Thermal evaluation of two phacoemulsification systems

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ABSTRACT • RÉSUMÉ

Objective: To compare thermal profiles of new transversal ultrasound power modulation to torsional ultrasound in an artificial chamber and cadaver eye.

Design: Laboratory investigation.

Methods: John A. Moran Eye Center Laboratories, University of Utah, Salt Lake City, Utah, was the study setting. Temperature increase after 30 seconds was measured at the needle midshaft in an artificial chamber and at maximal friction point in a cadaver eye. Ellips FX (transverse) was tested at 100% power, as was Signature with micropulse settings (6 milliseconds on and off). OZil (torsional only) was tested at 100% power in the artificial chamber and cadaver eye. Runs were completed with aspiration blocked. Temperature was continuously measured on the phacoemulsification sleeve using a microthermistor probe connected to the BAT-10 multipurpose thermometer, with an accuracy of $\pm 0.1°C$.

Results: Transversal FX had a greater temperature increase than micropulse ($p < 0.001$) and torsional ($p < 0.001$). Micropulse had a greater temperature increase than torsional ($p < 0.001$). The cadaver eye had a greater temperature increase than the artificial chamber for torsional ($p < 0.001$).

Conclusions: Higher heat accumulation and potential for incisional burn occurred with the cadaver model than with the artificial chamber, suggesting the need for caution when using 100% torsional ultrasound with aspiration blocked. Transversal FX generated more heat than was reported originally. Further study is needed to determine the incidence of incisional burn with varied power settings for this new model. Micropulse generated more heat than previous reports, but the increased efficiency is likely to negate potentially increased incisional burn risk.

Objectif : Comparer le profil thermique des nouveaux appareils à ultrasons transversaux avec modulation de la puissance aux appareils à ultrasons torsionnels dans une chambre artificielle et dans l'œil d'un cadavre.

Nature : Étude en laboratoire.

Méthodes : L'étude a été réalisée aux laboratoires du John A. Moran Eye Center de l'Université de l'Utah à Salt Lake City. La hausse de la température après 30 secondes a été mesurée au milieu de la tige de l'aiguille dans une chambre artificielle et au point de friction maximal dans l'œil d'un cadavre. Le Ellips FX (ultrasons transversaux) a été testé à puissance maximale (100 %), tout comme le Signature en mode micropulsé (6 ms marche-arrêt). Le OZil (ultrasons torsionnels seulement) a été testé à puissance maximale (100 %) dans la chambre artificielle et dans l'œil d'un cadavre. Les essais ont été réalisés en mode aspiration bloquée. La température a été mesurée en continu, sur le manchon de phacoémulsification, à l'aide d'une sonde à microthermistance branchée à un thermomètre multifonctions BAT-10, dont la précision est de +/- 0,1 ° C.

Résultats : La hausse de température était plus élevée avec l'appareil à ultrasons transversaux qu'avec l'appareil en mode micropulsé ($p < 0{,}001$) ou l'appareil à ultrasons torsionnels ($p < 0{,}001$). La hausse était aussi plus élevée en mode micropulsé que dans le cas des ultrasons torsionnels ($p < 0{,}001$). La hausse de température était également plus élevée dans l'œil du cadavre que dans la chambre artificielle avec l'appareil à ultrasons torsionnels ($p < 0{,}001$).

Conclusion : L'accumulation de chaleur et le risque de brûlure à l'incision étant plus élevés dans l'œil du cadavre que dans la chambre artificielle, nous suggérons la prudence lors de l'utilisation d'un appareil à ultrasons torsionnels à puissance maximale en mode aspiration bloquée. L'appareil à ultrasons transversaux a produit plus de chaleur que ce qui avait été signalé à l'origine. Il faudra approfondir l'étude pour déterminer l'incidence de brûlures à l'incision à des puissances variés pour ce nouveau modèle. L'appareil utilisant le mode micropulsé a produit plus de chaleur que dans les rapports précédents, mais son efficacité accrue surpassera sans doute le risque de brûlure plus élevé.

Complications of phacoemulsification during cataract surgery include incisional burn or contracture from friction-mediated heat[1,2] as a result of the ultrasonic movement of the tip.[3] Implicated causes for incisional burn secondary to phacoemulsification ultrasound include needle position, low flow, and ultrasound settings.[3–8]

A previous study compared transverse ultrasound power modulation using torsional (Infiniti OZil; Alcon, Inc., Fort Worth, Tex.) and transversal (Signature Ellips; Abbott Medical Optics, Santa Ana, Calif.) ultrasound.[9] Although the results were significant, additional study of the findings is warranted for several reasons. First, the development of a newer transversal ultrasound technology (Ellips FX; Abbott Medical Optics) has supplanted the previous technology and merits evaluation to confirm its temperature profile. Second, we recently determined that the optimal micropulse profile is 6 milliseconds on and off,[10,11] which differs from the previously reported settings of 6 milliseconds on and 12 milliseconds off.[9] Furthermore, much of our previous data have been based on an

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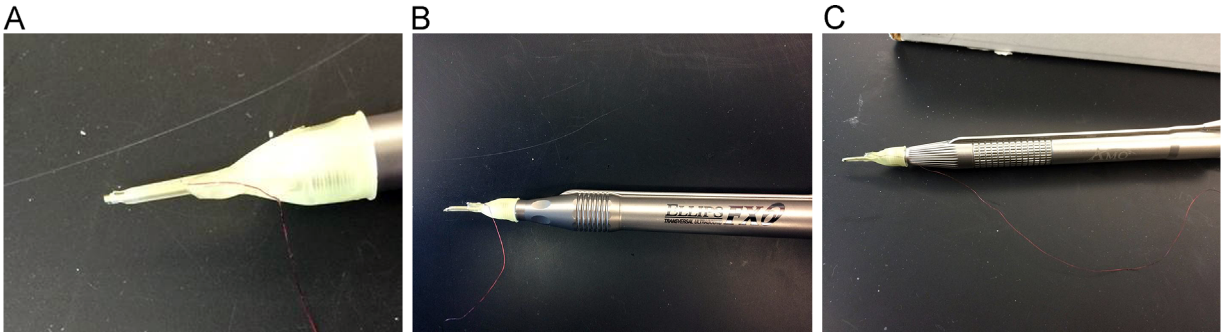

Fig. 1—(A) MST 0.9 mm bent phaco tip, 30° bevel with standard MST sleeve (2.4–2.75 mm incision, yellow, silicone) and attached thermistor probe. (B) Ellips FX handpiece with attached thermistor probe. (C) AMO Signature handpiece with attached thermistor probe.

in vitro model using an artificial chamber, which merits comparison to human cadaver eyes for clinical assessment with regards to incisional temperature.[10–14]

Methods

Methods were similar to those reported by Schmutz and Olson.[9] The Infiniti phacoemulsification unit was used with the OZil handpiece (torsional), and the Signature phacoemulsification unit was used with the Ellips FX (transversal or transversal FX) and Signature handpieces. Kelman needles measuring 0.9 mm, 30° angle, bent (Microsurgical Technology, Inc. [MST], Redmond, Wash.) were used throughout to control for variation attributable to needle shape or size. The dimensions were chosen to maintain consistency with previously published studies.[10,13,14] Each tip was fitted with a similar sleeve supplied by MST.

For the experiments completed with handpieces in the artificial chamber, the Alcon test chamber was used, as described in previous studies (Figs. 1–3).[9,11–13] Although follow-up measurement of incision length was not completed to assess for possible incision stretching after trial runs, on gross examination there was no appreciable leakage from the artificial chamber. A tight incision prevented leakage from the human cadaver eye as well, thus eliminating the variable of heat dissipation caused by fluid leakage.

Phacoemulsification handpieces were placed in a horizontal position on a table. Bottle height was maintained at 70 cm for each run. The Infiniti phacoemulsification unit was set at 100% torsional power, and at 0% longitudinal amplitude for the OZil IP handpiece in the artificial chamber and the human cadaver eye. Power settings were based on optimization shown in previous studies.[14,15] The Signature phacoemulsification unit was set at 100% power for the Ellips FX and Signature handpieces. Actual vacuum was adjusted to 300 mm Hg.[16] Aspiration was set to 20 mL/minute to more readily capture thermal differences; as previously described by Schmutz and Olson, higher aspiration rates may not allow for adequate thermal detection by the thermistor probe.[9]

Temperature was measured continuously using a microthermistor probe (IT-24P; Physitemp Instruments, Inc., Clifton, N.J.), which was connected to the BAT-10 multipurpose thermometer (Physitemp Instruments), with an accuracy of ±0.1°C, as previously described. The microthermistor probe was glued to the phacoemulsification sleeve in the exact same way for every test run. The thermistor and glue did not make direct contact to the wound edge (or edge of artificial chamber) and were not likely to contribute to the friction and heat generation in the systems tested.

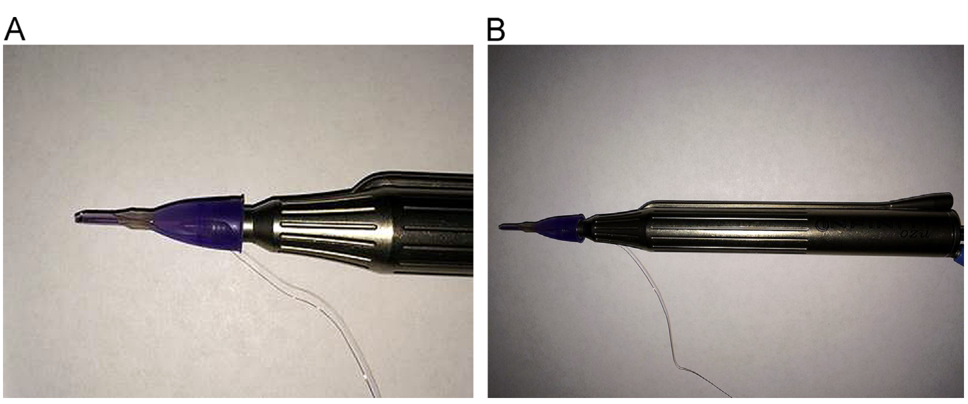

Fig. 2—(A) MST A1 0.9 mm 20° bent phaco tip 30° bevel with standard MST sleeve (2.6–2.8 mm incision, purple, silicone) and attached thermistor probe. (B) OZil handpiece with attached thermistor probe.