

Incidence of Conjunctivitis and Keratitis with Reusable Ophthalmic Laser Lenses at an Academic Medical Center

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Purpose: To determine the incidence of keratitis and conjunctivitis associated with reusable contact lens use during ophthalmic laser procedures at an academic medical center.

Patients and Methods: All laser procedures were performed at a single nonprofit academic medical center (Jacksonville, FL, USA). Data from patients that underwent neodymium-doped yttrium-aluminum-garnet (Nd:YAG) capsulotomy or selective laser trabeculoplasty (SLT) with reusable contact lenses between 2014 and 2023 was analyzed retrospectively. The post-procedure infection rate, defined as the incidence of newly diagnosed superficial keratitis and/or conjunctivitis within two weeks of the laser procedure, was calculated by dividing the total number of affected eyes by the total cohort size. A break-even analysis was conducted to evaluate the economic impact of reusable lens implementation.

Results: A total of 2285 eyes of 1363 patients were included in this study. The incidence of previous conjunctivitis in this cohort was small (0.4%) and no eyes had a prior history of keratitis. Of the 1372 Nd:YAG capsulotomy and 913 SLT procedures performed, only one eye (0.044%) developed signs of post-operative conjunctivitis and none developed keratitis. The single case of unilateral conjunctivitis occurred within one day of a Nd:YAG capsulotomy and was secondary to medicamentosa. A cost analysis showed that reusable ophthalmic laser lenses become more cost-effective than disposable lenses after approximately 86 SLT procedures and 91 Nd:YAG capsulotomies, while reducing medical waste by 79%.

Conclusion: Given the negligible rate of conjunctivitis, substantial cost savings, and significant reduction in environmental waste associated with reusable capsulotomy and trabeculoplasty lenses, the routine use of disposable ophthalmic lenses should be reconsidered.

Keywords: reusable ophthalmic lenses, Nd:YAG laser capsulotomy, selective laser trabeculoplasty

Introduction

Selective laser trabeculoplasty (SLT) and neodymium-doped yttrium-aluminum-garnet (Nd:YAG) laser capsulotomy are two of the most commonly performed ophthalmologic procedures.^{1,2} Approximately 150,000 United States Medicare beneficiaries with open angle glaucoma undergo SLT procedures each year³⁻⁵ and the incidence of Nd:YAG laser capsulotomy increases from 6% at one year to 38% at nine years following cataract extraction.⁶ In each of these procedures, focused laser energy is applied to the target tissue – the trabecular meshwork of eyes with glaucoma to improve aqueous outflow and reduce intraocular pressure (IOP)⁵ in SLT, and the opacified posterior lens capsule to surgically create an opening through which visual acuity is improved in Nd:YAG capsulotomy.⁷ For each procedure,

a reusable or single-use disposable ophthalmic contact lens improves the surgeon's visualization of the target tissue, thereby enabling more precise application of laser energy.⁸

Concerns have arisen over the spread of infectious diseases during procedures, and though transmission of human immunodeficiency virus (HIV), Hepatitis C, Hepatitis B, and prion diseases via these laser contact lenses has not been documented, cases of adenovirus and herpes simplex virus type 1 (HSV-1) have been linked to repeat-use tonometry tips.^{9–12} Consequently, ophthalmology practices attempt to mitigate the risk of infection by disinfecting reusable lenses or opting for single-use, disposable alternatives.^{5,13–17}

Single-use, disposable plastic products in health care unfortunately constitute large volumes of plastic waste and create considerable expense.^{9,13,18,19} Disposable lenses and tips have become increasingly popular in recent decades^{13,20} with 59.1% of ophthalmology practices in the United Kingdom using disposable tonometry tips.¹³ Several authors, however, have reported that disposable lenses are functionally inferior to their reusable counterparts, are prone to damage, and may produce an inferior treatment effect.^{5,21–23}

Disinfection techniques effectively prevent transmission of infections from reusable lenses and tips, with the American Academy of Ophthalmology reporting that sterilization with a dilute solution of sodium hypochlorite eliminates Adenovirus 8 and HSV-1.²⁴ Further supporting the use of reusable lenses is the persistent risk of infection with disposable tonometer prisms. In the Sussex Eye Hospital, 50% of providers touched the disposable tonometer prism before measuring IOP, and subsequent cultures grew *Staphylococcus epidermidis*, *Staphylococcus aureus*, and *Bacillus* species.²⁵ Thus, it is not clear that disposable lenses and tips prevent infection relative to their reusable counterparts.

Since single-use disposable lenses create substantial economic and environmental burdens, and are less effective, understanding the infection risks associated with reusable ophthalmic lenses becomes an important health and economic issue. This study aims to better understand the rate of conjunctivitis and/or keratitis due to reusable laser lenses that are cleaned with isopropyl alcohol, followed by soap and water, and thorough drying, after SLT and Nd:YAG laser capsulotomies.

Methods

Cohort and Consent

A retrospective chart review included all eyes undergoing a Nd:YAG capsulotomy or SLT procedure with reusable laser lenses between January 1, 2014, and December 31, 2023, at a single, nonprofit academic medical center (Mayo Clinic, Jacksonville, FL). During the study period, only reusable lenses were used. The study protocol was approved by the Mayo Clinic Institutional Review Board (IRB) on August 12, 2024 (IRB #24-006702), and informed consent was waived due to the retrospective study design. This study complies with the tenets outlined in the Declaration of Helsinki and adheres to the Health Insurance Portability and Accountability Act regulations.

Patient Data

For each procedure, patient demographic data (age at the date of the Nd:YAG laser capsulotomy and/or SLT procedure, race, and biological sex), procedure type, physician name, date of procedure, laterality, history of conjunctivitis and/or keratitis, and incidence of conjunctivitis and/or keratitis within two weeks post-procedure were recorded. Data from three ophthalmologists (R.D.T., S.K.D., D.D.M.) were included in the analysis. At the completion of the procedure, patients were instructed to contact the office immediately if they developed pain, blurred vision, redness, irritation, photosensitivity, discharge, photopsias, floaters, “curtains”, or “clouds”. For each patient who contacted the office with any of these symptoms, they were examined promptly (within 24 hours). For all Nd:YAG capsulotomy and SLT lasers, no topical antibiotics were instilled before or after the procedures. Prior to and after all Nd:YAG capsulotomy lasers, neither topical corticosteroids nor non-steroid anti-inflammatory drugs were instilled or prescribed. Prior to and after all SLT procedures, no topical corticosteroids were used. One ophthalmologist (R.D.T.) prescribed topical ketorolac 0.5% four times per day for one week after SLT. All patients received follow-up appointments approximately four weeks after each procedure.

Post-Use Sterilization of Reusable Lenses

Reusable lenses were thoroughly cleaned after each procedure with 70% ethyl alcohol followed by soap and water for at least two minutes. The lenses were then completely dried using sterile wipes prior to the next use.

Statistical Analysis

Data were analyzed with the SPSS 22.0 program (SPSS Inc., Chicago, IL). Demographic variables were expressed as percentages. The primary outcome was the incidence of conjunctivitis and/or keratitis (diagnosed by the treating surgeon) within the first two weeks after the laser procedure. The keratitis and conjunctivitis rates were calculated by dividing the total number of affected eyes by the total cohort size. For each new case of keratitis and/or conjunctivitis, the dates when symptoms first appeared and when they resolved were documented.

A cost analysis was conducted to assess the economic implications of using reusable versus disposable lenses for both laser procedures. A break-even analysis was used, calculating the per-procedure cost of reusable lenses by dividing the total cost of two lenses of each type ($\$755 \times 2$ for Nd:YAG laser capsulotomy; $\$719 \times 2$ for SLT) by the number of corresponding procedures and adding the sterilization cost per use. The analysis assumed that cleaning time incurred minimal cost and that reusable lenses required no replacement over a 10-year period. For purposes of this analysis, the per unit cost of each disposable Nd:YAG lens and SLT lens was \$16.70 per lens. A medical waste analysis was performed incorporating the weight of the disposable lens along with the individual plastic packaging and the box (one for every ten disposable lenses).

Results

Baseline Characteristics

A total of 2285 eyes from 1363 patients were included in this study (Table 1). The mean age (standard deviation) of treated patients was 71.6 (7.4) years with most being female (57%) and Caucasian (83%). A low percentage of treated eyes (0.4%; four eyes with non-specific conjunctivitis and five eyes with chronic allergic conjunctivitis) had a history of conjunctivitis but none were active at the time of the laser surgery and none had a history of prior keratitis. A total of

Table 1 Demographic Characteristics

Characteristics	Total
Number of eyes	2285
Number of patients	1363
Age, mean (SD), years	71.6 (7.4)
Sex	
Male (%)	592 (43)
Female (%)	771 (57)
Race	
White (%)	1131 (83)
Black (%)	82 (6)
Asian (%)	55 (4)
Hispanic (%)	68 (5)
Choose Not to Disclose (%)	27 (2)
Laterality of eye	

(Continued)

Table 1 (Continued).

Characteristics	Total
Right (%)	1097 (48)
Left (%)	1188 (52)
History of conjunctivitis	
No (%)	2276 (99.6)
Acute toxic conjunctivitis (%)	4 (0.2)
Chronic allergic conjunctivitis (%)	5 (0.2)
History of keratitis	
No (%)	2285 (100)
Yes (%)	0 (0)
Type of procedure	
Nd:YAG laser capsulotomy	1372 (60)
Selective laser trabeculoplasty	913 (40)

Abbreviation: SD, Standard deviation.

1372 Nd:YAG laser capsulotomies and 913 SLT procedures were performed, accounting for 60% and 40% of the study population, respectively.

Cases of Keratitis and/or Conjunctivitis

Of the 2285 eyes, one developed conjunctivitis within the two-week window after undergoing a Nd:YAG capsulotomy. Symptoms began within 24 hours of the laser and the patient was examined on the second post-operative day. A diagnosis of medicamentosa was made and the patient was treated with preservative-free lubricating ophthalmic eye drops with resolution of symptoms within five days. No cases of keratitis were seen.

Cost Analysis

Cost analysis results are presented in [Table 2](#). The per-unit cost of a disposable lens was \$16.70 for both Nd:YAG laser capsulotomy and SLT, while reusable lenses were priced at \$755 (Nd:YAG) and \$719 (SLT). Over the 10-year study period, two reusable lenses of each type were repeatedly used and remained fully functional without requiring replacement. As the manufacturer did not specify expiration or usage limits, reusable lens costs were amortized across the entire study duration. Reprocessing required minimal resources: one 70% isopropyl alcohol wipe (\$0.011 per wipe), one pump of liquid soap (estimated \$0.008 per wash), a 10-second tap water rinse (0.002 gallons at \$0.005/gallon = \$0.00001), and one paper tissue (\$0.01 per tissue), resulting in an estimated supply cost of \$0.03 per use. Manual cleaning, completed by clinical staff in under one minute, required no specialized equipment, detergents, or autoclaving, and did not disrupt clinic workflow. Break-even analysis indicated that reusable lenses became more cost-effective than disposable lenses after approximately 86 SLT procedures and 91 Nd:YAG laser capsulotomies ([Table 2](#)).

Medical Waste

In terms of medical waste, a single Nd:YAG procedure produced approximately 12.1 g of waste with a disposable lens and 3.0 g with a reusable lens. Similarly, an SLT procedure generated 17.8 g and 3.0 g of waste with disposable and reusable lenses, respectively. Across 1372 Nd:YAG capsulotomies and 913 SLT procedures, the total waste from

Table 2 Cost Analysis

	Nd:YAG Capsulotomy		Selective Laser Trabeculoplasty	
	Disposable Lens	Reusable Lens	Disposable Lens	Reusable Lens
Cost per lens	\$16.70	\$755.00	\$16.70	\$719.00
Total number of procedures	1372	1372	913	913
Amortized lens cost per procedure	\$16.70 (1 lens per procedure)	\$1.10 (2 lenses over 10 years)	\$16.70 (1 lens per procedure)	\$1.57 (2 lenses over 10 years)
Sterilization cost per use	–	\$0.03	–	\$0.03
Total cost per procedure	\$16.70	\$1.13	\$16.70	\$1.60
Total 10-year cost	\$22,912.40	\$1551.16	\$15,247.10	\$1465.39
Total 10-year savings (disposable lens- reusable lens)	–	\$21,361.24	–	\$13,781.71

disposable lenses was estimated at 32.9 kg, compared to 6.9 kg for reusable lenses, which represents a 79% reduction with reusable lenses during the study period.

Discussion

This study identified low post-operative keratitis (0/2285; 0%) and conjunctivitis rates (1/2285; 0.044%) in patients undergoing SLT or Nd:YAG laser eye surgeries with reusable ophthalmic laser lenses. Because symptoms occurred within one day of the procedure, the single case of conjunctivitis was determined to be secondary to medicamentosa (ocular inflammation from ophthalmic drops with preservatives given prior to the procedure) and was not deemed to be infectious.²⁶ The contralateral eye, which also underwent Nd:YAG laser capsulotomy using preservative-free topical drops, did not develop conjunctivitis, and the patient's history of chronic dry eye syndrome likely contributed to the risk of an adverse reaction. The two week time window was used since symptoms of infectious conjunctivitis and keratitis present during this time period.²⁷

The near total absence of keratitis and conjunctivitis in this study suggests that reusable ophthalmic laser lenses do not constitute a significant risk for infection after laser procedures and that transitioning to single-use, disposable ophthalmic lenses may be unnecessary. Given the lack of evidence linking reusable lenses to an increased infection risk, the benefits of disposable lenses may not outweigh their associated drawbacks, such as increased susceptibility to laser damage and reduced treatment efficacy.^{5,21–23}

Reusable ophthalmic lenses are generally classified as semi-critical equipment, which includes devices that come into contact with mucous membranes or nonintact skin.^{28,29} As such, high-level disinfection, commonly achieved using hydrogen peroxide, glutaraldehyde, peracetic acid with hydrogen peroxide, or ortho-phthalaldehyde, with a minimum exposure time of 12 minutes, is recommended.^{29,30} In contrast, noncritical equipment, which contacts only intact skin, requires low-level disinfection³¹ with a minimum exposure of one minute to alcohol, sodium hypochlorite, or quaternary ammonium compounds.^{30,31} Since reusable capsulotomy and trabeculoplasty lenses rarely cause infection after low-level disinfection, it is reasonable to consider reclassifying them from semi-critical equipment requiring high-level disinfection to noncritical equipment requiring low-level disinfectants.

A recent study at the Mayo Clinic in Rochester, MN, analyzed laser-induced damage to disposable gonioscopy lenses used during 113 SLT procedures. Damage was found in $6.7 \pm 7.5\%$ of the total lens area, with 73% of lenses exhibiting damage to more than 1% of the area.⁵ The area of lens damage correlated with both total laser energy and mean energy per application, whereas patient and physician factors were not significant.⁵

Three small studies also support a strong association between laser and damage to single-use gonioscopy lenses.^{21–23} Damage to the reflective coating was noted after SLT in 16 of 17 (94%) disposable gonioscopy lenses in one study,²¹ 2 of 2 (100%) in a second,²² and 6 of 6 (100%) in a third.²³ The high susceptibility of disposable lenses to laser damage was thought to be attributed to their design, which consists of an external, unsupported silver coating over the gonioprism. In contrast, reusable lenses feature a first-surface anti-reflective mirror with the silver coating reinforced by a glass slide.²²

Additional design differences of disposable lenses include increased adhesion to the ocular surface, which can make post-procedure removal challenging and can lead to corneal injury.

Damaged lens mirror coatings can scatter light, distort beams, and reduce delivery of laser energy to the trabecular meshwork, which can diminish efficacy.²¹ Two studies have examined the relationship between single-use gonioscopy lens damage and post-operative IOP reduction.^{5,21} One found an association between increased lens damage and decreased IOP reduction,⁵ while the other found no significant difference in IOP-reducing efficacy between disposable and reusable gonioscopy lenses following SLT.²¹ The different results noted in these two studies may result from the definition of lens damage, since the latter study measured the number of affected reflective coatings,²¹ and the former quantified the total ablated area of the reflective coating.⁵ Repeated exposure to disinfectants can damage reusable lenses but this can be mitigated by avoiding acetone and peroxide,²⁸ routinely inspecting reusable lenses, and replacing them at the first sign of damage. This strategy can result in significant cost savings.⁹

There is an economic burden imposed by single-use ophthalmic products. A district general hospital in the United Kingdom found that disposable tonometry tips incur an excess cost of at least £15,000 annually (approximately \$17,330 USD),¹³ and an ophthalmology outpatient service of comparable size to ours in the United States reported that single-use equipment, including gonioscopy lenses and applanation tonometry tips, generates an additional \$65,185 in costs and 109.6 kg of plastic waste per year.⁹ In our analysis, reusable ophthalmic laser lenses became more cost-effective than disposable alternatives after 86 SLT procedures and 91 Nd:YAG capsulotomies, highlighting their potential for substantial cost savings. Reusable lenses also reduced medical waste, generating only 3.0 g per procedure compared to 12.1 g for Nd:YAG capsulotomies and 17.8 g for SLTs with disposable lenses. Across all procedures, this corresponded to a 79% reduction in total waste (6.9 kg vs 32.9 kg). These findings support reusable lenses as a cost-efficient and environmentally sustainable alternative in high-volume clinical settings, aligning with institutional goals to reduce healthcare costs and environmental impact without compromising clinical efficiency or patient safety.

Disposing of large quantities of plastic waste and consuming non-renewable petroleum resources, consequences of the increased use of plastic consumables, poses significant environmental concerns.³² Non-biodegradable plastic products accumulate in terrestrial, saltwater, and marine environments, where they adversely affect wildlife by releasing toxic chemicals and persistent organic pollutants. Wildlife can be injured by ingesting or becoming entangled by these pollutants.^{9,33,34} Considering the substantial financial and environmental impact of single-use disposable lenses and the lack of evidence supporting their prevention of infections, their routine use should be re-evaluated. Alternatives to disposable lenses, such as reusable trabeculoplasty and capsulotomy lenses that are less susceptible to laser-induced damage, may offer an equally safe and more cost-effective and sustainable option.⁵

To our knowledge, this is the first study to evaluate the post-procedure incidence of keratitis and conjunctivitis associated with reusable gonioscopy and capsulotomy lenses, thereby addressing an unmet need in the literature. Study limitations include the single-center design and the homogeneity of the patient population. The retrospective nature of this study may have led to an underestimation of mild or self-limiting infections. Additionally, assumptions made in the cost analysis, including minimal labor costs and no lens replacement over 10 years, may have led to an underestimation of the true cost of reusable lenses. The study's strengths lie in its large sample size and long-term data, which provide valuable insights into the safe and effective use of reusable ophthalmic lenses.

Conclusion

Single-use disposable ophthalmic lenses impose significant economic and environmental burdens without offering a clear safety advantage, emphasizing the importance of understanding infection risks associated with reusable ophthalmic lenses. In this study of 2285 eyes undergoing Nd:YAG capsulotomy (1372 eyes) and SLT (913 eyes) with reusable lenses, only one case of postoperative conjunctivitis (0.044%), secondary to medicamentosa, occurred within two weeks, with no cases of keratitis. Reusable lenses became more cost-effective after approximately 86 SLT and 91 Nd:YAG capsulotomy procedures, and reduced medical waste by 79%. Given the negligible infection risk, substantial cost savings, and environmental benefits, the routine use of disposable ophthalmic lenses warrants reconsideration.

Data Sharing Statement

The author's institution does not permit data sharing. Other queries and requests should be directed to the corresponding author (D.D.M.).

Consent for Publication

This study was carried out in accordance with the tenets of the Declaration of Helsinki. Approval from the Mayo Clinic Institutional Review Board was obtained. All data has been deidentified, and no personal identifying information is contained within this report.

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Author Contributions

All authors made a significant contribution to the work reported (conception, study design, execution, acquisition of data, analysis and interpretation, or in all these areas); took part in drafting, revising or critically reviewing this article; gave final approval of the version to be published and agreed on the journal the article was submitted to; and agree to be accountable for all aspects of the work.

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