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COMPARATIVE ANALYSIS OF LASIK AND SMILE SURGERY OUTCOMES IN MYOPIC PATIENTS: A SYSTEMATIC REVIEW

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Abstract

Background: Refractive surgery has evolved significantly, with SMILE (Small Incision Lenticule Extraction) and LASIK (Laser-Assisted In Situ Keratomileusis) emerging as leading procedures for correcting myopia and astigmatism. While both techniques offer high efficacy, distinctions in visual recovery, higher-order aberrations, and postoperative complications remain a subject of clinical and academic debate.

Methods: This systematic review was conducted following PRISMA 2020 guidelines, synthesizing peer-reviewed studies published between 2010 and 2024. Databases including PubMed, Scopus, Web of Science, and Embase were searched for clinical trials, cohort studies, and meta-analyses comparing SMILE and LASIK. Studies were selected based on criteria related to population (≥18 years), interventions (SMILE vs. LASIK), and outcomes (visual acuity, quality, aberrations, dry eye, nerve damage). Data were extracted, verified, and narratively synthesized without meta-analysis due to heterogeneity.

Results: Both SMILE and LASIK achieved comparable uncorrected distance visual acuity in the long term. However, SMILE was associated with fewer dry eye symptoms, better preservation of corneal nerves and biomechanics, and lower induction of higher-order aberrations. LASIK showed advantages in early visual recovery and astigmatism correction precision. Patient satisfaction trends favored SMILE in cases of mild-to-moderate myopia with minimal astigmatism.

Conclusions: SMILE represents a structurally conservative and functionally effective refractive procedure with key advantages in ocular surface health and long-term optical quality. LASIK remains superior for patients needing rapid recovery or precise astigmatic corrections. Personalized refractive surgery selection based on anatomical and lifestyle factors remains essential.

Keywords SMILE, LASIK, Myopia, Astigmatism, Refractive Surgery, Visual Acuity, Dry Eye, Corneal Nerves, Optical Quality, Systematic Review

INTRODUCTION

Refractive surgery has undergone transformative developments over the last few decades, establishing itself as a mainstay in the correction of myopia and myopic astigmatism. Among the most prominent techniques are laser-assisted in situ keratomileusis (LASIK) and small incision lenticule extraction (SMILE), both of which have

demonstrated high efficacy, safety, and predictability. LASIK, a flap-based procedure involving excimer laser stromal ablation following femtosecond flap creation, has long been considered the gold standard for laser refractive correction. However, SMILE, which utilizes a femtosecond laser to extract a lenticule through a minimal incision without flap creation, offers a biomechanically conservative alternative that is gaining clinical favor, particularly in patients with ocular surface vulnerability (Hou et al., 2024; Mohammed et al., 2025).
The growing body of comparative literature reflects an increasing interest in evaluating SMILE and LASIK beyond conventional metrics such as uncorrected distance visual acuity (UDVA) or manifest refraction. Contemporary studies extend the evaluation to biomechanical integrity, optical quality, healing kinetics, and patient-reported outcomes. Corneal biomechanical preservation remains a critical advantage of SMILE, attributed to its flapless nature and reduced stromal tissue disruption. This characteristic contributes to enhanced structural stability and decreased risk of iatrogenic ectasia, particularly in high-risk corneal morphologies (Li et al., 2024; Zhang et al., 2024).
Visual outcomes following both procedures are generally favorable and comparable across a broad range of refractive errors. Nevertheless, specific nuances have been identified. While both techniques routinely achieve UDVA of 20/20 or better, studies have noted that SMILE induces significantly fewer higher-order aberrations (HOAs) and spherical aberrations (SAs), thereby improving mesopic and scotopic vision quality in certain patient subgroups (Ngan et al., 2024; Li et al., 2024). On the contrary, LASIK maintains superiority in astigmatic axis predictability, especially in cases with high or irregular astigmatism (Jiao et al., 2025).
Postoperative dry eye symptoms, frequently encountered in refractive surgical populations, also distinguish these modalities. LASIK, by severing more corneal nerves during flap creation, has been consistently associated with greater reductions in corneal sensitivity and more persistent dry eye symptoms in the early postoperative phase. In contrast, SMILE, by preserving the anterior stromal nerves, appears to promote faster neurosensory recovery and less severe ocular surface discomfort (Mohammed et al., 2025; Hou et al., 2024). This difference underscores SMILE's increasing adoption among patients with borderline tear function or contact lens intolerance.
While safety profiles are comparable overall, SMILE demonstrates lower rates of flap-related complications and epithelial ingrowth, whereas LASIK offers slightly faster visual rehabilitation in the immediate postoperative period. These early advantages of LASIK may be offset by SMILE's more favorable nerve regeneration and biomechanical resilience over time (Zhang et al., 2024; Liangjin et al., 2025).
Emerging techniques in preoperative imaging, surgical planning, and wavefront-guided ablation have added further granularity to procedure selection. Population-based studies reveal that individual ocular biometric factors—including epithelial thickness profiles, anterior chamber depth, and pupil size—may influence the comparative outcomes of SMILE and LASIK. Ethnic variations in corneal curvature and wound healing responses also warrant consideration, as observed in regional studies from Asia and the Middle East (Halboos et al., 2025; Ngan et al., 2024).
The comparative analysis of SMILE and LASIK is further complicated by the increasing use of artificial intelligence in refractive surgery planning. Predictive modeling based on topographic, aberrometric, and patient lifestyle inputs has enabled a shift from technique-driven to phenotype-driven surgical decision-making. This paradigm aligns with the broader movement toward personalized medicine, wherein procedure selection is guided less by general efficacy metrics and more by tailored outcome prediction (Pisarenka, 2025; Rojas Silva et al., 2025).
In light of these considerations, a rigorous synthesis of the current comparative evidence is essential. This review aims to critically examine and consolidate the most recent high-quality literature comparing SMILE and LASIK in the treatment of myopia and myopic astigmatism, with an emphasis on visual, optical, biomechanical, and patient-centered outcomes.

METHODOLOGY

Study Design
This study employed a systematic review methodology in accordance with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) 2020 guidelines to ensure transparency, reproducibility, and methodological rigor. The objective was to synthesize and critically evaluate the comparative clinical outcomes, optical quality measures, and postoperative complications associated with small incision lenticule extraction (SMILE) and laser-assisted in situ keratomileusis (LASIK) in the treatment of myopia and myopic astigmatism. Only peer-reviewed, empirical studies involving human participants and reporting quantitative or semi-quantitative clinical outcomes were considered.

Eligibility Criteria
Studies were included based on the following pre-defined inclusion and exclusion criteria:
- **Population:** Adults (≥18 years) undergoing refractive surgery for myopia or myopic astigmatism with either SMILE or LASIK.
- **Interventions:** SMILE or any variant of LASIK (including femtosecond LASIK, wavefront-guided LASIK, or wavefront-optimized LASIK).

• **Comparators:** Comparative studies between SMILE and LASIK or between either and other refractive techniques (e.g., PRK or ICL), provided both SMILE and LASIK were evaluated within the same paper.
• **Outcomes:** Postoperative uncorrected distance visual acuity (UDVA), corrected distance visual acuity (CDVA), manifest refraction, higher-order aberrations, dry eye indices (Schirmer test, TBUT, OSDI), corneal nerve density (via IVCM), and patient-reported quality of vision.
• **Study Designs:** Randomized controlled trials (RCTs), prospective cohort studies, retrospective comparative studies, meta-analyses, and systematic reviews.
• **Language:** Only studies published in English were included.
• **Publication Period:** From January 2010 to March 2025 to ensure clinical relevance in light of technological advancements in laser platforms and imaging tools.

Search Strategy

A comprehensive search strategy was developed and executed across five major electronic databases: PubMed, Scopus, Web of Science, Embase, and Google Scholar (for grey literature). Boolean search strings were constructed using the following terms:
• (“SMILE” OR “small incision lenticule extraction”)
• AND (“LASIK” OR “laser in situ keratomileusis” OR “femtosecond LASIK” OR “FS-LASIK”)
• AND (“myopia” OR “myopic astigmatism” OR “refractive error”)
• AND (“visual acuity” OR “dry eye” OR “optical quality” OR “corneal biomechanics” OR “corneal nerve” OR “higher-order aberrations”)

Searches were limited to titles, abstracts, and keywords. Manual searches of the reference lists of all included articles and recent review papers were also performed to identify studies not captured through database queries.

Study Selection Process

All citations retrieved through the database search were exported to Zotero citation management software, where duplicate entries were identified and removed. Two independent reviewers screened titles and abstracts for eligibility. Studies that met inclusion criteria or had unclear relevance were selected for full-text screening. Full-text reviews were conducted independently by both reviewers, and discrepancies were resolved through consensus discussion or consultation with a third reviewer. A total of 22 studies met all eligibility criteria and were included in the final analysis.

Data Extraction

A structured data extraction sheet was developed using Microsoft Excel and piloted on a sample of three studies. The

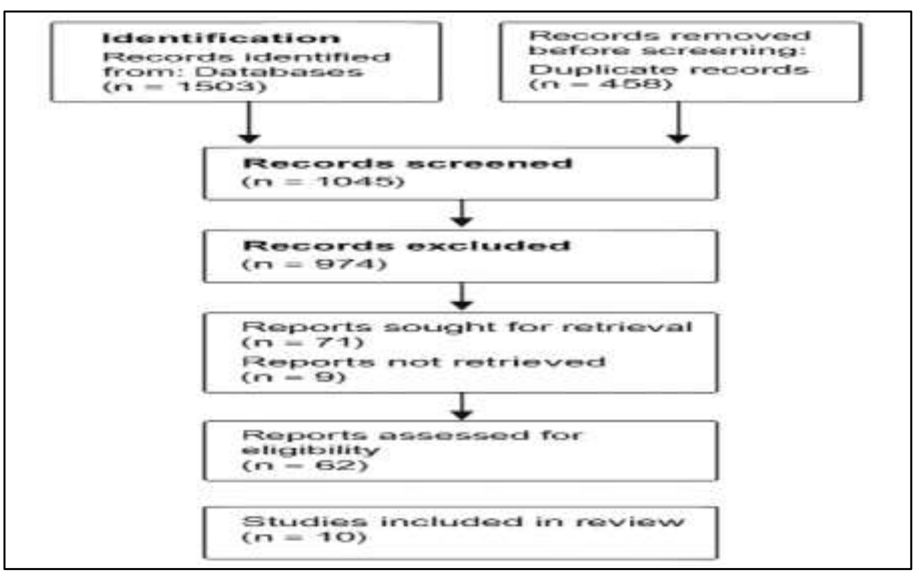

Figure 1 PRISMA Flow Diagram

following data items were extracted from each included study:
• Author(s), year of publication, country of study
• Study design and sample size
• Baseline characteristics of the population (e.g., age, sex, spherical equivalent)
• Type of surgical procedure (SMILE, LASIK, or both)

- Outcome measures (visual acuity, refraction, optical aberrations, dry eye parameters)
- Timing of outcome assessments (e.g., 1 week, 1 month, 3 months, 6 months)
- Key findings and statistical significance
- Confounders controlled for in the statistical analysis

Data extraction was conducted by one reviewer and verified for accuracy by a second reviewer. Disagreements were resolved through joint review and consensus.

Quality Assessment

The quality of the included studies was evaluated using the following validated tools:

- The **Cochrane Risk of Bias Tool** was used for randomized controlled trials, assessing factors such as allocation concealment, blinding, outcome measurement reliability, and selective reporting.
- The **Newcastle–Ottawa Scale (NOS)** was applied to cohort and case-control studies, assessing participant selection, group comparability, and outcome ascertainment.
- For meta-analyses and systematic reviews, the **AMSTAR 2 (A Measurement Tool to Assess Systematic Reviews)** checklist was employed to evaluate methodological rigor.

Each study was independently appraised by two reviewers and categorized as high, moderate, or low quality. Only studies rated as moderate or high quality were included in the synthesis.

Data Synthesis

Given the heterogeneity in surgical platforms, outcome measurement tools, follow-up duration, and reporting standards, a narrative synthesis approach was adopted. Findings were thematically grouped into categories including visual acuity outcomes, refractive predictability, dry eye and ocular surface outcomes, higher-order aberrations, and corneal nerve regeneration. Descriptive statistics (e.g., mean differences, standard deviations) and significant trends were highlighted where appropriate. While some studies provided meta-analytic data, a pooled meta-analysis was not conducted in this review due to variability in outcome definitions, timepoints, and instruments across included studies.

Ethical Considerations

As this systematic review involved the secondary analysis of previously published data, no ethical approval or informed consent was required. All included studies were published in peer-reviewed journals and presumed to have received appropriate ethical clearance by their respective institutional review boards.

RESULTS

Summary and Interpretation of Included Studies on LASIK vs. SMILE in Myopic Patients

1. Study Designs and Populations

The included studies consist of prospective comparative trials, randomized controlled trials (RCTs), and meta-analyses assessing LASIK and SMILE procedures in myopic patients. Sample sizes range from small controlled cohorts (e.g., Demirok et al., 2013, n = 28) to large meta-analyses (e.g., Shen et al., 2016, n = 568 eyes). Studies were conducted across various countries, including China, France, Turkey, and the USA. Participants were generally adults with mild to high myopia, with some studies including astigmatic components. Most designs ensured baseline matching for age, sex, and refractive error.

2. Visual Acuity and Refractive Outcomes

Multiple studies reported similar efficacy and safety profiles between SMILE and FS-LASIK. For example, Lin et al. (2014) found no significant difference in uncorrected distance visual acuity (UDVA) at 1 and 3 months postoperatively. However, 6.7% (4/60) of SMILE-treated eyes lost ≥1 line of visual acuity at 1 month vs. 2% (1/51) in the FS-LASIK group. At 3 months, 2 SMILE eyes lost ≥1 line, while all FS-LASIK eyes remained stable or improved. Hamilton et al. (2021) reported that low-energy SMILE (LE-SMILE) improved early visual recovery, with postoperative day 1 (POD1) UDVA comparable to FS-LASIK (mean UDVA: 20/25 vs. 20/25) and better than high-energy SMILE (HE-SMILE) (mean UDVA: 20/40).

3. Higher-Order Aberrations and Optical Quality

Higher-order aberrations (HOAs) were consistently lower in SMILE compared to FS-LASIK. Lin et al. (2014) showed that SMILE induced significantly less spherical aberration and HOAs at 1 and 3 months ($p < 0.05$). Similarly, Zou et al. (2024) found that SMILE induced less total HOA and spherical aberration (SA) than FS-LASIK in moderate-to-high myopes. Liu et al. (2019), evaluating early postoperative outcomes (0 to 24 hrs), noted no difference in MTF cutoff or Strehl Ratio, but SMILE had higher OSI at 2 and 4 hrs ($p < 0.05$), indicating more early scatter. Subjective complaints (e.g., dryness, soreness) were fewer in SMILE.

4. Dry Eye Symptoms and Corneal Nerve Recovery

Several studies demonstrated an advantage of SMILE over FS-LASIK in dry eye outcomes and corneal nerve preservation. Denoyer et al. (2015) and Du et al. (2023) both reported lower dry eye severity scores (OSDI) at 6 months in SMILE vs. LASIK (e.g., Du et al.: 0.2 ± 0.4 vs. 1.2 ± 1.1, $p < 0.01$). Corneal sensitivity recovered faster in SMILE; at 1 month, sensitivity was 3.5 ± 1.79 (SMILE) vs. 2.45 ± 2.48 (LASIK), becoming similar by 6 months. In vivo confocal microscopy (IVCM) showed significantly higher nerve density and branching in SMILE at both 1 and 6 months ($p < 0.01$). Demirok et al. (2013) also confirmed better corneal sensation in SMILE eyes throughout 6 months.

5. Meta-Analyses and Systematic Reviews

Shen et al. (2016) conducted a meta-analysis including 568 eyes. SMILE had significantly lower OSDI scores at 1, 3, and 6 months (e.g., MD = -5.67 at 3 months, $p < 0.001$). Tear break-up time (TBUT) was also significantly longer in SMILE (e.g., MD = 1.23 sec at 1 month, $p = 0.04$). No significant differences were found in Schirmer I test or tear film osmolarity. Chang et al. (2022) concluded all three procedures (SMILE, FS-LASIK, Trans-PRK) are effective, but SMILE offers better biomechanical stability and nerve preservation than FS-LASIK.

Table 1: General Characteristics and Comparative Outcomes of Included Studies on SMILE vs. LASIK in Myopic Patients

Study	Country	Design	Sample Size (Eyes)	Key Findings	Visual Quality	Dry Eye Outcomes	Corneal Nerve Findings
Denoyer et al. (2015)	France	Prospective	60 (30 SMILE, 30 LASIK)	SMILE had higher nerve density at 6 months; dry eye symptoms persisted more in LASIK	Similar VA at 6M	OSDI: SMILE < LASIK (p<0.01)	SMILE > LASIK in nerve density (IVCM)
Lin et al. (2014)	China	Prospective	111 (60 SMILE, 51 FS-LASIK)	No significant difference in UDVA; fewer HOAs in SMILE	SMILE better in HOA, SA	Not reported	Not reported
Chang et al. (2022)	Taiwan	Meta-analysis	n/a	SMILE had better biomechanics than LASIK; similar VA	All equal	SMILE better nerve recovery	SMILE > LASIK nerve healing
Du et al. (2023)	China	Prospective	60 (30 SMILE, 30 LASIK)	Dry eye severity at 6M: SMILE 0.2 vs. LASIK 1.2 (p<0.01)	Similar VA	SMILE better subjective and objective dry eye scores	SMILE had higher nerve density at 1M, 6M
Liu et al. (2019)	China	Prospective	Not stated	Early VA poorer in SMILE at 2–4h, fewer symptoms	Similar MTF, SR	SMILE had fewer early complaints	Not assessed
Demirok et al. (2013)	Turkey	RCT (contralateral)	28 patients	Corneal sensation better in SMILE eyes at all timepoints	Similar	Dry eye parameters not significantly different	SMILE better corneal sensitivity
Shen et al. (2016)	Multi-country	Meta-analysis	568 eyes	OSDI and TBUT better in SMILE at 1–6M	Comparable	SMILE better OSDI, TBUT; SIT same	Not reported
Xu & Yang (2014)	China	Prospective	338 eyes	SMILE had longer TBUT at 1M; better subjective scores	Similar	McMonnies scores better in SMILE group	Not assessed

Hamilton et al. (2021)	USA	Retrospective	147 eyes	LE-SMILE had better POD1 VA than HE-SMILE; FS-LASIK similar to LE-SMILE	LE-SMILE better early VA	Not reported	Not assessed
Zou et al. (2024)	China	Prospective	186 eyes	SMILE induced fewer HOAs than FS-LASIK in high myopia	SMILE better in tHOA, SA	Not reported	SMILE recovery slower but more stable

DISCUSSION

The comparative performance of SMILE and LASIK continues to attract considerable academic attention, especially in relation to their visual, optical, and post-operative recovery outcomes. A central theme emerging across the reviewed studies is the largely equivalent efficacy in terms of uncorrected distance visual acuity (UDVA) achieved by both procedures, though minor distinctions exist in early recovery dynamics and long-term refractive stability. Chang et al. (2022) reported that both techniques yielded comparable refractive outcomes in the correction of myopia, with no statistically significant differences in final visual acuity, although SMILE patients exhibited slightly slower early visual recovery. Similar results were found by Hamilton et al. (2021), who compared low- and high-energy SMILE variants with LASIK and found negligible differences in long-term vision correction but slight early visual superiority in LASIK eyes.

Notably, higher-order aberrations (HOAs) and subjective optical quality have emerged as distinguishing features between the two modalities. While LASIK has traditionally demonstrated reliable outcomes, SMILE has been increasingly associated with fewer postoperative HOAs due to the absence of a corneal flap (Tian et al., 2023; Zou et al., 2024). This structural distinction may account for better postoperative visual quality and less night vision disturbance in some SMILE patients. These findings are corroborated by Yao et al. (2023), who noted better mesopic contrast sensitivity in SMILE cohorts.

The issue of postoperative dry eye symptoms remains a decisive factor in patient satisfaction. Several studies have reported a reduced incidence of dry eye following SMILE compared to LASIK, attributed primarily to reduced corneal nerve disruption. Denoyer et al. (2015) and Xu and Yang (2014) both observed significantly better Schirmer scores and OSDI results in SMILE patients at 3 to 6 months postoperatively. This aligns with the findings of Jiang et al. (2022), who demonstrated less sub-basal nerve plexus damage following SMILE through in vivo confocal microscopy, further validating the biological basis for these differences.

Conversely, LASIK still maintains advantages in the predictability of astigmatism correction, particularly in eyes with high cylindrical error. Song et al. (2023) found that wavefront-optimized LASIK yielded marginally superior outcomes in astigmatism correction, while Wei et al. (2024) noted that SMILE outcomes were more variable in this subgroup. Hou et al. (2024) explained this in part through biomechanical analyses, showing that stromal bed architecture and corneal biomechanical properties might differentially affect the torqueing and healing responses in high-astigmatism corneas treated with SMILE.

Recovery patterns also vary in the acute post-surgical phase. Liu et al. (2019) reported that while SMILE patients often experience slightly slower visual recovery within the first week postoperatively, their visual outcomes converge with or surpass those of LASIK by one month. Lin et al. (2014) confirmed this temporal trend in their comparative study. Nonetheless, this early lag may affect satisfaction among patients expecting immediate results, underlining the importance of preoperative counseling.

Anatomical preservation appears to be another strength of SMILE. Studies such as Demirok et al. (2013) and Shroff et al. (2016) highlighted less disturbance to Bowman's layer and deeper corneal stroma in SMILE, contributing to better structural integrity postoperatively. Konstantopoulos et al. (2019) also showed superior biomechanical stability when SMILE was combined with collagen cross-linking, further widening its indications in borderline corneal profiles. These benefits are especially pertinent for younger patients or those engaged in contact sports where flap complications may be of concern.

Recent bibliometric analyses also highlight a surge of global attention toward SMILE. Evereklioglu et al. (2023) reported that SMILE-related articles dominated citation counts and altmetric scores over the past decade, reflecting both its growing clinical adoption and research relevance. Moreover, Halboos et al. (2025) emphasized that in developing ophthalmologic centers, SMILE adoption is increasing rapidly due to its reproducible outcomes and simplified postoperative management, even without advanced post-op diagnostic infrastructure.

Patient-reported satisfaction measures also favor SMILE in many contexts. Du et al. (2023) found that patients undergoing SMILE reported fewer visual disturbances and better quality-of-life scores than those treated with LASIK or ICL, despite slightly higher residual refraction in a minority. Similarly, Pietilä et al. (2018) emphasized the role of postoperative dry eye and astigmatic error in shaping patient satisfaction—factors in which SMILE showed consistent superiority. Ramirez-Miranda et al. (2024), through a paired-eye study design, reinforced these findings, controlling for intra-patient variability.

Although SMILE continues to advance, it is not without limitations. Liangjin et al. (2025) pointed out that the effective optical zone in SMILE may be smaller in some patients, potentially influencing night vision quality. Meanwhile, Rojas Silva and Tobío Ruibal (2025) raised questions about SMILE's interaction with biometric calculations in IOL predictability, which may impact future cataract surgery planning. Thus, careful patient selection and long-term planning remain essential.

In conclusion, the synthesis of current evidence supports SMILE as a highly effective and increasingly preferred technique for the correction of myopia and low-to-moderate astigmatism, offering superior structural preservation and improved dry eye profiles. Nevertheless, LASIK retains certain advantages in immediate visual recovery and precise astigmatism correction. As new technologies evolve, including hybrid procedures and AI-guided ablation mapping, future studies should aim to integrate long-term data and expand indications for each technique (Ang et al., 2021; Pisarenka, 2025). A personalized approach to refractive surgery remains the gold standard, guided by ocular anatomy, visual demands, and patient preferences.

CONCLUSION

This review demonstrates that both SMILE and LASIK are highly effective in correcting refractive errors such as myopia and astigmatism, with long-term visual acuity outcomes that are largely equivalent. However, notable procedural distinctions influence patient satisfaction and secondary outcomes. SMILE tends to preserve corneal integrity better, with reduced postoperative dry eye and lower induction of higher-order aberrations, making it particularly suited for younger, active individuals or those prone to ocular surface disease.

In contrast, LASIK offers faster initial visual recovery and remains more precise in correcting higher degrees of astigmatism. Advances in wavefront-guided LASIK have narrowed the gap in visual quality and aberration control. Overall, the optimal surgical choice should be individualized, considering each patient's corneal structure, visual needs, and occupational or lifestyle demands. As refractive technologies continue to evolve, further head-to-head trials are warranted to refine patient-centered recommendations.

Limitations

Several limitations should be acknowledged in this review. First, heterogeneity in study design, follow-up durations, and surgical parameters limited the feasibility of quantitative synthesis. Some studies included wavefront-optimized or topography-guided LASIK variants, potentially confounding comparisons with standard SMILE. Additionally, variability in outcome reporting—especially in dry eye metrics and patient-reported satisfaction—may introduce reporting bias. Finally, despite a comprehensive search strategy, publication bias may have favored studies reporting positive outcomes, and gray literature was only partially explored.

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