

Comparison of Outcomes of Laser Trabeculoplasty Performed by Optometrists vs Ophthalmologists in Oklahoma

Joshua D. Stein, MD, MS; Peter Y. Zhao, MD; Chris Andrews, PhD; Gregory L. Skuta, MD

IMPORTANCE Oklahoma is one of the few states where optometrists have surgical privileges to perform laser trabeculoplasty (LTP). Optometrists in other states are lobbying to obtain privileges to perform LTP and other laser procedures. Little is known whether outcomes of patients undergoing this procedure by optometrists are similar to those undergoing LTP by ophthalmologists.

OBJECTIVE To compare outcomes of LTPs performed by ophthalmologists with those performed by optometrists to determine whether differences exist in the need for additional LTPs.

DESIGN, SETTING, AND PARTICIPANTS This retrospective longitudinal cohort study used a health care claims database containing more than 1000 eyes of Medicare enrollees with glaucoma who underwent LTP in Oklahoma from January 1, 2008, through December 31, 2013. For each procedure, the data specify the type of eye care professional who performed the LTP. The rate of LTPs performed by ophthalmologists that required 1 or more additional LTPs in the same eye was compared with the rate of LTPs performed by optometrists. Regression models determined factors affecting risk of undergoing more than 1 LTP in the same eye.

MAIN OUTCOMES AND MEASURES Proportion of enrollees requiring additional LTPs, hazard ratio with 95% CIs of undergoing additional LTPs.

RESULTS A total of 1384 eyes of 891 eligible patients underwent LTP from January 1, 2008, through December 31, 2013. There were 1150 eyes that received LTP (83.1%) by an ophthalmologist and 234 eyes (16.9%) that had the procedure performed by an optometrist. The mean (SD) age at the initial LTP was 77.7 (7.5) years for enrollees with ophthalmologist-performed LTP and 77.6 (8.0) years for those with optometrist-performed LTP ($P = .89$). Among the 1384 eyes receiving LTP, 258 (18.6%) underwent more than 1 LTP in the same eye. The proportion of eyes undergoing LTP by an optometrist requiring 1 or more subsequent LTP session (35.9%) was more than double the proportion of eyes that received this procedure by an ophthalmologist (15.1%). Medicare beneficiaries undergoing LTP by optometrists had a 189% increased hazard of requiring additional LTPs in the same eye compared with those receiving LTP by ophthalmologists (hazard ratio, 2.89; 95% CI, 2.00-4.17; $P < .001$) after adjusting for potential confounders.

CONCLUSIONS AND RELEVANCE Considerable differences exist among the proportions of patients requiring additional LTPs comparing those who were initially treated by ophthalmologists with those initially treated by optometrists. Health policy makers should be cautious about approving laser privileges for optometrists practicing in other states until the reasons for these differences are better understood.

JAMA Ophthalmol. 2016;134(10):1-7. doi:10.1001/jamaophthalmol.2016.2495
Published online July 28, 2016.

← Invited Commentaries pages 1 and 1

+ CME Quiz at jamanetworkcme.com and CME Questions eme160010

Author Affiliations: Department of Ophthalmology and Visual Sciences, University of Michigan, Medical School, WK Kellogg Eye Center, Ann Arbor (Stein, Andrews); Institute for Healthcare Policy and Innovation, University of Michigan Medical School, Ann Arbor (Stein); Department of Health Management and Policy, University of Michigan, School of Public Health, Ann Arbor (Stein); Department of Internal Medicine, Lankenau Medical Center, Wynnewood, Pennsylvania (Zhao); Dean McGee Eye Institute, Department of Ophthalmology, University of Oklahoma College of Medicine, Oklahoma City (Skuta).

Corresponding Author: Joshua D. Stein, MD, MS, Department of Ophthalmology and Visual Sciences, University of Michigan Medical School, WK Kellogg Eye Center, 1000 Wall St, Ann Arbor, MI 48105 (jdstein@med.umich.edu).

Laser trabeculoplasty (LTP) is a common procedure that can effectively decrease intraocular pressure in patients with primary and some secondary forms of open-angle glaucoma. It can augment the ability to lower intraocular pressure in patients who are already taking glaucoma medications and is useful in patients who have difficulty administering eye drops or with medication adherence. In fact, LTP may be a more cost-effective option for treating glaucoma than medication, especially for patients who have difficulty with adherence.^{1,2} The advent of selective LTP contributed to a 46% increase in this procedure among Medicare beneficiaries from January 1, 2002, through December 31, 2009.³

Ophthalmologists have been performing LTP since 1979 when the procedure was first developed by Wise and Witter.⁴ Recently, optometrists have been lobbying state legislatures for expanded privileges so they may perform LTP. In Oklahoma, optometrists were given permission to perform LTP on patients with glaucoma in 1998.⁵ More recently, legislation was passed in Kentucky and Louisiana allowing optometrists to perform laser ocular surgical procedures.^{6,7} Ophthalmologists learn how to perform LTP during residency training. The Accreditation Council for Graduate Medical Education mandates that graduating residents perform a minimum of 5 LTPs.⁸ Case logs show that the average ophthalmological resident performs 14 LTPs and 83 other laser procedures during residency training.⁹ In Oklahoma, training of optometrists to perform lasers involves a 2-day course, “Laser Therapy for the Anterior Segment,” which is held at the Northeastern State University Oklahoma College of Optometry. This course consists of 9 hours of lectures and 4 hours of laboratory sessions, including gonioscopy, LTP, laser iridotomy, and capsulotomy.¹⁰

To our knowledge, there has never been a study comparing outcomes of LTP performed by ophthalmologists vs procedures performed by optometrists. Using a health care claims database containing more than 1000 eyes of Medicare beneficiaries with glaucoma who underwent LTP in Oklahoma, we compared outcomes of those receiving this procedure by ophthalmologists vs enrollees undergoing LTP by optometrists. These analyses may help guide health policy makers in other states who are trying to decide whether to give optometrists privileges to perform laser procedures.

Methods

Data Source

We used a 20% nationally representative sample of Medicare claims to identify beneficiaries undergoing LTP. The database contained information including *International Classification of Diseases, Ninth Revision, Clinical Modification (ICD-9-CM)*¹¹ diagnosis codes, *Current Procedural Terminology (CPT-4)*¹² procedure codes, National Provider Identifier numbers to identify specific eye care professionals, and service dates for all encounters. Claims data were merged with Medicare denominator files for information on enrollment dates in Medicare and demographic characteristics of the beneficiaries. Data were linked by a patient identifier, allowing lon-

Key Points

Question Are there differences in the frequency and likelihood of undergoing additional laser trabeculoplasty among Medicare enrollees in Oklahoma who underwent this procedure by an ophthalmologist vs others who underwent the procedure by an optometrist?

Findings Among the 1384 eyes receiving laser trabeculoplasty, the proportion of eyes treated by optometrists requiring additional laser trabeculoplasty in the same eye (35.9%) was more than double the proportion of those treated by ophthalmologists (15.1%). Optometrist-treated eyes had a 189% increased risk of requiring additional laser trabeculoplasty.

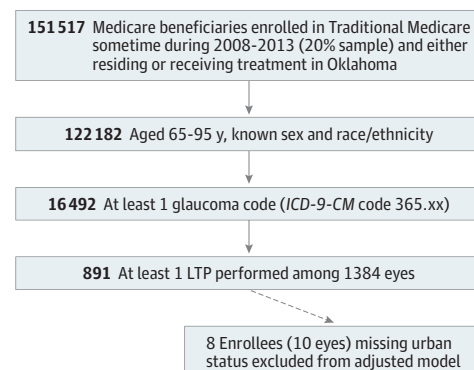
Meaning Future work seems warranted to substantiate whether the differences identified affect clinical outcomes and costs.

gitudinal, person-specific analysis from January 1, 2008, through December 31, 2013. A similar data source was used previously to study patients with ocular diseases.^{13,14} The University of Michigan institutional review board approved this study, which used deidentified claims data.

Study Sample

We identified all individuals with any form of glaucoma (*ICD-9-CM* code 365.xx) who underwent 1 or more LTP (*CPT-4* code 65855) from January 1, 2008, through December 31, 2013, in Oklahoma (**Figure 1**). *Current Procedural Terminology* codes do not distinguish argon LTP, selective LTP, and micropulse LTP; therefore, beneficiaries who underwent any of these procedures were included. Individuals younger than 65 and older than 95 years were excluded as were enrollees in Medicare Advantage plans because our data source does not fully describe all care received by persons in such plans. Procedures that were submitted for payment but not paid and those missing eye laterality were also excluded. Each claim specifies whether an ophthalmologist or optometrist performed the LTP and whether it was performed on the right or left eye. Bilateral codes were counted as separate procedures for each eye.

Figure 1. STROBE Sample Selection Figure



Identification of beneficiaries eligible for current study from 20% Medicare claims database. *ICD-9-CM* indicates *International Classification of Diseases, Ninth Revision, Clinical Modification*; LTP, laser trabeculoplasty.

Statistical Analysis

All analyses were performed using SAS software, version 9.4 (SAS Inc) and R, version 3.2.3 (R Foundation for Statistical Computing). Characteristics of the study population were summarized using means (SDs) for continuous variables and frequencies and percentages for categorical variables. For all inference procedures, $P < .05$ (Kaplan-Meier method, Wald test, and Cox proportional hazards regression model) was considered statistically significant.

Receipt of Additional LTPs

The primary outcome was receipt of additional LTPs in the same eye. This outcome was identified as another record of CPT-4 code 65855 on a separate date on the same eye as the initial procedure. Subsequent LTPs could have been performed by the same eye care professional or an ophthalmologist or optometrist other than the health care professional who performed the initial procedure. The unit of observation was the eye, but a clustering term was included to allow for the correlation between eyes of the same beneficiary.¹⁵ Observations were right censored at the end of eligibility.

We calculated product limit estimates (with robust SEs) of the time to the second LTP as a function of the type of initial eye care professional (ophthalmologist or optometrist). These estimates were compared at 6 months and 3 years with Wald tests. We used proportional hazards regression models (created by generalized estimating equations to allow for correlated observations) to determine a single estimate of the effect of the key predictor variable: type of eye care professional who performed the initial LTP. An additional model was created adjusting for age at initial LTP, sex, race/ethnicity, where the enrollee lived (urban, large rural, or small rural town), and year of the procedure. In a separate model, we studied whether an interaction between race/ethnicity (non-Hispanic white vs black, Hispanic, American Indian, and persons of other races/ethnicities) and type of eye care professional performing the initial LTP affected the hazard of undergoing additional LTPs.

Receipt of Incisional Glaucoma Surgical Procedures After LTP

Finally, we determined the proportion of patients receiving LTP by each type of eye care professional who subsequently underwent incisional glaucoma surgery (trabeculectomy or glaucoma drainage-device insertion) during the follow-up.

Results

A total of 1384 eyes of 891 eligible patients underwent 1 or more LTPs in Oklahoma during the study period. There were 1150 eyes that received LTP (83.1%) by an ophthalmologist and 234 eyes (16.9%) that had the procedure performed by an optometrist. A total of 493 patients (55.3%) underwent LTP at least once in both eyes. The number of LTPs performed by ophthalmologists ranged from 1 to 277 procedures; 57 ophthalmologists performed this procedure at least once. Optometrists each performed from 1 to 38 LTP procedures; 23 optometrists performed LTP at least once. The most common ICD-9-CM glau-

coma diagnosis code listed on the date of the initial LTP was 365.11 (1206 [87.1%]) and was similar for both types of eye care professionals (975 [86.6%] of patients with an ophthalmologist-performed LTP and 231 [89.7%] with an optometrist-performed procedure). All enrollees in both groups were observed for up to 72 months. The median time from study eligibility to the first LTP was 28.8 months for patients first treated by ophthalmologists and 20.0 months for patients first treated by optometrists. The median times from the first LTP to the end of follow-up were 31.3 and 42.4 months, respectively. The mean (SD) age at the initial LTP was 77.7 (7.5) years for enrollees with ophthalmologist-performed LTP and 77.6 (8.0) years for those with optometrist-performed LTP ($P = .89$). The proportions of white, black, and other patients receiving LTP by ophthalmologists vs optometrists were 85.2% vs 75.5% ($P = .004$), 8.2% vs 10.8% ($P = .33$), and 6.5% vs 13.7% ($P = .004$), respectively (Table 1). Twenty-five enrollees (2.8%) received bilateral LTP on the same day.

Among the 1150 eyes undergoing LTP by an ophthalmologist, 174 (15.1%) received 1 or more LTPs on the same eye during the follow-up. Of the 234 eyes treated with LTP by optometrists, 84 (35.9%) underwent 1 or more additional LTPs on the same eye during follow-up ($P < .001$). Figure 2 displays the distribution of time to second procedure. Second procedures within 6 months were much less common when the first procedure was performed by an ophthalmologist (3.9%) vs an optometrist (24.9%) ($P < .001$). The difference persisted with time, for example, 17.7% vs 34.3% at 3 years ($P < .001$).

We also studied the timing of the additional LTPs by the 2 eye care professional groups relative to the 10-day global period (ie, the immediate post-LTP period, when charges for normal postoperative care are included in the global surgical procedure fee). For patients first treated by ophthalmologists, no additional procedures occurred during the global period, and the probability of a subsequent LTP between 11 and 30 days was 1.1% (95% CI, 0.7%-1.9%). For patients first treated by optometrists, the probability of subsequent LTPs in the global period was 0.4% (95% CI, 0.1%-3.0%) and between days 11 and 30 was 10.3% (7.0%-15.0%).

For the 174 eyes that received LTP by ophthalmologists that required additional laser treatment, 155 (89.1%) received the subsequent LTP by the same ophthalmologist, 13 (7.5%) by a different ophthalmologist, and 6 (3.4%) by an optometrist. Among the 1150 eyes initially treated by ophthalmologists, 21 (1.8%) underwent 3 or more LTPs on the same eye. In comparison, for the 84 eyes that received LTP by optometrists that required additional LTPs, 73 (86.9%) received the subsequent LTP by the same optometrist, 5 (6.0%) by a different optometrist, and 6 (7.1%) by an ophthalmologist. Of the 234 eyes treated initially by optometrists, 11 (4.7%) underwent 3 or more LTPs on the same eye.

After adjustment for potential confounding factors, eyes that received LTP by optometrists had a 189% greater hazard for a subsequent LTP in the same eye during follow-up (hazard ratio, 2.89; 95% CI, 2.00-4.17; $P < .001$) compared with those undergoing LTP by an ophthalmologist. Female patients had a 43% increased hazard of undergoing a subsequent LTP in the same eye during follow-up (hazard ra-

Table 1. Demographics of Patients Receiving LTP by an Ophthalmologist or Optometrist

Characteristic	Overall	LTP Initially by an Ophthalmologist	LTP Initially by an Optometrist	P Value
Individuals, No.	891	752	139	
Eyes, No.	1384	1150	234	
Patient age, mean (SD), y	77.7 (7.6)	77.7 (7.5)	77.6 (8.0)	.89
Sex, No. (%)				
Male	345 (39)	294 (39)	51 (37)	.59
Female	546 (61)	458 (61)	88 (63)	
Race, No. (%)				
White	746 (84)	641 (85)	105 (76)	.02
Black	77 (9)	62 (8)	15 (11)	
Hispanic	7 (<1)	6 (<1)	1 (<1)	
Native	57 (6)	40 (5)	17 (12)	
Other	4 (<1)	3 (<1)	1 (<1)	
Year of first procedure, mean (SD) ^a	2010.3 (1.7)	2010.4 (1.7)	2009.9 (1.6)	.001
Year of first procedure, No. (%)				
2008	171 (19.2)	135 (18.0)	36 (26.0)	.04
2009	168 (18.9)	137 (18.2)	31 (22.3)	
2010	147 (16.5)	120 (16.0)	27 (19.4)	
2011	148 (16.6)	131 (17.4)	17 (12.2)	
2012	135 (15.2)	120 (16.0)	15 (10.8)	
2013	122 (13.7)	109 (14.4)	13 (9.4)	

Abbreviation: LTP, laser trabeculoplasty.

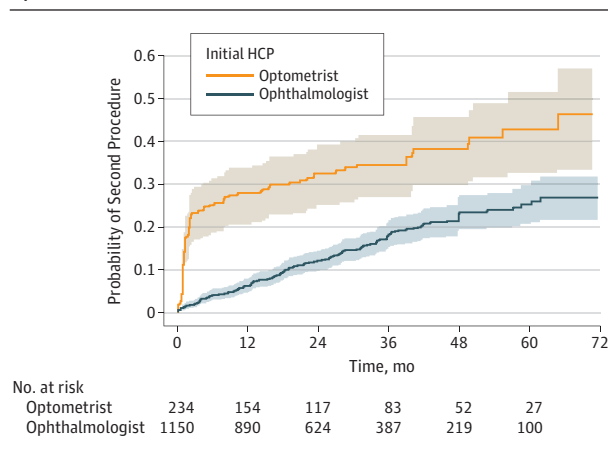
^a The average of the 1384 dates of the initial LTP.

tio, 1.43; 95% CI, 1.02-2.01; $P = .04$). There was no association between age (hazard ratio, 1.04 per 10 years; 95% CI, 0.84-1.28) at initial LTP ($P = .72$), between black, Hispanic, or American Indian individuals, and persons of other races/ethnicities vs white ($P = .79$; hazard ratio, 1.06; 95% CI, 0.71-1.57), or between large rural vs urban residence of the patient ($P \geq .15$; hazard ratio, 0.75; 95% CI, 0.48-1.17) and between small rural vs urban residence of the patient ($P \geq .15$; hazard ratio, 0.73; 95% CI, 0.48-1.12) and the hazard of additional LTPs (Table 2). The

interaction model used to investigate whether race/ethnicity affected the hazard ratio of additional LTPs for ophthalmologist-performed vs optometrist-performed LTP was not statistically significant.

Among the 1150 eyes that underwent LTP by ophthalmologists, 49 (4.3%) subsequently underwent incisional glaucoma surgery. By comparison, of the 234 eyes that underwent LTP by an optometrist, 5 (2.1%) subsequently underwent such surgery.

Figure 2. Time to Second Laser Trabeculoplasty in Same Eye for Beneficiaries Receiving Initial Treatment by Ophthalmologists and Optometrists



Kaplan-Meier estimates of cumulative incidence for each group. Data are clustered because of some beneficiaries having both eyes studied. The study lasted 72 months: follow-up began at the first laser trabeculoplasty. Therefore, there was none at risk at month 72. HCP indicates health care professional.

Discussion

In this analysis of more than 1000 eyes of Medicare beneficiaries with glaucoma who underwent LTP in Oklahoma from January 1, 2008, through December 31, 2013, we note substantial differences in the receipt of additional LTPs by patients who underwent the procedure by an ophthalmologist compared with an optometrist. After adjustment for demographic and other factors, patients who underwent LTP by an optometrist had an approximate 2-fold higher likelihood of undergoing additional LTPs in the same eye compared with others who received this procedure by an ophthalmologist. Most additional LTPs performed by optometrists were done soon after the initial procedure and were performed by the same optometrist as the initial LTP.

Although this study highlights major differences in outcomes of patients undergoing subsequent LTPs after the initial procedure performed by ophthalmologists and procedures performed by optometrists, it is difficult with claims data to discern the reasons for the differences observed. Possible

Table 2. Factors Affecting the Hazard of Requiring Additional Laser Trabeculoplasty^a

Factor	Model	Hazard Ratio (95% CI) ^b	P Value
Initial LTP by an OD vs initial LTP by an EyeMD	Crude	2.58 (1.84-3.61)	<.001
Initial LTP by an OD vs initial LTP by an EyeMD	Adjusted	2.89 (2.00-4.17)	<.001
Each year later LTP was initially performed (eg, 2013 vs 2012)	Adjusted	1.03 (0.92-1.16)	.57
Female vs male	Adjusted	1.43 (1.02-2.01)	.04
Other races vs white	Adjusted	1.06 (0.71-1.57)	.79
Each additional decade of age	Adjusted	1.04 (0.84-1.28)	.72
Large rural town vs urban	Adjusted	0.75 (0.48-1.17)	.20
Small rural town vs urban	Adjusted	0.73 (0.48-1.12)	.15

Abbreviations: EyeMD, ophthalmologist; LTP, laser trabeculoplasty; OD, optometrist.

^a The adjusted model included all of the covariates listed in the table: whether the LTP was performed by an optometrist (vs an ophthalmologist), calendar year the LTP was performed, sex, race/ethnicity, age, and patient residence. The interpretation of the calendar year of the initial LTP is as follows: Persons who underwent their initial LTP in 2013 had a 3.4% increased hazard of

requiring additional LTPs compared with those who had their initial LTP in 2012. This difference was not statistically significant. SEs were adjusted for clustering because of some beneficiaries having both eyes studied. P values and 95% CIs are from robust Wald procedures.

^b Hazard ratios are calculated from crude and adjusted proportional hazards regression models for time to event (second procedure in same eye).

explanations include differences in the sociodemographic characteristics of ophthalmologists' vs optometrists' patients and how each group responds to LTP, differences in disease severity between the 2 groups, differences in selection of patients who are appropriate candidates for LTP between the 2 types of eye care professionals, and differences in how the LTP was performed, including the type of laser used, laser settings, amount of the drainage angle treated in one setting, or whether the procedure was performed properly. Unfortunately, without access to clinical data, such as the preoperative and postoperative intraocular pressure levels, gonioscopy findings, and records describing how the procedures were performed, it is impossible to identify which of these or other factors are contributing to the observed differences in receipt of subsequent LTPs between the groups.

Another possible explanation for differences observed may be that ophthalmologists can perform incisional surgery on patients with failed LTP, whereas optometrists, who cannot do so, may perform additional LTPs. Likewise, because incisional glaucoma surgery is reimbursed more than LTP, this could influence decision making. However, we doubt that this factor is contributing much to the differences observed because a subset of ophthalmologists routinely performs incisional glaucoma surgery, whereas most eye care professionals (optometrists and comprehensive ophthalmologists) would refer patients to glaucoma subspecialists for surgery and thus not benefit financially from recommending incisional surgery vs additional LTPs. Furthermore, few patients in both groups underwent incisional glaucoma surgery during the follow-up; therefore, it is unlikely that this is a major factor responsible for the differences in additional LTPs between the 2 groups.

Some of the patients undergoing LTP by optometrists may reside in communities where access to incisional glaucoma surgery is limited, which may explain some of the differences. Moreover, despite the fact that all the patients in this analysis had Medicare, patients of ophthalmologists may have been better able to make the copayments of incisional glaucoma sur-

gery compared with those receiving care by optometrists. Additional research is needed to study these various potential explanations.

The success of LTP depends on various patient-related and health care professional-related factors. Laser trabeculoplasty has been most effective in patients with primary open-angle glaucoma, exfoliation glaucoma, and pigmentary glaucoma.¹⁶⁻¹⁸ Other glaucoma types, such as angle-closure and angle-recession glaucoma, usually respond poorly to LTP. The degree of angle pigmentation can also affect the success of the procedure and risk for intraocular pressure increases after LTP.^{19,20} Experience and expertise of the eye care professional can also affect outcomes because the effectiveness of LTP requires proper identification of the angle structures to treat. Although, to our knowledge, this is the first study that directly compared LTP performed by ophthalmologists vs optometrists, Lowry et al²¹ showed that LTP performed by attending ophthalmologists was more effective than procedures performed by resident physicians, suggesting that experience in performing the procedure is important.

An interesting finding from these analyses is that many of the patients who underwent additional LTPs by optometrists did so soon after the initial LTP, whereas additional LTPs among patients treated by ophthalmologists tended to occur much later after the initial procedure. One can speculate the reasons for the differences observed. One possibility is that the optometrists performing this procedure may have been more cautious, scheduling the procedure into 2 or more sessions to try to limit postoperative inflammation or intraocular pressure increases.^{22,23} Alternatively, to maximize reimbursement, some optometrists may schedule LTP into more than 1 session, with the timing of subsequent LTPs after the 10-day global period of the initial procedure. The large increase in additional LTPs for the patients undergoing the procedure by optometrists immediately after the global period suggests that this may be a contributing factor, although we are unaware of any reports indicating that optometrists systematically practice in this manner. A third possibility is that because the pres-

sure-decreasing effect of LTP may take several weeks to months to occur, ophthalmologists may be more aware that it may take some time to observe the effect of the initial LTP before proceeding with additional LTPs. However, we know of no studies directly comparing the knowledge level about LTP of these 2 eye care professional groups. With claims data, we cannot tell whether any of these or other factors are responsible for the differences in performance of subsequent LTPs immediately after the global period.

Several studies have assessed the outcomes of additional LTPs.²⁴ Feldman et al²⁵ found a 35% success rate at 6 months with additional argon LTPs, which decreases to 11% after 24 months. Starita et al²⁶ reported that 18% of patients who underwent additional argon LTPs had an intraocular pressure increase of more than 10 mm Hg. As a result, authorities often discourage the performance of additional argon LTPs. The success of additional selective LTPs has been more promising. Hong et al²⁷ described additional intraocular pressure reduction after additional selective LTPs. Durr and Harasymowycz²⁸ did as well. Others have shown that selective LTP can decrease intraocular pressure in eyes that have undergone argon LTP previously.²⁹ Unfortunately, our data source lacks details regarding the amount of the angle treated and the type of laser used during the initial procedure to assess whether the subsequent LTPs performed by eye care professionals in both groups are consistent with recommended clinical practice guidelines.

To our knowledge, this is the first study to examine differences in outcomes of LTP between patients receiving care by ophthalmologists and those by optometrists. A strength of this study is its large diverse population of patients with glaucoma enrolled in Medicare throughout Oklahoma. We are not only including patients receiving care at one particular academic institution or by a small group of eye care professionals but are also including patients who underwent LTP performed by 57 ophthalmologists and 23 optometrists. We had

longitudinal follow-up for several years after the initial LTP to compare the longer-term outcomes. Finally, the data come from claims submitted by ophthalmologists and optometrists, and not from patient self-report, which may be less reliable.³⁰

Our study has several limitations. First, claims data lack clinical details, such as intraocular pressure levels before or after LTP, slitlamp and gonioscopy findings, or details of how the procedures were performed. Second, our study focused on Medicare beneficiaries. It is unclear whether the findings would be similar for younger patients or those with other forms of health insurance. Third, there may be systematic differences between the patients receiving care by ophthalmologists and those by optometrists, including differences in disease severity between the groups. Unfortunately, there were not enough eyes that were coded with the new glaucoma severity codes to assess for this difference. One would expect that patients with more severe glaucoma would be receiving their care by ophthalmologists and thus would be more, not less, likely to require additional LTPs. Although we adjusted our models for some confounding factors, including age and race/ethnicity, there are other unmeasured confounders not included in claims data.

Conclusions

Based on the findings of these analyses, we urge state legislatures and health policy makers to be cautious about giving optometrists privileges to perform LTP in other states until additional research is performed to better delineate the reasons for the differences in the use of additional LTP we are observing in Oklahoma. Furthermore, researchers should determine the effect that these differences have on costs of care and, most important, on clinical outcomes such as disease progression.

ARTICLE INFORMATION

Accepted for Publication: May 27, 2016.

Published Online: July 28, 2016.

doi:10.1001/jamaophthalmol.2016.2495

Author Contributions: Dr Stein had full access to all the data in the study and takes responsibility for the integrity of the data and the accuracy of the data analysis.

Acquisition, analysis, or interpretation of data: All authors.

Drafting of the manuscript: Stein, Zhao.

Critical revision of the manuscript for important intellectual content: Zhao, Andrews, Skuta.

Statistical analysis: Andrews.

Administrative, technical, or material support: Stein. **No additional contributions:** Zhao, Skuta.

Conflict of Interest Disclosures: All authors have completed and submitted the ICMJE Form for Disclosure of Potential Conflicts of Interest and none were reported.

Funding/Support: This study was supported by a Research to Prevent Blindness Physician Scientist

Award, the American Academy of Ophthalmology, and an unrestricted grant from Research to Prevent Blindness.

Role of the Funder/Sponsor: The funding organizations had no role in the design and conduct of the study; collection, management, analysis, and interpretation of the data; preparation, review, or approval of the manuscript; and decision to submit the manuscript for publication.

REFERENCES

- Stein JD, Kim DD, Peck WW, Giannetti SM, Hutton DW. Cost-effectiveness of medications compared with laser trabeculoplasty in patients with newly diagnosed open-angle glaucoma. *Arch Ophthalmol*. 2012;130(4):497-505.
- Cantor LB, Katz LJ, Cheng JW, Chen E, Tong KB, Peabody JW. Economic evaluation of medication, laser trabeculoplasty and filtering surgeries in treating patients with glaucoma in the US. *Curr Med Res Opin*. 2008;24(10):2905-2918.
- Jampel HD, Cassard SD, Friedman DS, et al. Trends over time and regional variations in the rate

of laser trabeculoplasty in the Medicare population. *JAMA Ophthalmol*. 2014;132(6):685-690.

4. Wise JB, Witter SL. Argon laser therapy for open-angle glaucoma: a pilot study. *Arch Ophthalmol*. 1979;97(2):319-322.

5. Optometrists seek surgery rights in more states after Kentucky victory. www.amednews.com/article/20110523/profession/305239946/2/. Posted May 23, 2011. Accessed June 20, 2016.

6. Lane, E. Bill approved by Louisiana Legislature lets optometrists perform some eye surgeries. http://www.nola.com/politics/index.ssf/2014/05/optometrists_surgery_louisiana.html. Updated May 22, 2014. Accessed June 21, 2016.

7. Staff. Kentucky law puts ODs at the laser. http://www.reviewofophthalmology.com/content/d/review_news/i/1471/C/27738/. Published April 12, 2011. Accessed June 21, 2016.

8. Accreditation Council for Graduate Medical Education Review Committee for Ophthalmology. Frequently asked questions: ophthalmology. http://www.acgme.org/Portals/0/PDFs/FAQ/240_Ophthalmology_FAQs.pdf. Updated November 2015. Accessed May 4, 2016.

9. Accreditation Council for Graduate Medical Education Department of Applications and Data Analysis. Ophthalmology/case logs: National Data Report. http://www.acgme.org/Portals/O/PDFs/240_National_Report_Program_Version.pdf. Updated September 23, 2015. Accessed May 4, 2016.
10. Northeastern State University Oklahoma College of Optometry. Continuing medical education advanced procedures. <https://optometry.nsuok.edu/Portals/5/PDF%20Files/CE/2016-Jan-AdvancedProcedures-Workbooks.pdf>. Published January 2016. Accessed May 2016.
11. Centers for Disease Control and Prevention. *International Classification of Diseases 9th Revision Clinical Modification*. Salt Lake City, UT: Contexo Media; 2006.
12. American Medical Association. *CPT 2006: Current Procedural Terminology Professional Edition*. Chicago, IL: American Medical Association; 2006.
13. Stein JD, Grossman DS, Mundy KM, Sugar A, Sloan FA. Severe adverse events after cataract surgery among medicare beneficiaries. *Ophthalmology*. 2011;118(9):1716-1723.
14. Stein JD, Ruiz D, Jr., Belsky D, Lee PP, Sloan FA. Longitudinal rates of postoperative adverse outcomes after glaucoma surgery among Medicare beneficiaries 1994 to 2005. *Ophthalmology*. 2008;115(7):1109-1116.e7.
15. Ying Z, Wei LJ. The Kaplan-Meier estimate for dependent failure time observations. *J Multivar Anal*. 1994;50(1):17-29.
16. Glaucoma Laser Trial Research Group. The Glaucoma Laser Trial, I: acute effects of argon laser trabeculoplasty on intraocular pressure. *Arch Ophthalmol*. 1989;107(8):1135-1142.
17. Threlkeld AB, Hertzmark E, Sturm RT, Epstein DL, Allingham RR. Comparative study of the efficacy of argon laser trabeculoplasty for exfoliation and primary open-angle glaucoma. *J Glaucoma*. 1996;5(5):311-316.
18. Ritch R, Liebmann J, Robin A, et al. Argon laser trabeculoplasty in pigmentary glaucoma. *Ophthalmology*. 1993;100(6):909-913.
19. Chen E, Golchin S, Blomdahl S. A comparison between 90 degrees and 180 degrees selective laser trabeculoplasty. *J Glaucoma*. 2004;13(1):62-65.
20. Harasymowycz PJ, Papamatheakis DG, Latina M, De Leon M, Lesk MR, Damji KF. Selective laser trabeculoplasty (SLT) complicated by intraocular pressure elevation in eyes with heavily pigmented trabecular meshworks. *Am J Ophthalmol*. 2005;139(6):1110-1113.
21. Lowry EA, Greninger DA, Porco TC, Naseri A, Stamper RL, Han Y. A comparison of resident-performed argon and selective laser trabeculoplasty in patients with open-angle glaucoma. *J Glaucoma*. 2016;25(3):e157-e161.
22. Weinreb RN, Ruderman J, Juster R, Zweig K. Immediate intraocular pressure response to argon laser trabeculoplasty. *Am J Ophthalmol*. 1983;95(3):279-286.
23. Barkana Y, Belkin M. Selective laser trabeculoplasty. *Surv Ophthalmol*. 2007;52(6):634-654.
24. Stein JD, Challa P. Mechanisms of action and efficacy of argon laser trabeculoplasty and selective laser trabeculoplasty. *Curr Opin Ophthalmol*. 2007;18(2):140-145.
25. Feldman RM, Katz LJ, Spaeth GL, Crapotta JA, Fahmy IA, Ali MA. Long-term efficacy of repeat argon laser trabeculoplasty. *Ophthalmology*. 1991;98(7):1061-1065.
26. Starita RJ, Fellman RL, Spaeth GL, Poryzees E. The effect of repeating full-circumference argon laser trabeculoplasty. *Ophthalmic Surg*. 1984;15(1):41-43.
27. Hong BK, Winer JC, Martone JF, Wand M, Altman B, Shields B. Repeat selective laser trabeculoplasty. *J Glaucoma*. 2009;18(3):180-183.
28. Durr GM, Harasymowycz P. The effect of repeat 360-degree selective laser trabeculoplasty on intraocular pressure control in open-angle glaucoma. *J Fr Ophthalmol*. 2016;39(3):261-264.
29. Birt CM. Selective laser trabeculoplasty retreatment after prior argon laser trabeculoplasty: 1-year results. *Can J Ophthalmol*. 2007;42(5):715-719.
30. Patty L, Wu C, Torres M, Azen S, Varma R; Los Angeles Latino Eye Study Group. Validity of self-reported eye disease and treatment in a population-based study: the Los Angeles Latino Eye Study. *Ophthalmology*. 2012;119(9):1725-1730.