Laser in Situ Keratomileusis Outcomes and Complications: 2016 to 2023

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ABSTRACT

PURPOSE: To review current clinical outcomes, complications, and patient satisfaction of laser in situ keratomileusis (LASIK) from studies published between 2016 and 2023, with a specific focus on refractive outcomes and topography-guided LASIK (TG-LASIK).

METHODS: A literature review was conducted using PubMed and Scopus, identifying studies reporting LASIK outcomes, complications, and patient satisfaction. Inclusion criteria required studies to report aggregate clinical data, using validated metrics for subjective outcomes. Studies on re-treatment, specific corneal/systemic disorders, or follow-up shorter than 1 month were excluded. Separate analyses were performed for TG-LASIK and other LASIK treatments.

RESULTS: Ninety-five studies met the final inclusion criteria. Myopic treatment achieved better outcomes than hyperopic treatment, with 88.3% and 69.2% reaching an uncorrected distance visual acuity (UDVA) of 20/20, respectively. TG-LASIK demonstrated superior refractive outcomes to LASIK myopic treatment, with 91.8% having 20/20 or better UDVA, and 95% and 100% of eyes achieving refractive accuracy within ±0.50 and ±1.00 diopters, respectively. Complication rates were low, with the most common being flap folds (0.73%). Sight-threatening complications occurred in 0.07% of the eyes. Patient satisfaction remained high, with 92.6% reporting satisfaction with surgery, and 99% would recommend the procedure to a friend.

CONCLUSIONS: LASIK remains a safe, effective, and highly satisfying refractive surgery, with TG-LASIK demonstrating superior outcomes compared to other LASIK treatments. Complications were infrequent, and subjective visual symptoms generally improved postoperatively. Future research should use standardized methods for assessing and reporting subjective outcomes, including preoperative and postoperative comparisons, to provide a more comprehensive understanding of LASIK outcomes.

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Laser in situ keratomileusis (LASIK) is the most commonly performed refractive and elective surgical procedure for ametropia correction, consistently demonstrating excellent outcomes and patient satisfaction.[1] This is underscored by the Patient-Reported Outcomes With Laser In Situ Keratomileusis (PROWL 1 and 2) studies, which systematically evaluated patient satisfaction, revealing that more than 96% of participants were highly satisfied with their results.[2] Multiple studies have continued to examine LASIK outcomes. The most recent comprehensive review, published in 2016, confirmed that LASIK is a safe and effective procedure with high patient satisfaction rates.[3]

With the widespread use of LASIK, recent U.S. Food and Drug Administration (FDA) guidance emphasizing the importance of comprehensive patient education,[4] and significant technological advancements over the past decade—including the approval

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of new platforms,[5] improvements in eye tracking and femtosecond laser flap creation technologies,[6] and the introduction of novel treatment options, such as topography-guided LASIK (TG-LASIK)—a reassessment of current LASIK outcomes is timely.[7,8]

This study reviewed the literature on LASIK published after 2016, focusing on standardized outcome graphs for refractive outcomes, surgical complications, subjective visual disturbances, and patient satisfaction, with a separate analysis of refractive outcomes specific to TG treatments.

METHODS

We conducted a literature search in August 2024 on PubMed and Scopus databases for articles published between January 2016 and July 2023 using the terms "LASIK" and "laser in situ keratomileusis." Three reviewers (BNS, NM, JBR) independently examined the titles and abstracts and selected relevant articles reporting LASIK clinical outcomes, complications, and patient satisfaction. We excluded studies that focused on patients with corneal or specific systemic disorder, such as corneal dystrophy and autoimmune disease. We also excluded studies on LASIK re-treatment or in eyes with prior ocular surgery, and those with follow-up periods shorter than 1 month. The full texts of relevant articles were analyzed, and articles were selected for final inclusion if they reported clinical outcomes data that could be aggregated (ie, provided standard refractive surgery outcome graphs).[9-12] Articles investigating presbyopia treatments were excluded from the refractive outcomes and subjective complication analyses, but were included in the objective/flap complication analysis.

Refractive Outcomes Analysis

Refractive outcomes were analyzed and reported using the quantitative data available on the standard graphs,[11] which included preoperative corrected distance visual acuity (CDVA), postoperative uncorrected distance visual acuity (UDVA), and changes in Snellen lines between preoperative CDVA and postoperative UDVA and between preoperative and postoperative CDVA. Additionally, we included accuracy data obtained from the target spherical equivalent (SE) and postoperative astigmatism graphs. Articles presenting data specifically on TG-LASIK were analyzed separately from conventional wavefront-optimized and wavefront-guided ablation treatments (hereafter referred to simply as "LASIK"). LASIK treatments were categorized into two groups based on the refractive correction: studies including myopia (myopia group) and hyperopia (hyperopia group) treatments.

LASIK Complications Analysis

We evaluated objective and subjective complications and patient satisfaction. Given the challenges in quantifying subjective complaints and the heterogeneity in assessment methods, we included only studies reporting the prevalence or rates of visual symptoms, dry eye, and patient satisfaction in the aggregate analysis, excluding those that provided only mean scores. Additionally, to limit variability in standards and subjective bias in the analysis of visual symptoms and dry eye, only studies that clearly described their assessment strategy—using either validated questionnaires or grading systems—were included.

Complication rates were categorized into three groups:

1. Objective complications: intraoperative flap complications, epithelial ingrowth, flap folds, flap dislocation, inflammatory or infectious keratitis, postoperative intraocular pressure increase, haze, melting, and transient light sensitivity syndrome;
2. Visual symptoms: glare, halos, starburst, visual fluctuation, double vision, light sensitivity, difficulty driving at night, and pain;
3. Dry eye: assessed subjectively (eg, via questionnaires) or objectively (eg, superficial keratopathy).

The data analysis of visual symptoms and dry eye followed two approaches. The first included all studies reporting their postoperative prevalence and the second included only studies reporting both preoperative and postoperative prevalence to evaluate the changes following LASIK. We conducted separate analyses for the overall and moderate-to-severe visual symptoms and dry eye.

Patient Satisfaction Outcomes

Studies assessing patient satisfaction were aggregated if they reported using specifically one or more of the following questions:

1. How satisfied are you with your surgery? (Very satisfied/satisfied/neither/dissatisfied/very dissatisfied);
2. Would you recommend it to a friend? (Yes/No);
3. Would you undergo the procedure again? (Yes/No);
4. Do you experience debilitating difficulty in any activities due to visual symptoms? (Yes/No).

All collected data were analyzed as prevalence using the Microsoft Excel software (version 16.78; Microsoft Corporation).

RESULTS

The initial search yielded 2,261 peer-reviewed articles, of which 234 met the inclusion/exclusion criteria

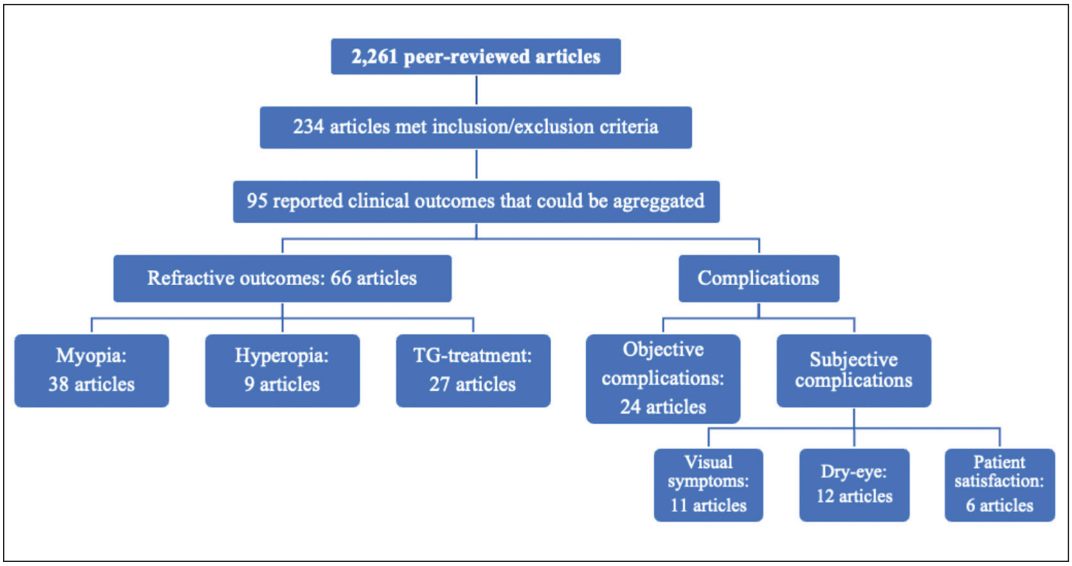

Figure 1. Article review process and results. TG = topography-guided.

TABLE 1

Most Commonly Used FSL/MKT and Excimer Lasers[a]

Laser	No. of Studies (Eyes)
FSL/MKT	
VisuMax 500	15 (2,744)
IntraLase iFS	14 (2,248)
WaveLight FS200	13 (1,626)
Ziemer LDV	2 (150)
Hansatome MKT	5 (6,4375)
Multiple	8 (9,353)
Other FSL[b]	2 (107)
Other MKT[c]	4 (273)
Not informed	3 (1,154)
Excimer laser	
WaveLight EX500	24 (45,099)
SCHWIND Amaris 750S	9 (665)
Visx Star S4 IR	8 (1,537)
MEL 80	5 (1,386)
Wavelight Allegretto Eye-Q	4 (431)
MEL 90	3 (1,460)
Multiple	11 (2,519)
Others[d]	2 (80)
Not informed	0 (0)

FSL – femtosecond laser; MKT = microkeratome
[a]Summary for studies that were included in all refractive outcomes aggregated analysis. Some articles included more than one FSL/MKT or excimer lasers, so these were counted multiple times in this table.
[b]Intralase FS 150, Intralase FS 60.
[c]Moria M2, Microkeratome Zyoptix XP, Microkeratome LSK-1, Microkeratome Carriazo-Pendular.
[d]Technolas-217z, SCHWIND Amaris 1050RS.

for full-text review. Of these, 95 articles reported clinical findings that could be aggregated.[1,2,7,13-104] Sixty-six articles (82,030 eyes) provided at least one standard graph data set and were included in the refractive outcomes analysis. Thirty-eight, 27, and 9 articles contributed to the myopia, TG treatment, and hyperopia analyses, respectively. Of the 38 studies on myopia treatment, 5 (13.2%) included only high myopia, with preoperative spherical refraction ranging from -5.50 to -14.00 diopters (D) (means reported by those studies ranged from -8.20 to -10.30 D).[46,58,74,88] Among the hyperopia studies, 7 (78%) included cases of moderate-to-high hyperopia, defined as a preoperative spherical refraction between +3.50 and +9.50 D (means reported by those studies ranged from +4.70 to +6.70 D).[16,40,76,77,85,102,103] Twenty-four studies reported objective complications that could be aggregated. Eleven, 6, and 12 studies reported on visual symptoms, patient satisfaction, and dry eye, respectively. These results are summarized in a flow diagram (**Figure 1**) and the references used for each analysis can be found in **Table A**.

Most studies were conducted in the United States or Canada (29.8%), followed by European countries (25.5%), then China, Japan, South Korea, and Singapore (23.4%). The remaining 18.1% were conducted in various countries, including Brazil, Mexico, Iran, India, Turkey, and Egypt. Three studies were multicentric (3.2%). Half of the studies were prospective (47/95), with 61.7% (29/47) having two arms. The median follow-up time was 6 months (range: 1 to 60 months), with 59.1% of studies reporting follow-up periods of 6 months or more, and 30% reporting 12 or more months.

Table 1 summarizes the excimer lasers and flap-creation devices in the 66 articles included in the visual outcomes aggregated analysis. Most studies used

TABLE 2

Summary of Topography-Guided Treatments

Laser System	Topography System	Treatment Planning Software	No. of Studies (Eyes)
WaveLight EX500	Vario Topolyzer	Wavelight T-CAT/Contoura	22 (44,035)
Allegretto Wave Eye-Q	Allegro Topolyzer	Wavelight T-CAT /Contoura	3 (509)
Nidek EC-5000	OPD-Scan Aberrometer	Final Fit	2 (171)
SCHWIND Amaris	Keratron SCOUT	SCHWIND ORK-CAM	1 (90)
MEL 80	Atlas Topographer	Customized Refractive Surgery Master	1 (35)

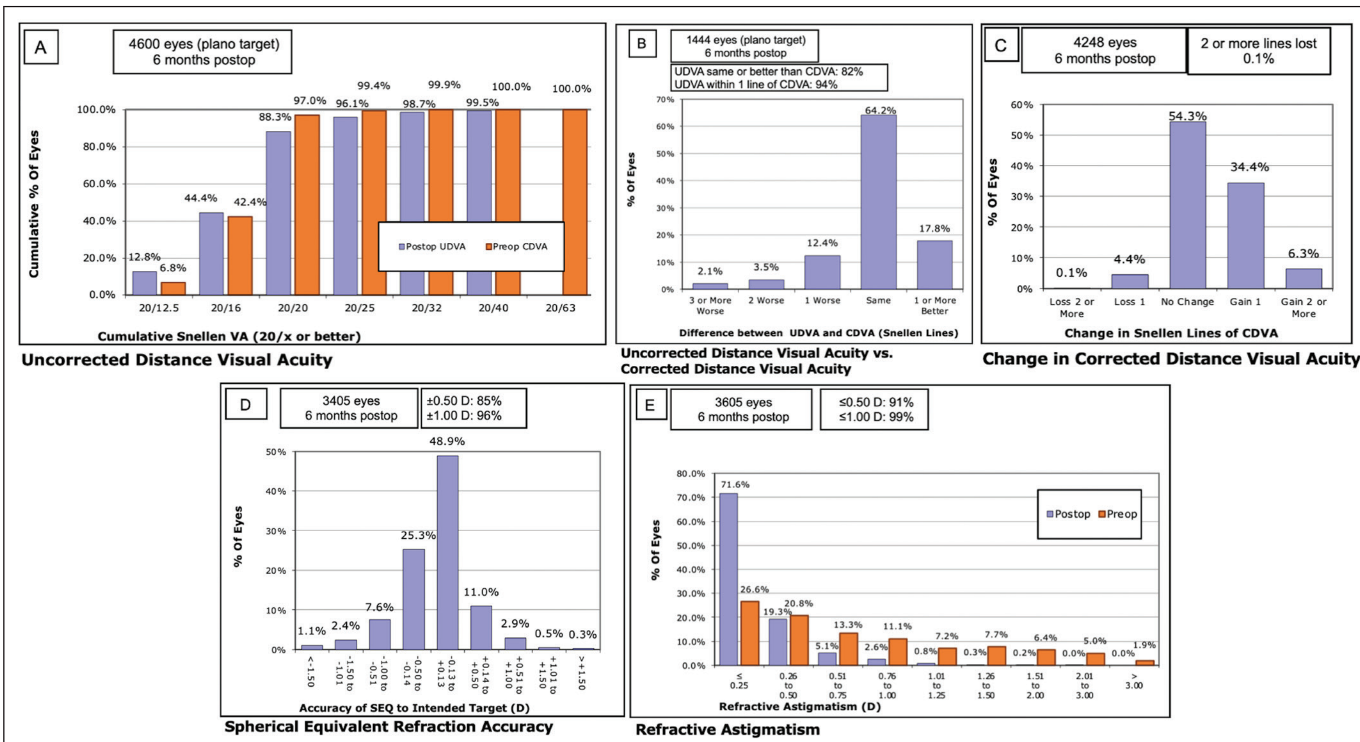

Figure 2. Visual outcomes of laser in situ keratomileusis (LASIK) in the myopia group. (A) Comparison of preoperative corrected distance visual acuity (CDVA) and postoperative uncorrected distance visual acuity (UDVA). (B) Difference between preoperative CDVA and postoperative UDVA in Snellen lines. (C) Comparison of preoperative and postoperative CDVA. (D) Distribution of spherical equivalent refraction (SEQ) accuracy. (E) Comparison of preoperative and postoperative refractive astigmatism. D = diopters

a femtosecond laser to create the flap (69.7%), with the VisuMax (Carl Zeiss Meditec AG) being the most common (15 of the 66 studies), followed by the IntraLase iFS (14/66). Although a microkeratome was used as the sole flap-creation device in only 9 studies, it accounted for 78.8% of the eyes (64,648/82,030). The WaveLight EX500 (Alcon Laboratories, Inc) was the most commonly described excimer laser (24/66), accounting for 55% of the eyes (45,099/82,030) in the studies included.

Thirty-one studies (47%) reported results on at least one platform newly approved by the FDA, with 71% (22/31) covering TG treatments (see **Table 2** for details on TG treatments). Contoura treatment was considered only if the study explicitly mentioned using it. Some studies also reported on other recently approved treatments, such as the STAR S4 IR iDesign (Johnson & Johnson Vision) (8/66) and the Allegretto WAVE Eye-Q Excimer Laser System (Alcon Laboratories, Inc) (4/66).

Visual Acuity and Refractive Outcomes

Considering the results of myopia and hyperopia treatments all together, 98.3% and 82.5% of the eyes achieved a UDVA of 20/40 and 20/20, respectively. **Figures 2-3** illustrate the results of LASIK procedures for the myopia and hyperopia groups separately. The percentages of eyes achieving UDVA of 20/40 and 20/20 were 99.5% and 88.3% for the myopia group and 97.7% and 69.2% for the hyperopia group, respectively (Graph A).

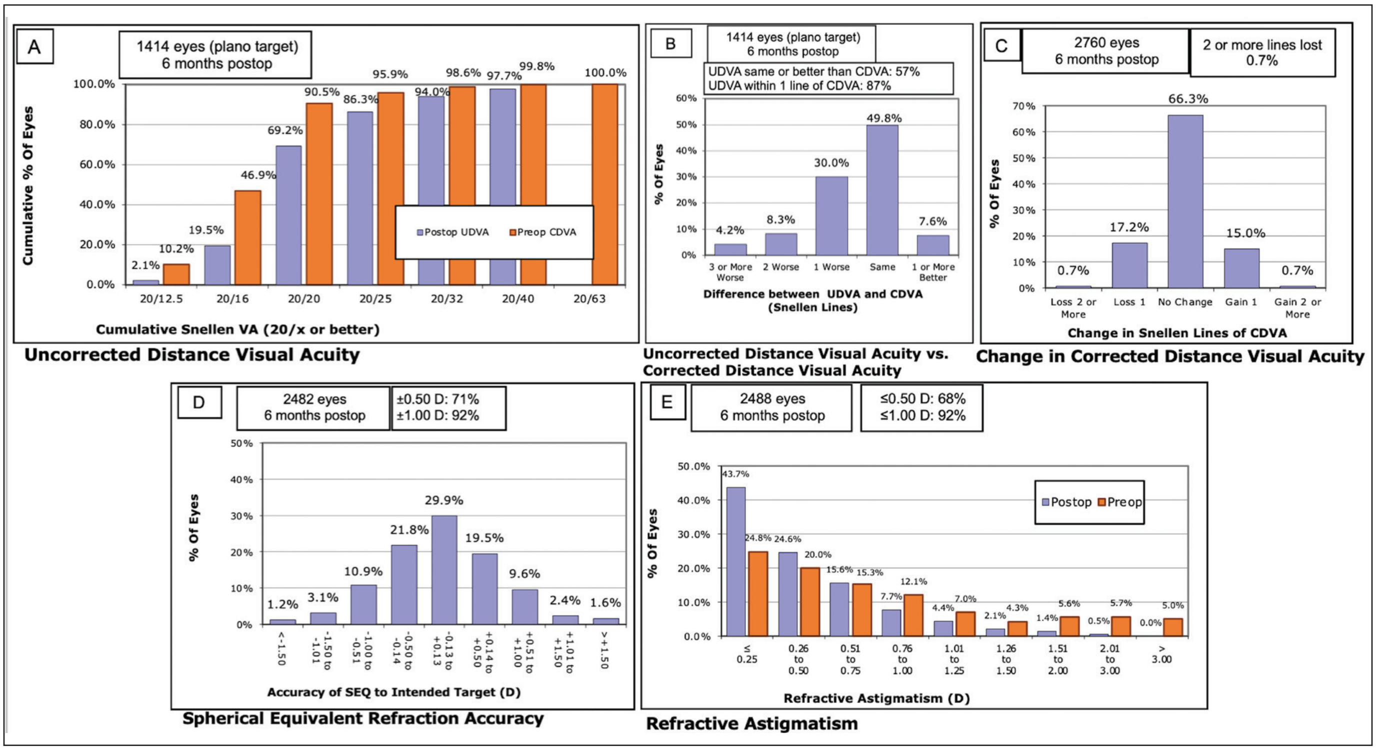

Figure 3. Visual outcomes of laser in situ keratomileusis (LASIK) in the hyperopia group. A) Comparison of preoperative corrected distance visual acuity (CDVA) and postoperative uncorrected distance visual acuity (UDVA). (B) Difference between preoperative CDVA and postoperative UDVA in Snellen lines. (C) Comparison of preoperative and postoperative CDVA. (D) Distribution of spherical equivalent refraction (SEQ) accuracy. (E) Comparison of preoperative and postoperative refractive astigmatism. D = diopters

Graph B compares the postoperative UDVA with the preoperative CDVA. For the myopia group (1,444 eyes), 82% had postoperative UDVA equal to or better than preoperative CDVA, with this percentage being 57% in the hyperopia group (706/1,229 eyes). In the myopia group, 5.6% (81 eyes) had postoperative UDVA two or more lines worse than preoperative CDVA, with 64.2% of these cases from a study that included only patients with high myopia (SE range: -8.00 to -14.50 D).[74] Across the myopic eyes, 0.1% lost and 6.3% gained two or more lines of CDVA, whereas in the hyperopia group 0.7% of eyes equally lost or gained two lines of CDVA (Graph C).

A total of 3,405 eyes provided data on refractive accuracy in the myopia group, of which 85% were within ±0.50 D, and 96% within ±1.00 D of the intended target (Graph D). In the hyperopia group (1,414 eyes), 71% and 92% of eyes were within ±0.50 and ±1.00 D, respectively. Postoperative refractive astigmatism was less than 0.50 and 1.00 D in 91% and 99% of eyes in the myopia group, and 71% and 92% of eyes in the hyperopia group, respectively (Graph E).

Figures A-B present the results for high ametropia, showing worse outcomes compared to the overall myopia and hyperopia groups. Among eyes with high myopia, 76.4% achieved a UDVA of 20/20, whereas in high hyperopia cases, this rate was 64.3% (Graph A). Postoperative UDVA was at least two lines worse than preoperative CDVA in 12% of highly myopic eyes (Graph B), although the percentage of eyes losing two lines of CDVA after surgery remained similar to the overall myopic cohort (0.13%) (Graph C). In patients with high hyperopia, 13.7% had a postoperative UDVA at least two lines worse than preoperative CDVA (Graph B), whereas 0.7% lost two lines of CDVA (Graph C). This similarity to the overall hyperopic results is likely due to the fact that 7 of the 9 available studies included only eyes with high hyperopia. Refractive accuracy was also lower, with 61% of eyes with high myopia and 69% of eyes with high hyperopia within ±0.50 D of the target (Graph D).

TG-guided LASIK outcomes were reported by 27 studies, included only myopic treatment, and resulted in 44,768 eyes (**Figure 4**). The median follow-up was 3 months (range: 1 to 12 months), with 30% of the studies with 6 or more months of follow-up. Postoperative UDVA and preoperative CDVA was reported for 44,748 eyes (Graph A). After surgery, 91.8% of eyes had a cumulative Snellen UDVA of 20/20 or better, 91.4% of eyes had a postoperative UDVA equal to or better than preoperative CDVA (Graph B), and 98.6% of eyes had a postoperative CDVA within one line

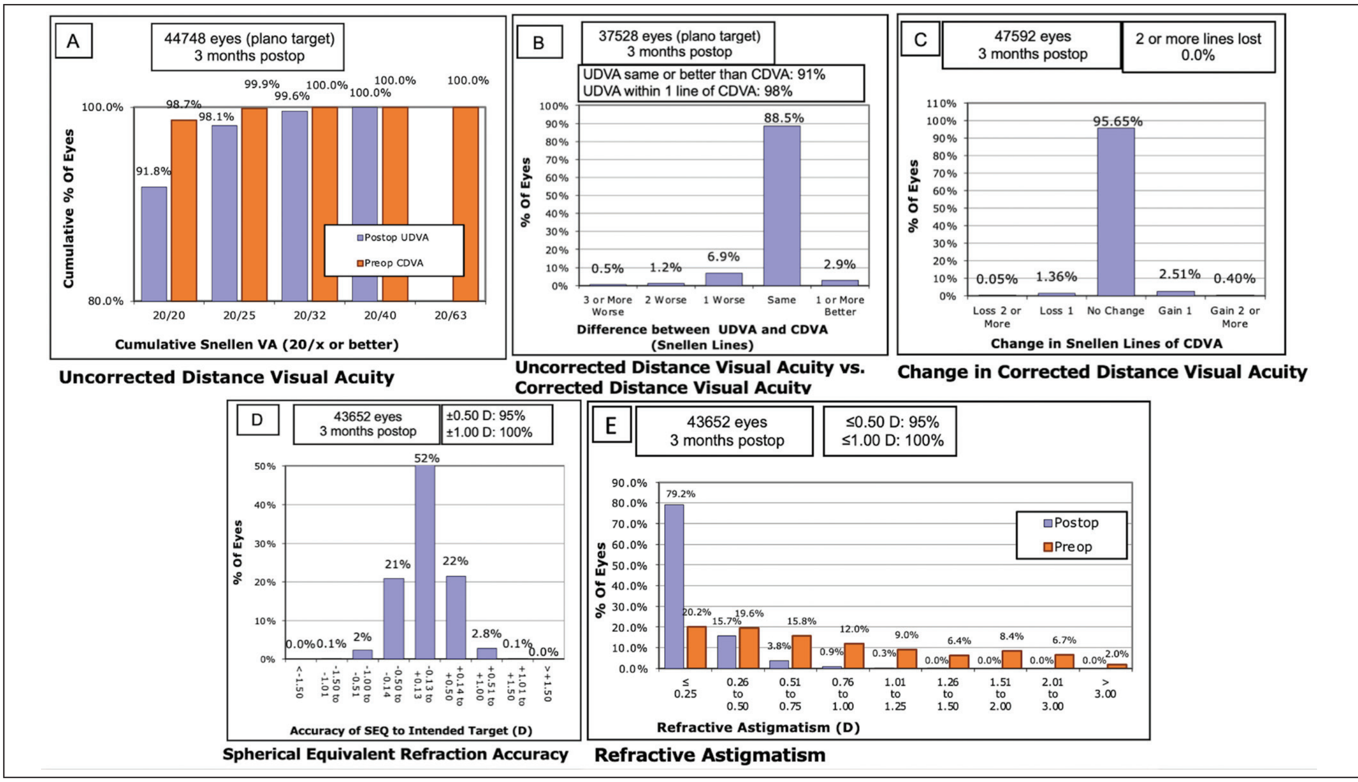

Figure 4. Visual outcomes of topography-guided laser in situ keratomileusis (LASIK) procedures. (A) Comparison of preoperative corrected distance visual acuity (CDVA) and postoperative uncorrected distance visual acuity (UDVA). (B) Difference between preoperative CDVA and postoperative UDVA in Snellen lines. (C) Comparison of preoperative and postoperative CDVA. (D) Distribution of spherical equivalent refraction (SEQ) accuracy. (E) Comparison of preoperative and postoperative refractive astigmatism. D = diopters

of the preoperative CDVA (Graph C). Accuracy data showed that 95% and 100% of the eyes were within ±0.50 and ±1.00 D of both the SE target and the refractive astigmatism, respectively (Graph D and E).

COMPLICATIONS

The incidence of objective complications is summarized in **Table 3**. A total of 12 studies, encompassing 849,625 eyes with a median follow-up of 12 months (range: 1 to 36 months), were included in this analysis. The most common complication was flap folds at 0.73%, followed by diffuse lamellar keratitis (DLK) at 0.38% and epithelial ingrowth (0.275%). The overall incidence of flap-related complications, such as incomplete flap creation, flap folds, dislocation, tear, and buttonhole, was 0.29%. Sight-threatening complications, including corneal melting, DLK grades 3 and 4, and keratitis, collectively accounted for an incidence of 0.07%.

Eleven studies (5,637 eyes) reported the total postoperative prevalence of visual symptoms with a median follow-up of 6 months (range: 3 to 60 months) (**Figure 5A**). Among these, starburst was the most frequently reported visual disturbance (39.43%), followed by glare (28.22%). Severe starburst and glare

TABLE 3

Overall Incidence of Objective Complications

Complication	Overall Incidence (%)	No. of Studies (Eyes)
Incomplete flap	0.010	9 (135,685)
Flap folds	0.727	13 (245,564)
Buttonhole	0.014	6 (63,167)
Flap dislocation	0.019	11 (136,916)
Flap tear	0.010	5 (62,470)
Decentered ablation	0.002	6 (133,288)
CTK	0.015	1 (61,833)
Corneal melting	0.008	1 (61,833)
Corneal haze	0.063	4 (134,238)
DLK grades 1-2	0.489	6 (99,576)
DLK grades 3-4	0.316	13 (162,648)
Epithelial ingrowth	0.275	11 (168,843)
IOP rise requiring treatment	0.004	2 (132,922)
TLSS	0.111	2 (63,043)
Keratitis	0.007	7 (609,315)

CTK = central toxic keratopathy; DLK = diffuse lamellar keratitis; IOP = intraocular pressure; TLSS = transient light sensitivity syndrome

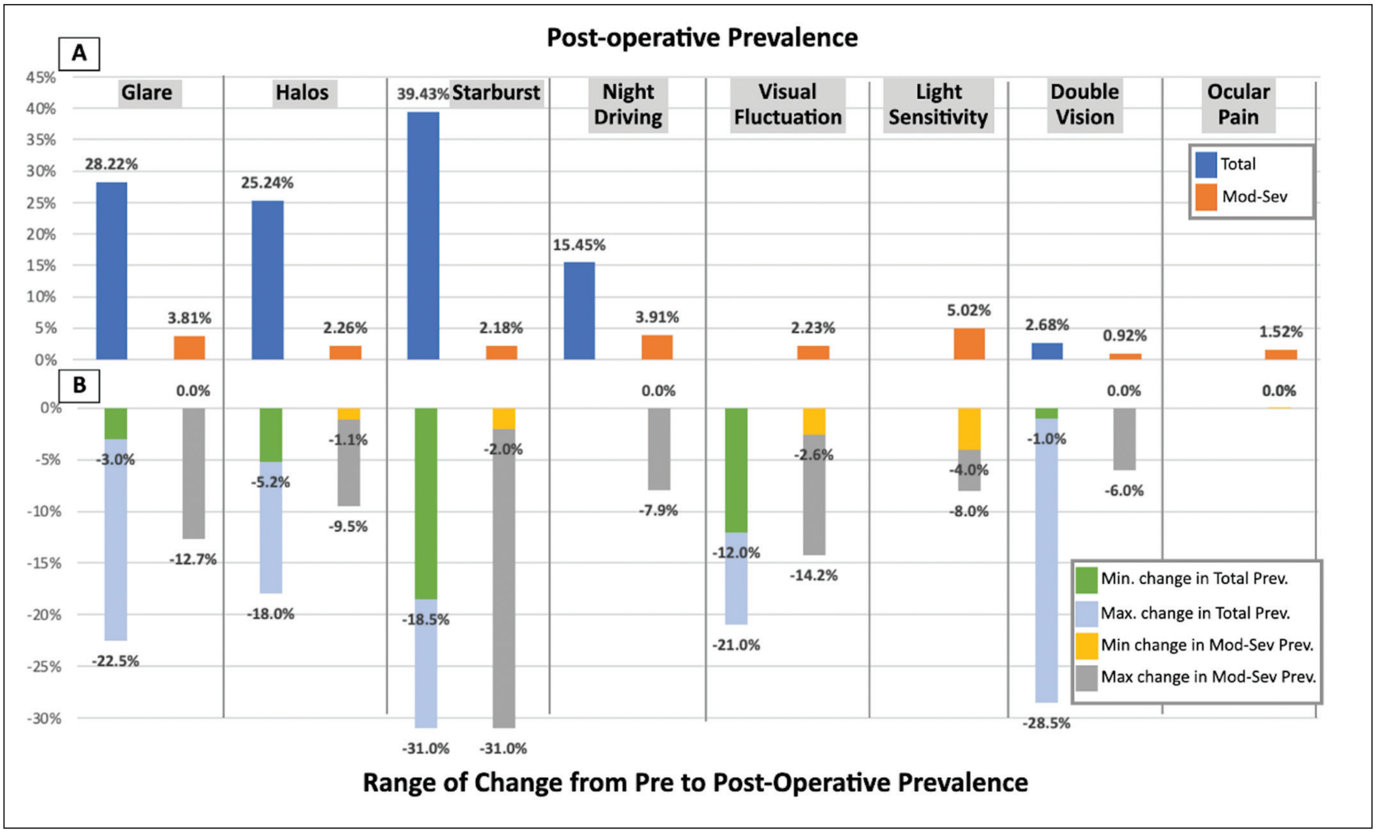

Figure 5. Prevalence of visual symptoms. (A) Postoperative prevalence of total (blue bar) and moderate-to-severe (orange bar) symptoms. (B) Range of change in total (green/blue bar) and moderate-to-severe (yellow/gray bar) symptoms, from preoperative to postoperative evaluation. Green and yellow bars refer to the minimum reported change, and blue and gray bars refer to the maximum reported change. Minus values indicates a reduction in prevalence.

were noted in 2.18% and 3.81% of cases, whereas severe light sensitivity was reported by 5.09%. Difficulty with night driving was reported by 15.45% of patients, with 3.91% experiencing severe symptoms.

Seven studies (2,754 eyes) compared preoperative and postoperative prevalence of visual symptoms, all of which employed validated questionnaires (**Table 4**). Of these, 5 performed statistical analyses, all reporting significant improvement in at least one symptom. **Figure 5B** illustrates the range of differences in symptom prevalence before and after LASIK, as reported by the included studies. Total prevalence of light sensitivity, night driving, and pain was reported by only one study; hence, for these symptoms, only the change in the prevalence of severe symptoms, as reported by 3 studies, was included.

The dry eye analysis aggregated data from 12 studies (101,274 eyes). The overall postoperative prevalence of dry eye was 8.53%, with severe dry eye, as defined by each study criteria, occurring in 1.29% of the cases. Only 6 studies reported dry eye preoperative and postoperative prevalence as opposed to mean scores.[1,2,14,70,76] Based on these studies, the change in prevalence of moderate-to-severe dry eye ranged from a 6% increase to a 17.9% decrease. Only 4 studies performed a statistical analysis on their finding; 2 of them demonstrated that dry eye significantly improved[32,70] and the other 2 studies found no statistically significant change.[1,27]

Seven studies provided data on patient satisfaction (4,266 eyes and median follow-up of 12 months). Five studies questioned "How satisfied are you with your surgery?," for which 92.6% of patients answered they were either satisfied or very satisfied with LASIK.[2,31,43,57] Dissatisfaction was reported by 2.4% of patients, with 1.3% being very dissatisfied. Three studies reported that 99% of patients would recommend the procedure to a friend,[1,56,57] and two studies found that 94.7% would undergo LASIK again.[56,57] Four studies investigated the impact of symptoms in daily activities, with 1.23% of patients reporting "debilitating difficulty," mainly at night driving.[1,2,57]

DISCUSSION

Detailed review of the literature demonstrates that LASIK continues to offer high efficacy, safety, and accuracy with all treatment platforms. Outcomes far exceeded the FDA efficacy benchmark (85% 20/40 or

TABLE 4

Studies Evaluating Change in Preoperative and Postoperative Visual Symptoms

Article	Sample Size (Eyes)	Follow-up (Months)	Questionnaire	Impression	Statistically Significant Change
Stulting et al[70]	130	3	FDA	Improvement	Reduction in the prevalence of moderate to severe glare, halos, starbursts, driving, visual fluctuation, and light sensitivity.
Moshirfar et al[14]	718	6	FDA	Improvement	Reduction in the prevalence of moderate to severe glare, halos, and difficulty driving at night.
Eydelman et al (PROWL 1)[2]	216	6	PROWL	Improvement	Did not perform statistical analysis.
Eydelman et al (PROWL 2)[2]	256	3	PROWL	Improvement	Did not perform statistical analysis.
Price et al[1]	1106	12	Self-developed	Improvement	Reduction in the prevalence of night driving and glare, halos, and starburst.
Ma & Manche[31]	40	12	PROWL	Improvement	Reduction in the mean scale score for double vision, halo, glare, and starburst.
Stulting et al[47]	230	12	RSVP	Improvement	Reduction in the prevalence of moderate-to-severe glare and difficulty at driving at night.
Wallerstein et al[56]	76	3.2	QoL	Improvement	Reduction in the severity scores of glares, starbursts, and visual fluctuation.

FDA = U.S. Food and Drug Administration; QoL = Quality of Life Questionnaire; PROWL = Patient-Reported Outcome with Laser; RSVP = Refractive Status and Vision Profile

better UDVA), with 98.3% of all eyes achieving UDVA of 20/40 or better, and 82.5% achieving 20/20 or better. In the myopic treatment group, 99.5% and 88.3% achieved a UDVA of 20/40 and 20/20 or better, respectively. These results are comparable to those reported by Sandoval et al,[3] with 99.5% 20/40 or better and 90.8% 20/20 or better UDVA.

Hyperopic LASIK, which is associated with less favorable outcomes than myopic LASIK, constituted a similar proportion in both reviews; however, 55% of the hyperopic eyes in our analysis had moderate-to-high ametropia. Only 69.2% of hyperopic eyes in this study achieved 20/20 or better UDVA, and 42.6% had UDVA one or more lines below their preoperative CDVA (4.2% three lines worse). This was more than twice the difference in the myopia group, of which 18% and 2.1% of the eyes experienced one- and three-line declines, respectively.

Overall, 78% of all eyes achieved refractive outcomes within ±0.50 D of the target, with the myopia group showing higher precision (85% within ±0.50 D) than the hyperopia group (71% within ±0.50 D). Notably, 4% of myopic eyes had a postoperative SE exceeding ±1.00 D, of which 54.8% belonged to a single study on high myopia (SE ranging from -8.00 to -14.00 D).[74] Without this study, only 2% of myopic eyes had postoperative SE greater than ±1.00 D, similar to earlier work.[3]

TG-LASIK achieved 20/20 or better UDVA in a higher percentage of eyes than in the myopic LASIK group (91.8% versus 88.3% respectively), even when excluding the high myopia study (89.5% achieving 20/20 or better UDVA). In the TG-LASIK group, 99% of eyes maintained or improved CDVA, compared to 95.5% in the LASIK myopic group.

TG-LASIK may induce fewer changes in corneal asphericity and higher order aberrations than wavefront-optimized ablation.[59,71,78] TG treatments were traditionally reserved for highly aberrated or irregular corneas and demonstrated considerable success in these cases.[105,106] With recent advancements, new platforms for treating normal corneas were approved by the FDA, with minimal higher order aberrations and discrepancies between corneal and refractive astigmatism.[107] Although initial FDA guidelines were restrictive, recent studies have shown promising outcomes with TG-LASIK in eyes outside these criteria. Wallerstein et al[64,65] conducted three large retrospective studies showing that discrepancies in astigmatism and high higher order aberrations [66] had negligible effects on TG-LASIK outcomes, with 99.8% of eyes achieving UDVA of 20/40 or better. Notably, among eyes with up to 45 degrees of astigmatism axis discrepancy, 93% reached UDVA of 20/20 or better. In cases with astigmatism greater than 2.00 D, TG-LASIK still reached an UDVA of 20/40 or better in 100% of the eyes,[56] although the 20/20 UDVA rate was lower (78%) compared to the aggregated results in this review (91.4%).

LASIK remains safe, with less than 0.5% of eyes experiencing significant vision loss, consistent with the 0.61% reported by Sandoval et al,[3] and 10 times lower than the FDA's safety threshold. Myopic LASIK had better outcomes than hyperopic LASIK, with 95.5% presenting equal or better CDVA after surgery, compared to 82% in the hyperopic group.

Intraoperative and postoperative objective LASIK complications were uncommon, with the most common being flap folds (0.73%). The aggregated incidence of potentially sight-threatening complications (sum of the eyes experiencing melting, DLK grades 3 and 4, and keratitis) was 0.07%, lower than 0.4% incidence of a large report that included both photorefractive keratectomy and LASIK, and from which all patients achieved a binocular CDVA of 20/40 or better.[25]

A comprehensive assessment of LASIK's impact on visual symptoms requires preoperative data to establish baseline prevalence. Although the PROWL studies successfully incorporated this crucial element, many other studies are limited by their exclusive focus on postoperative symptoms. Hence, we aggregated studies that reported preoperative and postoperative symptoms prevalence and calculated its overall change (2,696 eyes). All studies showed a statistically significant decrease in the prevalence of symptoms, with the greatest change observed in double vision and starburst. When considering only the overall postoperative prevalence of moderate-to-severe symptoms, night driving difficulty (3.91%) and light sensitivity (5.02%) were the most frequent, but also showed reduction in prevalence after surgery. In the PROWL studies,[2] although the overall prevalence of visual symptoms decreased, a large percentage of participants reported new visual symptoms after surgery, which was more related to dry eye severity than with optical HOAs.

Overall dry eye incidence was 8.53%, with 1.29% reporting severe dry eye. These findings align with prior studies (from 8.3% to 48.0%).[108-110] However, unlike earlier studies that associated LASIK with worsening in dry eye, our findings show that dry eye significantly improved postoperatively in two of four studies, whereas the remaining two found a non-significant change. Among studies reporting moderate-to-severe dry eye prevalence changes, four noted reductions (3% to 17.6%) and two observed increases (2.1% to 6%). Discrepancies may arise from varying dry eye assessment methods, diagnostic criteria, follow-up durations, and baseline dry eye prevalence, particularly among contact lens users.[2,27,111] In the PROWL studies, 59% of patients experienced symptom resolution, whereas 27% developed new symptoms, with 4% and 6% developing severe dry eye.[2] These results all together suggest that the impact of LASIK on dry eye could be less significant currently than it was in the past, probably related to a better vigilance and treatment aggressiveness before and after surgery. Given the nature of articles reviewed for this analysis, we were unable to capture meaningful data on long-term complications such as postoperative ectasia.[112]

Because patient satisfaction is influenced by postoperative binocular UDVA, visual disturbance severity, dry eye symptoms, and their impact on daily life activities, we aggregated studies that evaluated the patient answer to strategic questions that could include those concepts. Only five studies reported the prevalence of surgery satisfaction, and four described the prevalence of debilitating symptoms. We found that 63.39% of patients were highly satisfied with LASIK, higher than reported by Sandoval et al[3] (46.4%). The overall satisfaction rate was 92.6%, slightly lower than the PROWL study's findings (96.2%).[2] The largest study in our review, including 2,530 patients with five years of follow-up, reported a 91% satisfaction rate.[57] Although this duration suggests LASIK satisfaction is sustained long term, the extended evaluation may be influenced by memory bias, potentially affecting responses.

The main limitation in our review was the lack of standardized methods on reporting subjective outcomes, such as visual disturbance, dry eye, and patient satisfaction. Despite our effort, we found few studies that could be aggregated. Furthermore, most studies did not include preoperative data on visual symptoms and dry eye, which limited our ability to fully assess the impact of LASIK on visual quality. Finally, the absence of raw data constrained some statistical comparisons, especially between TG-LASIK and other myopic ablation treatments. Future research should focus on uniform reporting to provide a more comprehensive understanding of LASIK outcomes. Conducting a meta-analysis, rather than a narrative review, could enable the use of more robust statistical methods to address study heterogeneity.

CONCLUSION

This review confirms LASIK's high efficacy, accuracy, and safety, with TG-LASIK showing particularly favorable outcomes. Although visual symptoms generally decrease postoperatively, some patients may experience new or worse disturbances. Dry eye prevalence remains stable or reduces in many cases, likely due to improved perioperative management. Finally, patient satisfaction with LASIK is high and endures long term, but clear patient counseling on potential visual symptoms and outcomes is essential for optimizing satisfaction after surgery.

AUTHOR CONTRIBUTIONS

Study concept and design (MRS, JBR); data collection (BNS, NM); analysis and interpretation of data (BNS, JBR); writing the manuscript (BNS, NM, JBR);

critical revision of the manuscript (BNS, MRS, JBR); statistical expertise (MRS); supervision (JBR)

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Table A
References Used for Aggregated Analysis

Category (Number of References)	Citation Number	Outcomes analyzed
Myopia Group (n=38)	7, 17, 20, 21, 29, 30, 35, 36, 38, 42-44, 48, 51, 53, 56, 58, 60, 63, 68, 69, 71, 74, 78, 79, 81, 82, 86, 88-90, 92, 93, 96, 98, 99, 101, 104	At least one of the following outcomes: Pre-op CDVA, post-op UDVA, changes in pre-op CDVA and pos-op UDVA, changes in pre- and post-op CDVA, accuracy from the target SE, post-op astigmatism.
Hyperopia Group (n=9)	16, 40, 75-77, 85, 100, 102, 103	
Topo-guided Treatment Group (=27)	15, 18, 20, 36, 37, 47, 54-56, 59, 61, 63-66, 69-71, 78, 80, 83, 84, 87, 89, 94, 98, 101	
Objective Complications (n=24)	1, 19, 23-26, 28, 33, 34, 41, 46, 47, 62, 67, 72-74, 76, 81, 91, 93, 97, 99, 103	Intraoperative flap complications, epithelial ingrowth, flap folds, flap dislocation, inflammatory or infectious keratitis, post-operative IOP increase, haze, melting, and TLSS
Visual Symptoms (n=11)	1, 2, 14, 31, 39, 47, 50, 52, 57, 62, 70	Glare, halos, starburst, visual fluctuation, double vision, light sensitivity, difficulty driving at night, and pain.
Patient Satisfaction (n=6)	1, 2, 31, 43, 56, 57	Studies reporting answers to the following questions: 1.How satisfied are you with your surgery? (Very satisfied/ satisfied/ neither/ dissatisfied/ very dissatisfied) 2.Would you recommend it to a friend? (Yes/No) 3.Would you undergo the procedure again? (Yes/No) 4.Do you experience debilitating difficulty in any activities due to visual symptoms? (Yes/No)
Dry Eye (n=12)	1, 2, 14, 22, 27, 32, 47, 70, 72, 76, 91	Dry eye assessed subjectively (e.g., via questionnaires) or objectively (e.g., superficial keratopathy)

CDVA = corrected distance visual acuity; IOP = intraocular pressure; Pre-op = preoperative; Post-op = postoperative; TLSS = transient light sensitivity syndrome; UDVA = uncorrected distance visual acuity

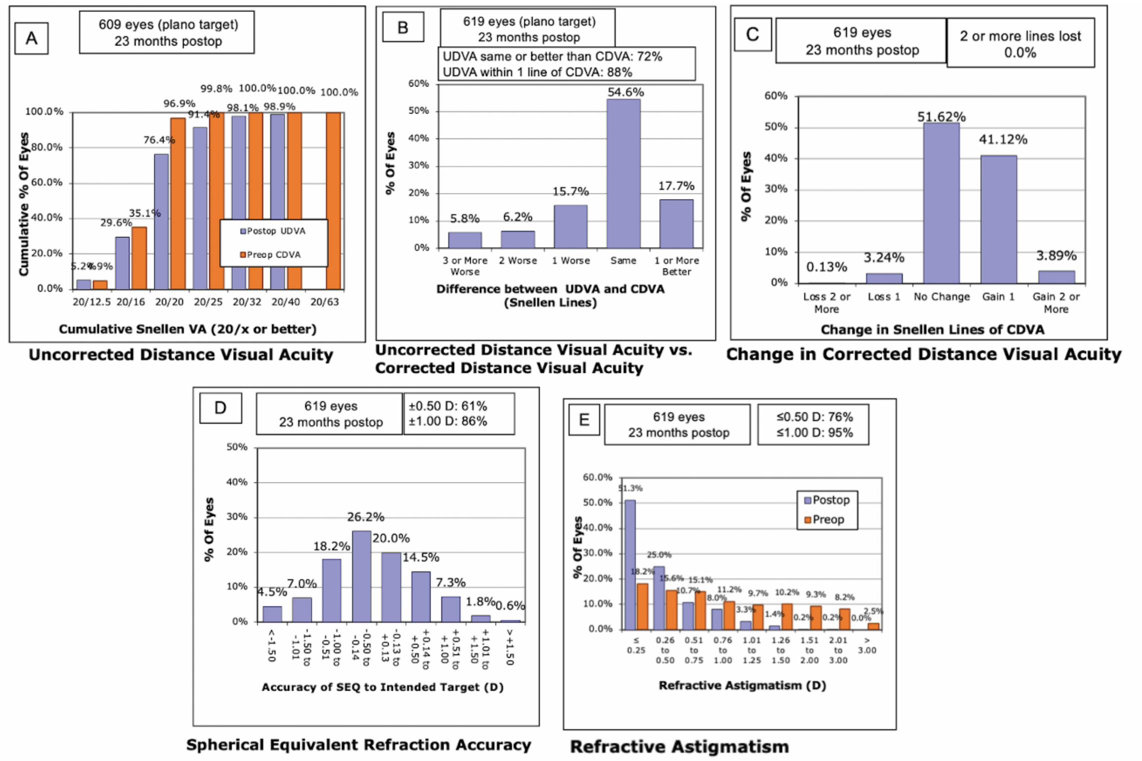

Figure A. Standard graphs for visual outcomes of laser in situ keratomileusis (LASIK) in studies including only high myopia. CDVA = corrected distance visual acuity; D = diopters; SEQ = spherical equivalent; UDVA = uncorrected distance visual acuity

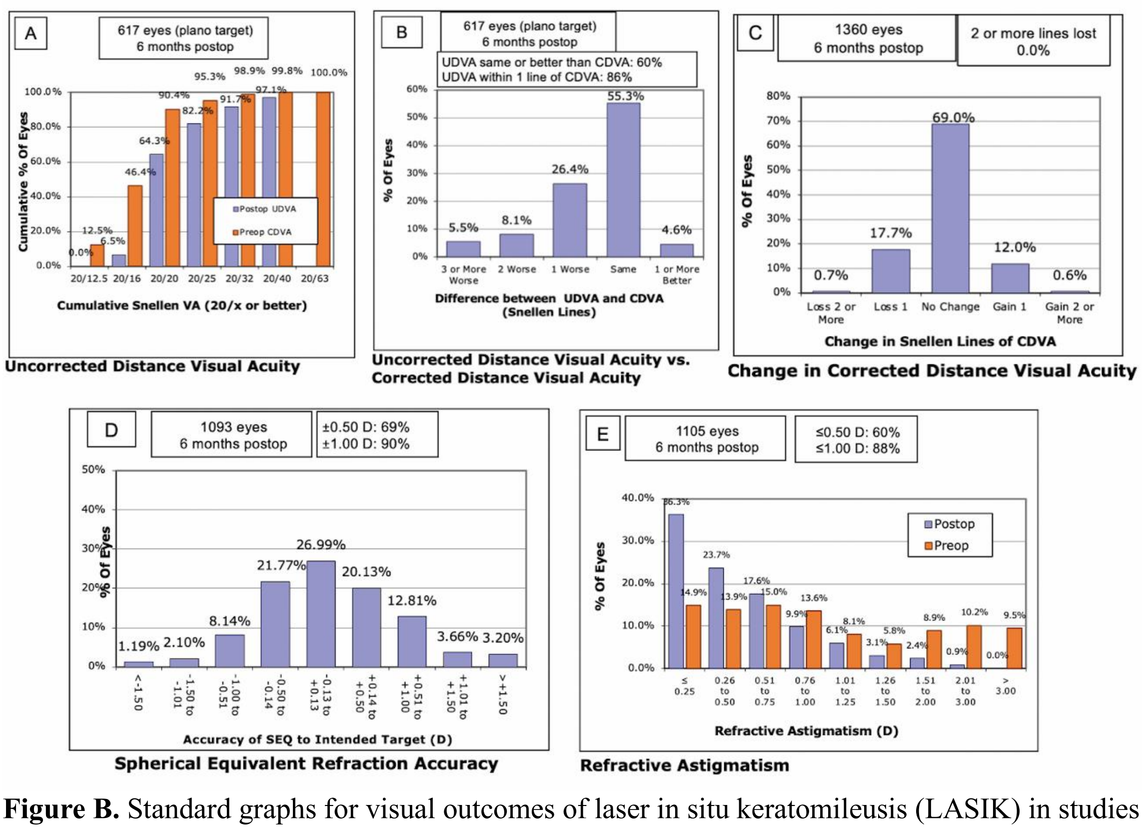

Figure B. Standard graphs for visual outcomes of laser in situ keratomileusis (LASIK) in studies including only high hyperopia. CDVA = corrected distance visual acuity; D = diopters; SEQ = spherical equivalent; UDVA = uncorrected distance visual acuity