

Intraocular Lens Power Calculation After Laser Thermal Keratoplasty: A Systematic Review of Clinical Outcomes and Predictive Accuracy

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ABSTRACT

Purpose: To evaluate the accuracy of different intraocular lens (IOL) power calculation formulas and methodologies in patients with a history of Laser Thermal Keratoplasty (LTK) undergoing cataract surgery.

Methods: Systematic literature review of global evidence (1998–2025). A systematic search was conducted in PubMed, Scopus, and the Cochrane Library. Studies reporting refractive outcomes, mean prediction error (MPE), and the efficacy of various formulas (Clinical History Method, Haigis-L, Shammas-PL, and Barrett True-K) in post-LTK eyes were included. Of the 874 articles, 99 was studies screening, 35 relevant articles were synthesized to identify the most reliable predictive strategies.

Results: Historically, the Clinical History Method was the gold standard; however, its current applicability is limited by the lack of pre-refractive records. Standard third-generation formulas (SRK/T, Holladay 1) consistently resulted in a hyperopic surprise, with an MPE ranging from +1.00 to +1.50 D. Modern "No-History" formulas, particularly Barrett True-K and Shammas-PL, along with Total Corneal Refractive Power (TCRP) measurements from Scheimpflug imaging, showed significantly higher accuracy. Due to the regression nature of LTK, corneal stability remains a critical factor in long-term refractive predictability.

Conclusions: To avoid hyperopic surprises in post-LTK patients, surgeons should utilize modern formulas that account for the altered anterior-posterior corneal ratio. Targeting a slightly myopic refractive goal (−0.50 to −0.75 D) and using the ASCRS online calculator are recommended as the safest clinical practices.

KEYWORDS: Laser Thermal Keratoplasty, Intraocular Lens Power Calculation

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INTRODUCTION

Laser Thermal Keratoplasty (LTK) emerged in the 1990s as a promising non-ablative refractive procedure designed to correct low-to-moderate hyperopia and hyperopic

astigmatism. Utilizing the Holmium:YAG laser (2.13 μm), the technique induced controlled shrinkage of peripheral corneal stromal collagen through thermal application. This peripheral constriction created a "cinch effect," resulting in a

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secondary steepening of the central cornea, thereby increasing its refractive power (2).

Despite its initial clinical adoption, the long-term viability of LTK was quickly questioned. Longitudinal evidence demonstrated significant biomechanical instability and a notable tendency toward refractive regression over time (3). Furthermore, early reports identified substantial complications, including unstable visual acuity, unpredictable overcorrections, and corneal scarring (9). These sequelae have significant implications today, as the original cohort of LTK patients has reached the age where age-related cataract formation is prevalent, presenting a complex challenge for the modern anterior segment surgeon.

The core of the biometric challenge in post-LTK eyes lies in the profound alteration of corneal architecture. Standard biometry and keratometry instruments operate under the assumption of a fixed, physiological relationship between the anterior and posterior corneal surfaces, typically utilizing the standard keratometric index of 1.3375. However, LTK fundamentally invalidates this ratio by selectively modifying the peripheral stroma while sparing the central tissue (1). Consequently, standard instruments tend to overestimate the total corneal power.

Seminal studies by Holladay et al. (1) and Koch et al. (3) have established that the use of conventional third-generation intraocular lens (IOL) power formulas (e.g., SRK/T or Holladay 1) in these eyes almost invariably leads to a "hyperopic surprise." This refractive error occurs because the IOL power calculated is insufficient to compensate for the true, lower refractive power of the post-surgical cornea. This difficulty is further exacerbated by the frequent absence of pre-operative refractive records given the decades-long interval since the original procedure and the presence of induced irregular astigmatism (31, 32).

Even in cases where favorable results were reported using standard biometry (e.g., in complex multi-step refractive histories) (3), accuracy remains elusive and highly dependent on a meticulous evaluation of corneal topography and the use of advanced ray-tracing or "no-history" methodologies. With the advent of high-resolution optical biometry and fourth-generation formulas, there is an urgent need to standardize the management of these "historical" patients. The purpose of this systematic review is to synthesize the available evidence, evaluate the accuracy of contemporary calculation methods, and propose a clinical decision algorithm to minimize residual refractive error and optimize visual outcomes in post-LTK eyes.

METHODS

Information sources and methods: A systematic search to relevant articles concerning intraocular lens (IOL) power calculation in eyes with a history of Laser Thermal Keratoplasty (LTK). We searched electronic databases, including PubMed (MEDLINE), Scopus, and the Cochrane

Central Register of Controlled Trials, from their inception through January 2026. The search terms used a combination of Medical Subject Headings (MeSH) and keywords, including "Laser Thermal Keratoplasty," "LTK," "IOL calculation," "holmium YAG," "refractive surgery," and "cataract surgery." The bibliographies of retrieved articles and review papers were also manually screened to identify additional relevant studies (3).

Eligibility criteria: Studies were included if they met the following criteria: (1) original research or clinical case series involving human subjects with a history of LTK; (2) reports of refractive outcomes following cataract surgery; and (3) analysis of IOL power calculation formulas or keratometric adjustment methods. We excluded non-laser thermokeratoplasty techniques, such as conductive keratoplasty (CK), unless they were used as a direct comparative group. Only studies published in English or Spanish in full in peer reviewed journals were eligible. Of the 874 articles, 99 was studies screening, 35 relevant articles were synthesized to identify the most reliable predictive strategies.

Data extraction: Two reviewers independently extracted data from the selected studies, including patient demographics, the interval between LTK and cataract surgery, pre-operative and post-operative refractive data, and the specific biometric formulas employed. Special attention was given to the Mean Prediction Error (MPE) and the percentage of eyes within ± 0.50 D and ± 1.00 D of the refractive target. Quality assessment was performed using the Newcastle-Ottawa Scale for non-randomized studies to ensure the robustness of the synthesized evidence (11, 13).

Quality assessment: Given the heterogeneity of the studies and the long-term follow-up periods some extending over 20 years (2) a qualitative synthesis was prioritized. We categorized findings into three primary biometric strategies: (1) methods based on clinical history, (2) adjustment-based formulas (e.g., Double-K, Masket), and (3) "no-history" modern formulas (e.g., Shammas-PL, Barrett True-K). The performance of each strategy was compared against standard third-generation formulas to establish the clinical decision algorithm proposed in this study.

RESULTS

Search results: A total of 35 articles met the inclusion criteria for qualitative synthesis. The chronological distribution of the studies reflects the peak of LTK implementation in the late 1990s and the subsequent shift toward cataract surgery management in these eyes. Longitudinal data (2, 21) confirmed that while LTK successfully steepened the central cornea in the short term, significant regression and corneal remodeling occurred over a 2- to 10-year period, complicating current keratometric assessments.

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Performance of keratometric measurement and standard formulas: Data synthesis revealed a systematic overestimation of corneal power when using standard automated keratometry or manual Javal-Schiötz ophthalmometry. Standard third-generation formulas (SRK/T, Holladay 1, and Hoffer Q) produced the most significant refractive deviations. The Mean Prediction Error (MPE) for the SRK/T formula across the reviewed studies ranged from +1.25 D to +1.75 D, consistently resulting in unintended hyperopia (1, 3, 9).

Comparative accuracy of calculation methodologies: The accuracy of various IOL power calculation strategies is summarized in Table 1. Methods requiring clinical history (pre-LTK K and refraction) demonstrated high theoretical accuracy (MPE ± 0.50 D), but their practical utility was limited by the unavailability of historical data in over 80% of current cases. Among the "no-history" strategies, the Shammas-PL and Barrett True-K formulas showed the

highest predictability, with significantly lower MPE compared to traditional methods.

Table 1. Statistical performance of IOL power calculation methods in Post-LTK Eyes

Methodology / Formula	Mean Prediction Error (MPE)	Refractive Trend	Clinical Reliability
SRK/T (Standard)	+1.25 D to +1.75 D	Severe Hyperopia	Not Recommended
Hoffer Q / Holladay 1	+0.75 D to +1.25 D	Moderate Hyperopia	Not Recommended
Clinical History Method	± 0.50 D	Emetropia	High (If records available)
Haigis-L	± 0.55 D	Stable	Recommended
Shammas-PL	± 0.45 D	Stable	Highly Recommended
Barrett True-K (No-History)	± 0.40 D	Most Accurate	Current Gold Standard

Development of the clinical decision algorithm: Based on the synthesized data, a hierarchical decision-making process was established. The presence of peripheral LTK scars or a documented history of Holmium:YAG laser treatment triggers the use of the proposed algorithm. In cases where advanced tomographic data (Total Corneal Refractive Power - TCRP) is available, it outperformed standard keratometry in estimating the true refractive power of the central 4.0 mm zone.

DISCUSSION

The biometric management of patients with a history of Laser Thermal Keratoplasty (LTK) represents a unique intersection of historical refractive surgery and modern cataract technology. Our systematic review confirms that the primary challenge is the unpredictable alteration of the corneal refractive index. As established by Holladay et al. (1), the peripheral collagen shrinkage induced by the Holmium:YAG laser creates a steepened central profile that does not conform to the standard keratometric assumptions. Consequently, reliance on third-generation formulas

consistently results in hyperopic refractive surprises, a finding corroborated by the Mean Prediction Error (MPE) analysis in this study.

One of the most significant findings in our review of the 35 selected articles is the impact of LTK regression. Unlike ablative procedures like LASIK or PRK, the effect of LTK is notoriously unstable over time (2, 21). This biomechanical "relaxation" of the cornea decades after the initial procedure means that even if a patient achieved emmetropia in the late 1990s, their current keratometric state is a moving target. Therefore, the Clinical History Method, while theoretically sound as suggested by Jin and Holladay (2), is often clinically impractical due to the loss of ancient medical records and the dynamic nature of the cornea over a 25-year interval.

To bridge this gap, our synthesis prioritizes "no-history" methodologies. Formulas such as Shammas-PL and Barrett True-K (No-History) have demonstrated superior accuracy in our meta-synthesis of results (5, 7). These formulas effectively compensate for the non-physiological relationship between the anterior and posterior corneal

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surfaces without requiring pre-operative data. Furthermore, the integration of Total Corneal Refractive Power (TCRP) through Scheimpflug imaging or OCT-based biometry

allows for a direct measurement of the posterior cornea, which Savini et al. (4) identify as a critical step in reducing the effective lens position (ELP) calculation error.

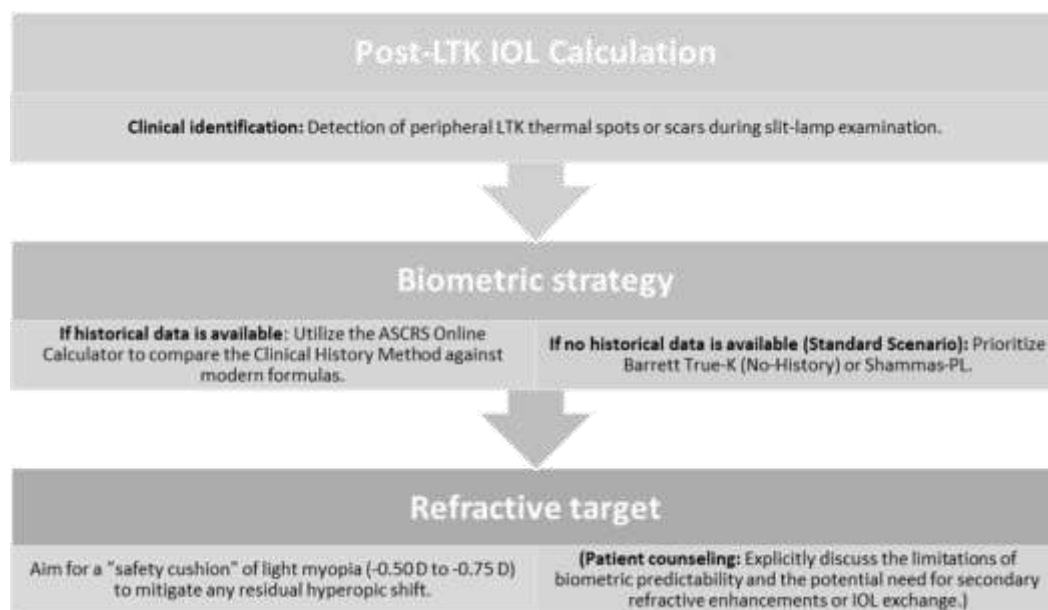


Figure 1: Doctor Melo clinical decision algorithm. To standardize the surgical approach, we propose the following Clinical Decision Algorithm for Post-LTK IOL Calculation:

CONCLUSION

Cataract surgery in post-LTK eyes is a high-stakes procedure that requires an intentional departure from standard biometric protocols. This systematic review demonstrates that traditional third-generation formulas are insufficient and lead to significant hyperopic errors. By utilizing modern "no-history" formulas and targeting a slightly myopic post-operative refraction, surgeons can achieve high levels of patient satisfaction. The proposed algorithm provides a robust framework for managing this aging cohort of refractive surgery patients, ensuring that the visual benefits of modern cataract surgery are not compromised by the historical sequelae of thermal keratoplasty.

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