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The Magnitude of IOP Elevation Associated with Eye Rubbing

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Abstract

Purpose: To determine the magnitude of IOP elevation associated with eye rubbing

Study Design: Experimental Study

Subjects: Three nonhuman primates (NHPs)

Methods: Three young adult male rhesus macaques were briefly anesthetized with ketamine and dexmedetomidine, and antibiotic ointment was placed in both eyes. The anesthetic was immediately reversed with atipamezole, and the animals quickly recovered. IOP was continuously recorded at 500 measurements per second during the experiment using a validated implantable wireless telemetry system; high-definition video was recorded while the NHP rubbed its eyes to remove the ointment, and rubbing events were marked in the IOP data. The experiment was repeated four times in each NHP, with numerous eye rubs recorded for each session, and these data were marked and the IOP elevation magnitudes were analyzed using NOTOCORD-hem software.

Main Outcome Measures: IOP elevation above baseline IOP due to eye rubbing

Results: IOP increased as much as 310 mmHg due to eye rubbing. The largest IOP elevations were associated with rubbing the eye and orbit with the back of the hand or wrist, rather than the fingers or knuckle. Eye rubs elicited mean IOP elevations of ~80–150 mmHg above baseline for 3–4 seconds, with peak IOP elevations reaching 205–310 mmHg depending on the individual NHP and eye.

Conclusions: Rubbing the eyes causes momentary IOP elevations that average 109 mmHg above baseline IOP and can exceed 300 mmHg above baseline IOP in NHP eyes.

Précis:

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Eye rubbing can cause acute IOP elevations up to 310 mmHg above baseline. Eye rubbing could, in theory, induce IOP-mediated mechanical damage to ocular structures that are relevant in diseases such as keratoconus and glaucoma.

Keywords

Intraocular Pressure; Eye Rubbing; Glaucoma; Nonhuman Primate; Telemetry

Introduction

Eye rubbing is a common behavior affecting both the ocular surface and the ocular coat through multiple pathways. While acute rubbing of the eye can cause elevated intraocular pressure (IOP), chronic rubbing has been associated with the progression or development of keratoconus, keratoglobus, pellucid marginal degeneration, glaucoma, corneal astigmatism, and corneal hydrops [1].

Eye rubbing increases IOP, presumably through direct application of force and/or indention of the anterior segment [2]. Intraocular pressure is a known risk factor in glaucoma and lowering IOP is the only proven treatment for the disease. The timescale at which IOP-related damage occurs is not known, and it is plausible that even transient IOP elevations may cause glaucomatous axon damage or ONH remodeling in some patients. Prior studies suggest that the acute IOP elevations from eye rubbing, and the elevated mechanical strain that should accompany them, may contribute to a host of changes at the cellular level that effect ocular homeostasis[3, 4].

While previous studies have measured IOP before and after eye rubbing in patients, [2] IOP elevations associated with eye rubbing have not been studied quantitatively in vivo. In this study, we use bilateral continuous IOP telemetry to measure and record IOP in awake, unrestrained nonhuman primates (NHPs) before, during, and after episodes of eye rubbing.

Methods

Three male rhesus macaques (NHPs) aged 4–6 years were used in this study. All animal experiments were conducted under IACUC approval according to the ARVO Statement governing the use of animals in vision research.

We have developed and validated a fully implanted wireless telemetry system (Konigsberg Instruments, Inc., Pasadena, CA) that allows continuous monitoring of IOP in awake, behaving NHPs [5]. IOP measurements are transmitted wirelessly at 500 Hz from a battery powered transceiver module implanted in the animal's abdominal wall. IOP transducer accuracy is ±0.2 mmHg from 0–500 mmHg, and barometric pressure was offset in real time. Data were recorded using NOTOCORD-hem (NOTOCORD Systems, Croissy-sur-Seine, France).

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Telemetry Calibration

IOP telemetry sensors were calibrated every two weeks at 5, 10, 15, 20, 30, and 40 mmHg via anterior chamber cannulation to a sterile BSS reservoir fitted with an in-line, digital pressure gauge (model XP2i; Crystal Engineering, San Luis Obispo, CA). IOP data were collected and adjusted based on the IOP calibration tests. IOP transducer drift is typically <1 mmHg per week, and transducer measurements were linear across all IOPs tested.

Eye Rub Data Collection and Analysis

IOP measurements were recorded at 500 Hz immediately before, during and after eye rubbing in three adult NHPs in four separate sessions at least one week apart in each animal. To elicit eye rubbing, each NHP was momentarily anesthetized with a reversible anesthetic (intramuscular injection of ketamine (3mg/kg) / dexmedetomidine (0.05mg/kg) and antibiotic ointment was applied to both eyes. Anesthesia was then reversed via intramuscular injection of atipamezole (0.05mg/kg), initiating immediate recovery. The NHPs rubbed their eyes to remove the ointment while IOP was monitored continuously, along with time-synced HD video. Eye rubs were identified in the HD video, and the corresponding IOP increase over baseline was marked and quantified using NOTOCORD-hem software. Baseline was defined as the average minimum IOP, ignoring transient IOP fluctuations, both before and after the eye rub (Figure S1, available at http://aaojournal.org). The type of eye rub (finger, knuckle, wrist) was noted for each event. A paired *t*-test was used to determine if the maximum magnitude of the acute IOP elevation due to eye rub was significantly greater than baseline IOP. Manual ocular massage was also performed on anesthetized NHPs to determine the reduction in IOP following eye rub.

Results

IOP increased as much as 310 mmHg above baseline due to eye rubbing (Figure S1, available at http://aaojournal.org). The highest IOP elevations were associated with rubbing the eye and orbit with the back of the hand or wrist, rather than the fingers or knuckle (data not shown). Eye rubs elicited mean IOP elevations of ~80–150 mmHg for 3–4 seconds (Table), with peak IOPs reaching 206–310 mmHg in different NHPs (Table). On average, eye rubbing elicited significant IOP elevations of 109 ± 26 mmHg over pre-rub baseline IOP ($p<0.0005$; n = 163 eye rubs in five eyes of three NHPs). We did not observe a significant lasting reduction in IOP immediately following eye rubbing; IOP was 1–4 mmHg lower that pre-rub IOP immediately after rub, but returned to the pre-rub baseline within ~1 s (Figure S2, available at http://aaojournal.org).

Discussion

Overall, eye rubbing elicited IOP elevations averaging 109 mmHg above baseline IOP (range; 3 – 310 mmHg) followed by small transient IOP reductions. Interestingly, the highest IOP elevations were due to rubbing with the back of the wrist, rather than either the finger or knuckle. This may seem counterintuitive, but an equal pressure applied over a larger area generates a larger force on the eye. Manual ocular massage in anesthetized NHPs

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elicited similar IOP elevation, and the transient post-rub IOP reduction was only 1–2 mmHg and returned to baseline values ~1s after massage.

This study has several limitations. First, our cohort size was limited to only 3 animals, and the reported results may not represent the wider population. However, our results were consistent both between animals and within eyes over four sessions in each NHP, and statistical analyses showed significant increases in IOP from eye rubbing in spite of our limited cohort size. Second, results in NHPs may not represent the effects that would be present in humans due to differences in hand, ocular, and orbital anatomy. NHPs have smaller eyes, smaller hands, and a more prominent brow ridge, although IOPs and forces in NHPs should be relatively similar to that in humans.

In conclusion, eye rubbing can cause acute IOP elevations up to 310 mmHg above baseline. The IOP elevation associated with eye rubbing was directly related to both the intensity of the rubbing and which part of the hand or wrist contacted the eye. Eye rubbing could, in theory, induce IOP-mediated mechanical damage to ocular structures that are relevant in diseases such as keratoconus and glaucoma.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

Acknowledgments

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Table:

IOP is significantly increased by 109 ± 26 mmHg over baseline values due to eye rubbing (163 eye rubs studied) in five eyes of three NHPs (p<0.0005). The number of rubs per eye, mean IOP elevation above baseline, as well as standard deviation (SD), maximum, and minimum values are provided for each eye. Overall values are reported in the right column. 98% (159 of 162) of eye rubs were > 10 mmHg.

IOP Elevation Due to Eye Rubbing (mmHg)						
NHP	**9028**		**9160**		**0804025**	**Overall**
Eye	**OS**	**OD**	**OS**	**OD**	**OS**	**OU**
n (eye rubs)	20	27	39	45	32	163
Mean	81	105	98	110	152	109
SD	76	77	64	50	97	26
Max	252	266	265	206	310	310
Min	3	12	20	29	10	3

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