottle height, and on 100% power. The chamber stabilization software setting was used for each of the 4 study arms with a maximum vacuum of 500 mm Hg. Arm 1 included 20 runs with the up time set to 2000 milliseconds. Arm 2 was performed with similar settings but with an up time of 0 millisecond. Arms 3 and 4 were run with up times of 1000 milliseconds and 500 milliseconds, respectively.

Results: The mean efficiency time of each run was as follows: 0 millisecond = 1.4 seconds, 500 milliseconds = 0.95 seconds, 1000 milliseconds = 0.88 seconds, 2000 milliseconds = 0.93 seconds. When compared with 0 millisecond, each of the other arms were significantly faster. Chatter events were comparable between the study arms.

Conclusion: The chamber stabilization software does not decrease efficiency when compared with full vacuum on if at least 500 milliseconds of up time is maintained.

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The maintenance of a stable anterior chamber is fundamental for successful and safe outcomes in phacoemulsification.[1–3] Aggressive phaco settings increase the risk for chamber flattening or collapse through postocclusion surge. To decrease postocclusion surge, Abbott Medical Optics, Inc. developed a software setting called Chamber Stabilization Environment. This software is designed to vary vacuum settings to meet the demands of surgery while decreasing surgical risk. A higher vacuum level is necessary to grasp a nucleus particle than that required to keep the particle attached to the tip for the completion of the lens fragment removal process. To accomplish this, the chamber stabilization software uses occlusion sensing and predetermined vacuum level fluctuations after set intervals. The theoretical goal behind the chamber stabilization software technology is to reduce postocclusion surge without decreasing surgical efficiency with the expectation of increasing anterior chamber stability throughout the phacoemulsification process.

To study this concept and software adaptation, we developed a porcine lens model that replicates 3+ to 4+ human cataracts.[4] We optimized linear ultrasound (US) pulsation and showed that a straight tip is better than a bent tip for cataract removal, the parameters of which guided this study.[5–8] Building on this research, the purpose of this study was to understand the effect of chamber stabilization software on micropulsed longitudinal US efficiency and chatter to determine whether this actually does maintain efficiency at the initial high vacuum levels.

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MATERIALS AND METHODS

Porcine Lens Preparation

This study consisted of 4 arms with 20 lenses per arm. Lens preparation was the same as performed in a previous study.[4] Briefly, porcine eyes were ordered from Visiontech, Inc. (Sunnyvale, Texas, USA). Within 48 hours of arrival, the lenses were dissected from the eye and placed in 10 mL of neutral buffered formalin for 2 hours to harden. The lenses were then washed 3 times in 10 mL of a balanced salt solution and incubated at room temperature for 24 hours to equilibrate. The lenses were then cut into 2.0 mm cubes and partially submerged in a balanced salt solution until experimentation.[9] Testing occurred no longer than 24 hours after cubing was finished.

Phacoemulsification

Emulsification was performed with the Whitestar Signature Pro (Abbott Medical Optics, Inc.) with the Whitestar handpiece using a 0.9 mm straight Dewey tip with a 30-degree bevel (Microsurgical Technology Inc.).

Efficiency was defined as the total time in seconds that was necessary to completely remove the lens fragment from the testing chamber. A stopwatch was used to record efficiency. Time started when the lens fragment was engaged with the tip and US was initiated, and stopped when the lens fragment fell or bounced off the tip to optimally separate chatter delay from efficiency. A chatter event was defined as any time the lens bounced from the tip when US was engaged. The emulsification occurred inside the phaco test sleeve, making it a closed system. After the lens particle is captured, it is physically no different than removing a lens fragment from inside the anterior chamber.

All runs were performed in peristaltic mode with 50 mL/min aspiration, 100 cm bottle height, 100% power, and 6 milliseconds on and off micropulse, and with a maximum vacuum of 500 mm Hg. The chamber stabilization software was turned on for all arms and set to the following parameters: 440 mm Hg up level, 385 mm Hg chamber stabilization software, and 300 mm Hg down vacuum. The up time, defined as the time spent at maximum vacuum, varied between the 4 arms of the study. Arm 1 was performed with 2000 milliseconds of up time, which was assumed to be longer than the evacuation time and therefore, the same as functioning continuously at the higher vacuum level. Arm 2 was performed at 0 millisecond of up time and therefore, functionally the same as emulsification at 300 mm Hg. Arms 3 and 4 were run at 1000 milliseconds and 500 milliseconds, respectively. The up level is the minimum vacuum level that must be obtained for the up time to begin. The chamber stabilization software level marks the first drop in vacuum level after reaching the full up time. The down vacuum is the second drop in vacuum pressure.

Statistical Analysis

Summary statistics, including the means ± SD, were compiled. Any outliers (defined as datapoints that fell above or below 2 SDs from the mean) that were found were removed from the dataset. Previous research has shown these outliers represented very hard lenses or lenses that took extra time before setting on the tip and emulsifying quickly.[4] There was 1 outlier removed for each arm except arm 4, which had 2 outliers removed. After the removal of outliers, summary statistics were recalculated. Two-factor *t* tests assuming unequal variance were used to calculate *P* values. A *P* value of 0.05 or less was considered statistically significant. All analyses were performed using Excel software (version 15.3, Microsoft Corp.)

RESULTS

Table 1 shows summary statistics for each of the 20 lens runs. A significant difference was found in each arm of the study when compared with 0 millisecond of up time (mean of 1.40 seconds), in other words, at the default 300 mm Hg vacuum level (Figure 1). An up time of 2000 milliseconds was over twice as long as the mean removal time; therefore, this met our goal of being functionally the same as having the higher vacuum for the entire lens fragment removal time. Up times of 2000 milliseconds ($P = .0017$ compared with 0 millisecond up time), 1000 milliseconds ($P < .0001$ compared with 0 millisecond up time), and 500 milliseconds ($P = .00012$ compared with 0 millisecond up time) were significantly better than at 0 millisecond of up time. No significant mean efficiency difference was found between 2000 milliseconds, 1000 milliseconds, and 500 milliseconds up times. Chatter events were not significantly different between the 4 arms of the study.

Table 1. Summary statistics of phacoemulsification of 2.0 mm porcine lens cubes using the chamber stabilization software at various up times.

Up Time (ms)	Efficiency (s) ± SD	Chatter Event (n) ± SD
0	1.40 ± 0.40	0.05 ± 0.20
500	0.95 ± 0.25	0.10 ± 0.30
1000	0.88 ± 0.29	0.05 ± 0.20
2000	0.93 ± 0.50	0.00 ± 0.00

DISCUSSION

The concept of a brief period of high vacuum dropping to a lower vacuum has been around for many years now. The concept that you could have the stable chamber of the lower vacuum as well as the improved efficiency of the higher vacuum was interesting but has never been proven as a factual claim to date. There would clearly be an advantage to such an approach, should it prove to be accurate. With our testing protocol, which tests the lens fragment removal phase, we duplicated that step in a closed system that physically will closely follow the clinical situation. This testing has proven invaluable in understanding many aspects of cataract removal in a way that a clinical study cannot duplicate because we cannot control a single variable with actual surgery.[4–7,10–19]

The chamber stabilization software claim that a higher vacuum efficiency can be obtained, even with the higher vacuum in place for less than a second, is not obviously true. Vacuum work would be the total area under the vacuum curve and it would seem, therefore, that you are trying to get something for nothing. Our efficiency testing procedure is tailor made to answer this question because the chamber stabilization software only activates when a lens fragment occludes the phaco tip. We found with the chamber stabilization software at 0.00 millisecond, which is the same as using 300 mm Hg, that all other up times studied of chamber stabilization software improved efficiency by approximately 30% to 35% with no real difference for any of the longer chamber stabilization software settings, even at 500 milliseconds, which is approximately one half the mean time for fragment removal. If we consider the marked