Thermal characterization of phacoemulsification probes operated in axial and torsional modes

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PURPOSE: To analyze temperature increases and identify potential sources of heat generated when sleeved and sleeveless phacoemulsification probes were operated in axial and torsional modes using the Infiniti Vision System with the Ozil torsional handpiece.

SETTING: Phacodynamics Laboratory, Pasteur Ophthalmic Clinic, Santiago, Chile.

DESIGN: Experimental study.

METHODS: Two computer-controlled thermal transfer systems were developed to evaluate the contribution of internal metal stress and tip-to-sleeve friction on heat generation during phacoemulsification using axial and torsional ultrasound modalities. Both systems incorporated infrared thermal imaging and used a black-body film to accurately capture temperature measurements.

RESULTS: Axial mode was consistently associated with greater temperature increases than torsional mode whether tips were operated with or without sleeves. In tests involving bare tips, axial mode and torsional mode peaked at 51.7°C and 34.2°C, respectively. In an example using sleeved tips in which a 30.0 g load was applied for 1 second, temperatures for axial mode reached 45°C and for torsional mode, 38°C. Friction between the sleeved probe and the incisional wall contributed more significantly to the temperature increase than internal metal stress regardless of the mode used.

CONCLUSIONS: In all experiments, the temperature increase observed with axial mode was greater than that observed with torsional mode, even when conditions such as power or amplitude and flow rate were varied. Tip-to-sleeve friction was a more dominant source of phaco probe heating than internal metal stress. The temperature increase due to internal metal stress was greater with axial mode than with torsional mode.

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Various modalities of ultrasonic (US) energy can be used during phacoemulsification for successful cataract removal. When using axial (also referred to as longitudinal) US, the aspirating tip of the phacoemulsification probe moves in a forward-and-back motion. When in close proximity to the lens, the forward stroke disrupts the material, causing it to break into smaller pieces that can be easily aspirated. In contrast, nonlongitudinal phacoemulsification systems use torsional motion in which the tip moves side to side or elliptical motion in which longitudinal movement is combined with a transverse motion. Because nonlongitudinal phacoemulsification is designed to decrease the repulsion of nuclear fragments from the tip (commonly called “chatter”), the motion may promote more efficient cataract extraction and reduce the risk for endothelial cell damage.

Advancements in US phacoemulsification technology during the past 3 decades have improved the outcomes of cataract surgery. For example, reduction