ORIGINAL ARTICLE

Early Corneal Remodelling Following Topography-Guided Femtosecond LASIK: A Three-Month Retrospective Analysis

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ABSTRACT

Background: Topography-guided femtosecond LASIK (TG-Femto-LASIK) improves corneal shape uniformity while correcting refractive errors. Although visual and refractive outcomes have been widely reported, fewer studies have focused on early corneal shape changes following treatment. This study aimed to assess three-month changes in corneal remodelling following TG-Femto-LASIK. **Methods:** A retrospective study was conducted on 50 eyes of 25 patients who underwent TG-Femto-LASIK at the IIUM Eye Specialist Clinic. Preoperative and three-month postoperative values of keratometry (K1, K2), corneal astigmatism, and axial inferior–superior (I–S) index were compared using paired t-tests. Preoperative Randleman ectasia scores and postoperative residual stromal bed (RSB) thickness were recorded for contextual reference. Results were expressed as mean ± standard deviation (SD), mean difference with 95% confidence intervals (CI), and p-values. **Results**: At three months, K1 decreased by 4.22 D (95% CI: -3.85 – -4.59, $p < 0.001$) and K2 by 3.55 D (95% CI: -3.20 – -3.90, $p < 0.001$). Corneal astigmatism was reduced by 1.04 D (95% CI: -0.65 – -1.42, $p < 0.001$). The axial I–S index increased by 0.24 D (95% CI: 0.07 – 0.41, $p = 0.006$), while remaining within physiological limits. The mean preoperative Randleman score was 2.12 ± 1.49, and postoperative RSB was 346.8 ± 38.9 µm. **Conclusion:** TG-Femto-LASIK is associated with significant early corneal remodelling characterised by reduction in keratometry and astigmatism at three months. However, these findings represent short-term structural changes following stromal ablation and should not be interpreted as definitive indicators of biomechanical stability. Further longitudinal studies are required to evaluate long-term corneal behaviour and ectasia risk.

INTRODUCTION

Laser in situ keratomileusis (LASIK) is a refractive surgical procedure that corrects ametropia through corneal flap creation followed by excimer laser stromal ablation to reshape corneal curvature. The use of femtosecond laser technology has improved flap precision, reproducibility, and predictability compared to mechanical microkeratomes (Farjo et al., 2013).

Topography-guided LASIK (TG-LASIK) is a customised technique that utilises detailed anterior corneal surface data to guide stromal ablation. Unlike conventional LASIK, which is primarily based on manifest refraction, TG-LASIK aims to improve corneal surface irregularities and reduce higher-order aberrations, thereby improving optical quality (Knorz & Jendritza, 2000; Alves et al., 2022).

Early postoperative changes following TG-LASIK are mainly driven by stromal tissue ablation and epithelial remodelling, with most structural alterations occurring within the first three months (Lyra et al., 2023; Zhang et al., 2024). This period is therefore important for evaluating early corneal shape changes.

Safety remains a key concern in refractive surgery due to the risk of post-LASIK ectasia, a progressive condition characterised by corneal thinning and biomechanical weakening. The Randleman ectasia risk score and residual stromal bed (RSB) thickness are widely used as preoperative risk stratification tools (Randleman et al., 2008; Santhiago et al., 2016). However, these parameters do not directly measure postoperative biomechanical stability and cannot independently predict long-term outcomes.

Corneal shape parameters such as keratometry (K1, K2), corneal astigmatism, and the axial inferior–superior (I–S) index provide useful indicators of geometric corneal changes following stromal ablation. These parameters reflect alterations in corneal curvature rather than direct measures of biomechanical behaviour.

This study aimed to evaluate early corneal shape changes

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at three months following TG-Femto-LASIK in myopic eyes, focusing on keratometric, astigmatic, and axial I–S index changes. These parameters were analysed as indicators of corneal remodelling rather than definitive measures of biomechanical stability.

MATERIALS AND METHODS

Study Design and Setting

This retrospective study used anonymized data from routine clinical practice at the International Islamic University Malaysia (IIUM) Eye Specialist Clinic, Kuantan. Written informed consent for the use of clinical data for research and audit purposes was obtained prior to surgery. No identifiable patient information was included. In accordance with institutional policy, formal ethical approval was waived for retrospective analysis of fully anonymized data.

Participants

All patients provided written informed consent prior to surgery, including permission for the use of anonymized clinical data for research and audit purposes.

A total of 50 eyes from 25 patients who met the eligibility criteria were included. Both eyes from the same patient were analysed, and this was accounted for in the statistical analysis.

Inclusion criteria were: Age ≥18 years, stable refraction for at least one year, and suitability for LASIK based on preoperative assessment. Eyes with keratoconus, corneal scarring, ocular surface disease, prior ocular surgery, or systemic conditions affecting wound healing were excluded.

Surgical procedure

All procedures were performed by a single experienced refractive surgeon using a femtosecond laser platform for flap creation and an excimer laser with a topography-guided algorithm for stromal ablation.

Ablation depth and optical zone were individualized based on preoperative corneal topography and refractive error, following standard excimer laser nomograms. As ablation depth is directly related to refractive correction, it was inherently accounted for in the calculation of the residual stromal bed (RSB).

Flap thickness was programmed at 110 µm using the femtosecond laser system. Due to the high precision and reproducibility of femtosecond laser technology, flap thickness variability is known to be minimal, with a lower standard deviation than that associated mechanical microkeratomes.

Outcome measures

The following parameters were analysed:

- Steep keratometry (K1, D)
- Flat keratometry (K2, D)
- Corneal astigmatism (D)
- Axial inferior–superior (I–S) index (D)
- Randleman ectasia score (preoperative) – Table 2
- Residual stromal bed (RSB, µm, postoperative)

Keratometric parameters (K1, K2) and corneal astigmatism were used to quantify changes in corneal curvature following stromal ablation, reflecting refractive effects rather than biomechanical stability.

The axial I–S index was evaluated as a measure of corneal asymmetry, with values <0.8 D considered within physiological limits. However, because it was assessed at a single postoperative time point, it reflects structural change rather than progression or long-term stability.

The Randleman score and RSB were included for contextual reference as established preoperative risk stratification parameters. While RSB is biomechanically relevant, neither parameter independently predicts postoperative stability. RSB was calculated as:

RSB = Preoperative pachymetry − Ablation depth − Flap thickness (110 µm)

Preoperative and three-month postoperative values of K1, K2, corneal astigmatism, and axial I–S index were compared to assess early corneal remodelling. Refractive and visual outcomes were not evaluated and should be addressed in future studies.

Statistical analysis

Data were analysed using IBM SPSS Statistics version 29. Continuous variables were expressed as mean ± standard deviation (SD).

Preoperative and three-month postoperative values were compared using paired t-tests. Mean differences with 95% confidence intervals (CI) were calculated. Correlation between preoperative and postoperative parameters was assessed using Pearson correlation analysis. Statistical significance was set at $p < 0.05$.

Both eyes from the same patient were included in the analysis. This may introduce inter-eye correlation and violate the assumption of independence required for parametric testing, potentially affecting statistical significance. Therefore, results should be interpreted with caution.

RESULTS

Baseline characteristics and safety parameters

A total of 50 eyes from 25 patients were analysed. The mean preoperative Randleman ectasia score was 2.12 ± 1.49 (range: 0–5). The Randleman Ectasia Risk Factor Score System and risk category classification used for preoperative risk stratification are summarized in Tables 2 and 3, respectively. The mean postoperative residual stromal bed (RSB) thickness was 346.8 ± 38.9 µm, with all eyes maintaining values above the safety threshold of 280 µm (Table 1).

Corneal remodelling at three months

At three months post–TG-Femto-LASIK, there was a significant reduction in corneal power. Detailed comparisons of preoperative and postoperative corneal parameters are presented in Table 4. Steep keratometry (K1) decreased by −4.22 D (95% CI: −4.59 to −3.85, $p < 0.001$), while flat keratometry (K2) decreased by −3.55 D (95% CI: −3.90 to −3.20, $p < 0.001$). Corneal astigmatism was also significantly reduced, with a mean change of −1.04 D (95% CI: −1.42 to −0.65, $p < 0.001$).

The axial inferior–superior (I–S) index showed a small but statistically significant increase (+0.24 D; 95% CI: +0.07 to +0.41, $p = 0.006$), although values remained within physiological limits (<0.8 D). As this represents a single postoperative time point, it does not indicate whether the observed change stabilizes, regresses, or progresses over time.

These findings represent early corneal shape changes following stromal ablation.

Table 1: Baseline Characteristics and Safety Parameters of Eyes Undergoing TG-Femto-LASIK

Parameter	**mean ± SD**	**Range**
Age (years)	29.7 ± 4.9	18 – 36
Randleman ectasia score	2.12 ± 1.49	0 – 5
Residual stromal bed (RSB, µm)	346.8 ± 38.9	281 – 449

Table 2: Randleman Ectasia Score - Ectasia Risk Factor Score System

	Points				
Parameter	4	3	2	1	0
Topography pattern	FFKC	Inferior steepening/SRA		ABT	Normal/SBT
RSB thickness µm	<240	240 – 259	260 - 279	280 - 299	>300
Age (years)		18 – 21	22 - 25	26 - 29	>30
CT (µm)	<450	451 – 480	481 - 510		>510
MRSE (D)	>-14	>-12 to – 14	>-10 to - 12	>-8 to - 10	-8 or less

Table 3: Ectasia Risk Factor Score Categories

Cumulative Risk Scale Score	Risk category	Recommendations	Comments
0-2	Low risk	Proceed with LASIK or surface ablation	
3	Moderate risk	Proceed with caution, consider special informed consent; safety of surface ablation has not been established	Consider MRSE stability, degree of astigmatism, between-eye topographic asymmetry, and family history
4 or more	High risk	Do not perform LASIK; safety of surface ablation has not been established	

MRSE = preoperative spherical equivalent manifest refraction.

Table 4: Comparison of Corneal Parameters Before and Three Months After TG-Femto-LASIK (n = 50 eyes; results interpreted with consideration of inter-eye correlation)

Parameter	**Preoperative (Mean ± SD)**	**3-Month Postoperative (Mean ± SD)**	**Mean Difference (D)**	**95% CI**	**Two-sided p-value**	**Cohen's *d***
Steep keratometry (K1, D)	44.25 ± 1.69	40.03 ± 1.78	−4.22	−4.59 to −3.85	< 0.001	3.26
Flat keratometry (K2, D)	43.03 ± 1.56	39.48 ± 1.75	−3.55	−3.90 to −3.20	< 0.001	2.91
Corneal astigmatism (D)	1.22 ± 0.44	0.18 ± 1.14	−1.04	−1.42 to −0.65	< 0.001	0.77
Axial I–S index (D)	0.29 ± 0.45	0.54 ± 0.29	+0.24	+0.07 to +0.41	0.006	0.40

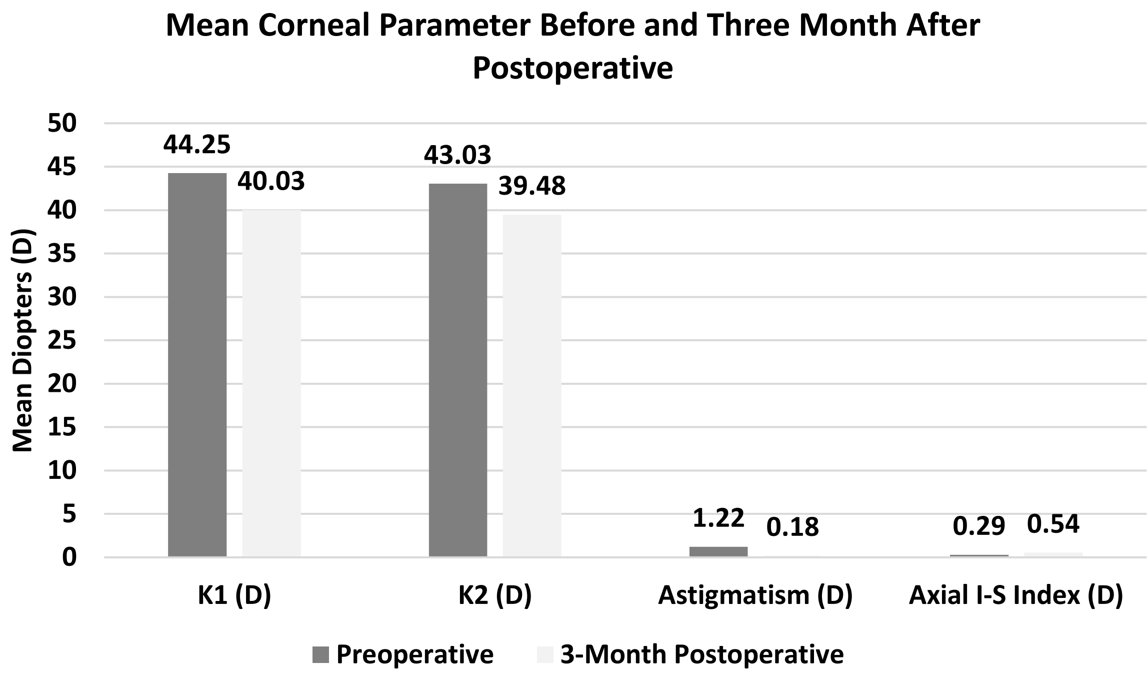

Figure 1: Mean corneal parameter before and three months after TG-Femto-LASIK

DISCUSSION

This study demonstrated significant reductions in corneal power following TG-Femto LASIK, reflected by decreases in K1 and K2, consistent with the intended refractive effect of stromal ablation and previous reports of early corneal flattening (Lyra et al., 2023; Zhang et al., 2024). Corneal astigmatism was also significantly reduced, supporting the effectiveness of topography-guided ablation in improving corneal surface regularity (Kanellopoulos, 2016; Wallerstein et al., 2019a).

A small but statistically significant increase in the axial inferior–superior (I–S) index was observed. Although values remained within physiological limits (<0.8 D), this represents a single postoperative time point and does not indicate whether the change stabilizes, regresses, or progresses over time.

Large effect sizes for keratometric changes indicate substantial refractive impact, while a moderate effect size for astigmatism reduction supports consistent cylindrical correction. The positive correlation between pre- and postoperative keratometry suggests proportional flattening rather than irregular corneal changes.

No cases of ectasia or visually significant complications were observed during follow-up. However, the Randleman score and residual stromal bed (RSB) should be interpreted as risk stratification and safety indicators rather than definitive measures of postoperative biomechanical stability. Post-LASIK ectasia is a progressive condition requiring longitudinal assessment.

Overall, TG-Femtosecond LASIK demonstrated effective corneal reshaping at three months; however, these findings reflect early postoperative changes rather than long-term structural stability.

Limitations

This study is limited by its short follow-up (three months), single postoperative time point, lack of direct biomechanical assessment, inclusion of both eyes with potential inter-eye correlation, and relatively small sample size.

Future studies with longer follow-up and incorporation of tomographic and biomechanical parameters are needed to evaluate long-term corneal stability.

CONCLUSION

Topography-guided femtosecond LASIK (TG-Femto-LASIK) demonstrated significant early corneal remodelling, with reductions in keratometry and astigmatism at three months. Corneal shape parameters remained within physiological limits; however, these findings represent short-term changes following stromal ablation rather than definitive evidence of biomechanical stability.

Given the retrospective design and single time-point assessment, results should be interpreted with caution. Further longitudinal studies incorporating tomographic and biomechanical evaluation are required to determine long-term corneal stability and ectasia risk.

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