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REVIEW ARTICLE **Open Access**

Incision-Site Descemet Membrane Detachment After Femtosecond Laser–Created Versus Manual Clear Corneal Incisions in Cataract Surgery: A Systematic Review

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ABSTRACT

Background: Clear corneal incision (CCI) is the standard approach in modern cataract surgery; however, incision-related Descemet membrane detachment (DMD) is increasingly recognized with the widespread use of anterior segment optical coherence tomography. Variations in incision architecture may affect posterior corneal stability and DMD risk.
Content: This systematic review compares the incidence of incision-site DMD following femtosecond laser-created versus manual CCI in adult undergoing cataract surgery. The review was conducted in accordance with PRISMA guidelines. PubMed, Cochrane Library, and ScienceDirect were searched using keywords related to femtosecond lasers, CCI, and cataract surgery. Comparative studies reporting DMD incidence intraoperatively or in the early postoperative period were included. Risk ratios were pooled using a random-effects model. Seven studies met the inclusion criteria. Across studies, femtosecond laser-created CCIs demonstrated a lower incidence of incision-site DMD than manual keratome incisions, particularly during intraoperative and early postoperative assessments using optical coherence tomography. Although not all studies reached statistical significance, the effect direction was consistent. Most DMDs were small, subclinical, and resolved spontaneously. The reduced DMD incidence associated with femtosecond laser-created incisions is biologically plausible and likely reflects improved incision geometry and posterior wound stability. Heterogeneity in study design and imaging protocols limits certainty, and the clinical relevance of subclinical DMD remains modest.
Conclusion: Femtosecond laser-created CCI are associated with a lower early risk of incision-site DMD compared with manual incisions, although most detachments are transient and clinically insignificant.

Keywords: Cataract surgery, clear corneal incision, Descemet membrane detachment, femtosecond laser, optical coherence tomography

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Introduction

Cataract surgery is one of the most frequently performed surgical procedures worldwide and continues to advance alongside developments in microsurgical techniques and imaging technologies. In contemporary practice, a clear corneal incision (CCI) has become the standard approach for anterior chamber access during phacoemulsification, largely due to its self-sealing nature, reduced conjunctival manipulation, and favorable postoperative recovery profile. Nevertheless, the corneal incision is not merely an entry point but a dynamic surgical interface whose architectural integrity has direct implications for intraoperative maneuverability, wound stability, and postoperative corneal health.[1,2]

Despite the overall safety of modern cataract surgery, incision-related complications remain clinically relevant. Among these, Descemet membrane detachment (DMD) has gained increasing attention over the past decade. DMD is defined as the separation of the Descemet membrane from the posterior corneal stroma and may occur intraoperatively or during the early postoperative period. While large or centrally extending detachments can lead to persistent corneal edema and visual deterioration, most incision-site DMDs are localized and subclinical, detectable primarily through high-resolution anterior segment optical coherence tomography (AS-OCT).[3,4] The increasing availability and routine use of AS-OCT have revealed that DMD following cataract surgery may be substantially more prevalent than previously recognized based on slit-lamp examination alone.

The development of incision-site DMD is thought to result from multiple contributing factors. Mechanical stress during incision creation, disruption of stromal–Descemet adhesion, endothelial cell trauma, and misdirection of fluid at the internal corneal lip have all been implicated as potential mechanisms.[5] Manual keratome-created CCIs rely heavily on surgeon experience and tactile feedback, resulting in inherent variability in incision length, depth, tunnel configuration, and internal wound smoothness. Even subtle irregularities at the internal wound margin may serve as focal points for shearing forces during phacoemulsification or irrigation–aspiration, predisposing the Descemet membrane to localized separation.[6]

Femtosecond laser–assisted cataract surgery has introduced an unprecedented level of precision to several surgical steps, including corneal incision formation. Femtosecond laser–generated CCIs are created according to predefined parameters, enabling reproducible control of incision depth, tunnel length, angulation, and multiplanar architecture. This level of precision theoretically minimizes irregular internal wound morphology and reduces unintended trauma to the posterior corneal layers.[7] Imaging-based comparative studies have demonstrated that femtosecond laser incisions are associated with smoother internal wound surfaces, more

consistent tunnel geometry, and reduced posterior wound gape when compared with manual keratome incisions.[8]

These structural advantages have led to the hypothesis that femtosecond laser–created CCIs may reduce the risk of incision-related complications, including DMD. Several comparative studies employing intraoperative or early postoperative AS-OCT have reported a lower incidence of DMD following femtosecond laser incision creation, particularly during the immediate and early postoperative phases.[4,9] These findings suggest that improved incision architecture may translate into greater posterior corneal stability at the incision site.

However, the available evidence remains heterogeneous and, in some cases, conflicting. Not all studies have demonstrated statistically significant differences in DMD incidence between femtosecond-laser–created and manually created CCIs. In smaller observational cohorts, although DMD rates were often numerically higher in manual incision groups, limited sample sizes and wide confidence intervals reduced statistical power, resulting in nonsignificant findings.[10] Furthermore, DMD has frequently been reported as a secondary or incidental observation rather than a predefined outcome, leading to variability in detection methods, imaging time points, and reporting standards across studies.

Another important consideration is the clinical relevance of incision-site DMD. Longitudinal imaging studies suggest that most small, localized DMDs resolve spontaneously over time without requiring intervention or affecting final visual outcomes.[3,5] Nevertheless, the presence of DMD may reflect underlying deficiencies in incision construction and wound integrity, serving as a surrogate marker of surgical quality rather than a benign incidental finding. From this perspective, reducing the incidence of DMD may be relevant not only for preventing rare clinically significant complications but also for optimizing incision architecture and corneal wound healing.

Despite increasing attention to incision morphology and corneal alterations detected by OCT, no previous systematic review has specifically examined incision-site DMD as an outcome in comparisons between femtosecond laser-created and manually constructed CCIs in cataract surgery. Most existing reviews of femtosecond laser–assisted cataract surgery have focused primarily on refractive outcomes, endothelial cell loss, or overall complication rates, without addressing DMD as a distinct and clinically relevant endpoint.[10]

Considering the growing recognition of subclinical DMD and its potential impact on corneal wound integrity, a targeted synthesis of the existing evidence is justified. Accordingly, this systematic review aims to compare the incidence of incision-site DMD in adult patients undergoing cataract surgery using femtosecond laser–created versus manually constructed

CCIs. Through a systematic evaluation of comparative studies incorporating intraoperative and postoperative OCT assessment, this review seeks to elucidate the magnitude and consistency of the relationship between incision technique and the risk of DMD.

Methods

Study design and reporting standards

This systematic review was conducted to evaluate the association between corneal incision techniques and the risk of incision-site DMD after cataract surgery. The review was designed and reported in accordance with PRISMA guidelines, using a predefined methodology to guide literature searching, study selection, data extraction, and qualitative synthesis.

Literature search strategy

A comprehensive literature search was conducted in PubMed, Cochrane Library, and ScienceDirect from database inception to April 2026, including all studies published up to the final search date without restriction on publication year to ensure that both earlier and recent comparative evidence on femtosecond laser–created and manual CCIs could be captured. In PubMed, the following search query was used: ("femtosecond laser" OR "femtosecond laser-assisted") AND ("clear corneal incision" OR "corneal incision") AND (cataract OR phacoemulsification), while in the Cochrane Library and ScienceDirect, the search was performed using the keywords/query: femtosecond laser AND corneal incision AND cataract. The search strategy was intentionally kept broad, and outcome-specific terms such as Descemet membrane detachment were not mandated at the search stage to avoid excluding relevant studies in which the outcome was reported as a secondary or incidental finding. In addition to electronic database searching, the reference lists of all included studies and relevant review articles were manually screened to identify any additional eligible studies.

Eligibility criteria

Studies were eligible for inclusion if they involved adult patients undergoing cataract surgery with a CCI, in which the intervention involved femtosecond laser–created CCIs and the comparison group included manual keratome-created CCIs. The outcome of interest was incision-site DMD detected intraoperatively or during the early postoperative period using clinical examination or imaging modalities, including anterior segment optical coherence tomography. Eligible study design included randomized controlled trials, as well as prospective or retrospective comparative cohort and observational study designs. Studies were excluded if involved non-cataract anterior segment procedures, absence of a manual incision comparator, lack of DMD outcome reporting, and publication formats such as reviews, editorials, case

reports, conference abstracts without full text, or non-English articles.

Study selection

Records retrieved from the electronic searches were entered into a reference management system, and duplicates were eliminated. Two reviewers independently screened titles and abstracts to identify potentially eligible studies, followed by full-text reviews to confirm eligibility based on predefined criteria. Any disagreements arising during the screening or full-text review stages were resolved through discussion until consensus was reached between the reviewers. The study selection process is summarized in a PRISMA flow diagram.

Data extraction

Two reviewers independently extracted data using a standardized form. Extracted information comprised publication details, study location and setting, study design, sample size, patient characteristics, femtosecond laser platform and incision parameters, manual incision technique, timing and modality of DMD detection, follow-up period, and incidence of incision-site Descemet membrane detachment.

When DMD was reported at multiple time points, data were extracted for each reported assessment, with particular attention to intraoperative and early postoperative findings. Any discrepancies in extracted data were resolved by re-reviewing the original articles.

Risk of bias assessment

An assessment of methodological quality and risk of bias was conducted for each included study. Given that most included studies employed non-randomized designs, domains including selection bias, comparability of intervention and comparator groups, outcome assessment, and completeness of follow-up were evaluated. Based on these domains, studies were categorized as having low, moderate, or high risk of bias. Overall, the risk of bias was judged to be moderate for most included studies, primarily due to observational study designs and limited sample sizes.

Data synthesis

Findings from the included studies were synthesized using a qualitative narrative approach to facilitate comparison. Due to heterogeneity in study design, incision architecture, imaging protocols, timing of DMD assessment, and outcome reporting, quantitative pooling of results was not performed.

Findings were synthesized descriptively, focusing on patterns in DMD incidence between femtosecond laser–created and manual CCIs, as well as the temporal evolution of DMD when longitudinal data were available. Emphasis was placed on consistency in the direction of effect rather than on formal statistical comparison. Clinical and methodological

heterogeneity among studies was explored qualitatively by comparing surgical techniques, laser platforms, imaging modalities, and follow-up durations.

Results

Study selection

The comprehensive database search yielded 647 records across the three selected databases, reflecting a deliberately sensitive search strategy designed to capture a broad spectrum of studies related to femtosecond laser–assisted and manual CCIs in cataract surgery. ScienceDirect contributed the majority of records (n = 548), followed by PubMed (n = 50) and the Cochrane Library (n = 49). This distribution reflects the predominance of surgical technique–focused observational studies indexed in broader biomedical databases rather than trial registries.

After screening titles and abstracts, 637 records were excluded. The primary reasons for exclusion at this stage included studies focusing on femtosecond laser–assisted cataract surgery without specific evaluation of corneal incision characteristics, studies addressing refractive or visual outcomes without reporting incision-related complications, review articles, editorials, and non-comparative case series. Duplicate assessment of the remaining records identified two duplicate publications, leaving eight full-text articles for detailed eligibility assessment.

During full-text review, one study was excluded because it involved an inappropriate population and intervention, specifically refractive surgery without cataract extraction and without reporting incision-site DMD as an outcome. In total, seven studies fulfilled all inclusion criteria and were incorporated into the qualitative synthesis. The study selection process, along with reasons for exclusion, is depicted in the PRISMA flow diagram (**Figure 1**).

Characteristics of included studies

The six included studies were published between 2014 and 2025. As resumed on **Table 1**, these studies reflect over a decade of evolving experience with femtosecond laser technology in anterior segment surgery. Geographically, the studies originated from Asia, North America, and South America, including research conducted in India, China, Brazil, and the United States, thereby encompassing a range of surgical settings and patient populations.

All included studies employed comparative study designs, predominantly prospective non-randomized cohorts and observational comparative studies, with one retrospective comparative case series. Importantly, no randomized controlled trials were identified that were specifically designed to evaluate incision-site DMD as a primary endpoint. Sample sizes varied

widely, from small cohorts involving fewer than 20 eyes per group to larger studies enrolling more than 100 eyes, contributing to variability in statistical power across studies.

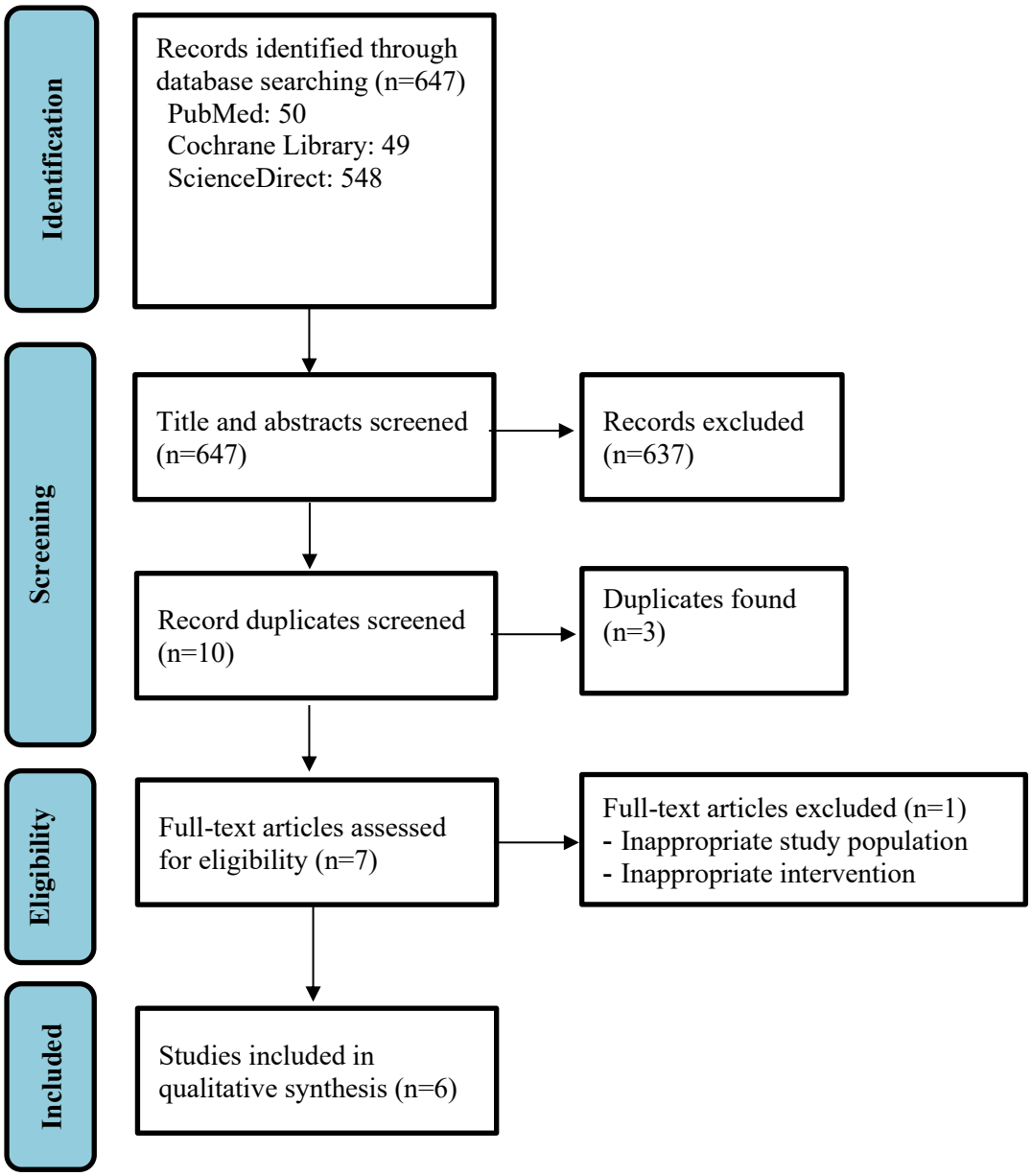

Figure 1. Diagram flow of literature search strategy for this systematic review

The study populations consisted of adult patients undergoing uncomplicated cataract surgery via a CCI. Most studies explicitly excluded eyes with pre-existing corneal pathology, previous ocular surgery, glaucoma, pseudo exfoliation, or intraoperative complications, thereby minimizing confounding factors known to influence corneal wound integrity. Surgical procedures were typically performed by single experienced surgeons, reducing inter-operator variability but potentially limiting generalizability.

Table 1. Summary source

First Author (Year)	Country / Setting	Study Design	Population Characteristics	Sample Size*	Surgical Technique Details	DMD Detection Method	Outcome Assessed	Main Findings	Summary of Findings	Risk of Bias
Titiyal *et al.* (2017)[11]	India; tertiary referral ophthalmic center (AIIMS New Delhi)	Prospective comparative cohort (non-randomized)	Adults with senile cataract undergoing uncomplicated phacoemulsification; excluded corneal pathology, glaucoma, pseudo exfoliation, prior ocular surgery	52 / 77	FL group: femtosecond laser–created 2.2-mm biplanar temporal CCI (LenSx); Manual group: 2.2-mm metal keratome biplanar CCI;	Microscope-integrated intra-operative OCT and anterior segment OCT (POD 1 & 30)	Incision-site Descemet membrane detachment (intraoperative and early postoperative)	Intraoperative DMD: 9.6% (FL) vs 49.4% (manual), $p < 0.001$; POD-1 DMD: 5.8% vs 37.6%; all DMD self-resolving by one month	Femtosecond laser CCIs were associated with significantly lower incidence of incision-site DMD compared with manual keratome CCIs; ragged incision	Moderate

					single surgeon				morphology strongly predicted DMD	
Horta *et al.* (2025)[4]	Brazil; tertiary ophthalmology centers (Horta Institute & University of São Paulo)	Prospective comparative cohort (non-randomized, investigator-masked)	Adults with cataract undergoing uncomplicated phacoemulsification; no significant baseline differences in age, sex, or laterality	18 / 19	FL group: femtosecond laser–created 2.2-mm triplanar clear corneal incision (LensX®, planned length 1.65 mm); Manual group:	Anterior segment OCT (AS-OCT) at 2–4 days and 1–3 months postoperatively	Incidence of incision-site Descemet membrane detachment in early and intermediate postoperative period	Early postoperative DMD: 22.2% (FL) vs 63.2% (manual), p = 0.012; late DMD (1–3 months): 0% vs 10.5% (NS)	Femtosecond laser–created CCIs showed significantly lower early postoperative DMD compared with manual keratome CCIs; most DMD resolved	Moderate

					2.2-mm keratome biplanar clear corneal incision				spontaneously over time	
Wang *et al.* (2018)[9]	China; Shanxi Eye Hospital	Prospective comparative cohort	Adults with senile cataract; LOCS III grade 3; pupil ≥8 mm; endothelial cell count >1,200/mm²; no prior ocular surgery or corneal pathology	58 / 34	FL group: LenSx femtosecond laser–created 2.2-mm two-plane primary CCI; Manual group: 2.2-mm single-plane	Spectral-domain anterior segment OCT at POD-1, week-1, month-1, month-3	Incidence of incision-site Descemet membrane detachment during early postoperative period	DMD incidence significantly lower in FL group at week-1, month-1, and month-3 (all $p < 0.05$); no DMD observed beyond 1 month in	Femtosecond laser–created CCIs were associated with a consistently lower incidence of postoperative incision-site DMD compared	Moderate

					steel keratome CCI; single experienced surgeon			FL group; posterior wound gape also lower at POD-1	with manual CCIs, suggesting more stable and reproducible incision architecture	
Grewal & Basti (2014)[8]	United States; Northwestern University Feinberg School of Medicine, Chicago	Comparative case series (retrospective analysis of consecutive cases)	Adults with age-related cataract undergoing uncomplicated phacoemulsification; excluded prior ocular surgery, corneal pathology, intraoperative complications,	20 / 16	FL group: Catalys femtosecond laser–created triplanar CCI, width 2.6 mm, intended	Anterior segment OCT at 1 month postoperatively; images analyzed using ImageJ by masked investigator	Incision-site Descemet membrane detachment at postoperative evaluation	DMD observed in 0/20 eyes (FL) vs 3/16 eyes (manual), p = 0.04; endothelial gape and misalignm	Femtosecond laser–created CCIs were associated with a significantly lower incidence of incision-site DMD	Moderate

			or need for wound enlargement		length 2.1 mm; Manual group: 2.65-mm steel keratome triplanar CCI; all surgeries by single surgeon			ent significant-ly lower in FL group	and superior incision morpholo-gy compared with manual keratome CCIs	
Rodrigues *et al.* (2019)[10]	Brazil; Hospital de Olhos Paulista, São Paulo	Prospective observational non-randomized cohort	Adults with cataract and low visual acuity; excluded ocular comorbidities, prior ocular surgery or trauma, corneal wound-healing	9 eyes / 9 eyes	FL group: VICTUS femtosecond laser–created 2.75-mm triplanar clear	Anterior segment OCT at postoperative day 1 and day 30; qualitative assessment by three	Incision-site Descemet membrane detachment and other wound-architecture features	POD-1 DMD: 33.3% (FL) vs 66.7% (manual), p = 0.35; POD-30 DMD: 0%	Although femtosecond laser incisions were more consistent-ly triplanar and precisely	Moderate

			disorders, intra- or postoperative complications		corneal incision; Manual group: 2.75-mm steel keratome CCI; all surgeries by a single surgeon	masked corneal specialists		vs 11.1%, p = 0.99; differences not statistical-ly significant	constructe d, the incidence of incision-site DMD did not differ significant-ly from manual keratome incisions	
Meng *et al.* (2025)[12]	China; Beijing New Vision Eye Hospital	Retrospect ive matched comparati ve cohort	Adults aged 18–45 years undergoing implantable collamer lens (ICL) surgery for moderate–high myopia; no prior ocular	42 eyes / 42 eyes	FL group: Catalys femtosec ond laser–created clear corneal incision	Not reported for DMD (OCT used for biometric assessment, not DMD incidence)	Visual acuity, astigmatis m, refractive predictabili ty, safety parameters	Short-term (≤1 month) visual acuity and astigma-tism were worse in the	Femtoseco nd laser–created CCIs did not provide clinical advantages over manual	Moder ate

	surgery or corneal pathology	(3.0–3.2 mm) for ICL implantation with blunt separation; Manual group: 3.0-mm manual clear corneal incision; single experienced surgeon	femtosecond group; mid- and long-term outcomes (3–6 months) were comparable; no superiority of femtosecond incision demonstrated	CCIs in ICL surgery; Descemet membrane detachment was not assessed or reported

*Sample size number based on FL CCI/Manual CCI ratio

Femtosecond laser–created incisions were generated using various commercially available platforms, including LenSx, Catalys, and VICTUS systems, with predefined incision parameters. These incisions were predominantly bi- or triplanar, with precisely controlled tunnel length, depth, and angulation. In contrast, manual incisions were performed with conventional steel keratomes, with incision architecture determined by the surgeon's technique and tactile feedback. This fundamental difference in incision creation methodology underpins the hypothesized disparity in wound morphology and subsequent risk of DMD.

Figure 2 shows risk-of-bias summary of the included observational studies using the Newcastle–Ottawa Scale domains. Green indicates low risk of bias, yellow indicates moderate risk of bias, and red indicates high risk of bias. Most studies were judged to have an overall moderate risk of bias, mainly because of non-randomized study design, limited sample size, and potential selection bias.

Figure 2. Risk of bias assessment result using NOS

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Assessment and detection of Descemet membrane detachment

Across the included studies, DMD was primarily detected using anterior segment optical coherence tomography (AS-OCT), underscoring the importance of high-resolution imaging in identifying subtle incision-related corneal changes. Several studies performed OCT imaging within the early postoperative period, most commonly on postoperative day 1 or within the first postoperative week, while others extended imaging to one month or beyond.

One study uniquely incorporated microscope-integrated intraoperative OCT, allowing real-time detection of DMD occurring during incision creation or intraoperative manipulation. This approach provided valuable insight into the temporal onset of DMD and suggested that many detachments originate at the internal wound lip during surgery rather than developing exclusively postoperatively.

The use of standardized OCT protocols across studies enhanced comparability, although heterogeneity persisted regarding imaging time points, scan orientation, and criteria for defining DMD. Most studies defined DMD as any visible separation of Descemet membrane from the posterior corneal stroma at the incision site, regardless of size or clinical significance.

Incidence of Descemet membrane detachment

All included studies reported numerically higher rates of incision-site DMD following manual CCIs compared with femtosecond laser–created incisions, although the absolute incidence and statistical significance varied. In studies employing intraoperative OCT, the difference was particularly pronounced, with manual incision groups demonstrating markedly higher rates of immediate DMD formation. One prospective study reported intraoperative DMD in nearly half of eyes undergoing manual incision, compared with approximately one-tenth of eyes in the femtosecond laser group.

Early postoperative OCT assessments corroborated these findings. Reported early DMD incidence in femtosecond laser groups is ranged from 0% to approximately one-third of eyes, whereas corresponding rates in manual incision groups frequently exceeded 50% in some cohorts. Several studies demonstrated statistically significant differences favoring femtosecond laser–created incisions, suggesting superior wound integrity and reduced mechanical stress on Descemet membrane.

Nevertheless, not all studies have reached statistical significance. In smaller observational cohorts, although DMD rates remained numerically higher in the manual incision group, limited sample size and wide confidence intervals reduced the ability to detect significant differences. These findings highlight the influence of study power and underscore

the need for cautious interpretation of null results.

Temporal course and clinical relevance of DMD

Longitudinal OCT follow-up revealed that the majority of incision-site DMDs were transient and self-resolving, regardless of incision technique. Studies that extended follow-up to one month or longer consistently demonstrated progressive reattachment of Descemet membrane, with few or no persistent detachments observed beyond the early postoperative period.

Importantly, none of the included studies reported visually significant DMD requiring surgical intervention, such as air or gas descemetopexy. Visual outcomes were generally unaffected by the presence of small, localized DMDs, suggesting that most detachments represented subclinical imaging findings rather than clinically consequential complications.

Despite their transient nature, the higher early incidence of DMD in manual incision groups may reflect less predictable incision architecture, increased endothelial trauma, or greater susceptibility to internal wound lip irregularities. These mechanistic considerations support the biological plausibility of reduced DMD risk with femtosecond laser–created incisions.

Overall summary of findings

The timing of OCT-based DMD assessment varied across the included studies. Most studies evaluated DMD during the early postoperative period, particularly on postoperative day 1 or within the first postoperative week, when incision-related mechanical changes are expected to be most apparent. Other studies extended the assessment to one month or longer, allowing evaluation of the temporal resolution of DMD. This variation is important because early OCT tends to capture transient and subclinical detachments, whereas later OCT may underestimate the initial incidence due to spontaneous reattachment. Therefore, DMD incidence was interpreted according to the timing of assessment rather than as a uniform endpoint across all studies.

Taken together, the evidence from six comparative studies indicates that femtosecond laser–created CCIs are associated with a lower incidence of incision-site DMD compared with manual keratome incisions, particularly during the intraoperative and early postoperative phases. While heterogeneity in study design, incision parameters, and imaging protocols exists, the direction of effect was consistent across studies.

However, the certainty of evidence is limited by the absence of randomized controlled trials and the predominance of non-randomized observational designs. Furthermore, the largely self-limiting nature of most DMDs raises questions regarding the clinical significance of these

findings. These considerations warrant cautious interpretation and emphasize the need for well-designed prospective trials to clarify the impact of femtosecond laser incision technology on meaningful clinical outcomes.

Discussion

This systematic review presents a targeted synthesis of comparative evidence evaluating incision-site DMD following femtosecond laser–created versus manual CCIs in cataract surgery. The principal finding of this study is that femtosecond laser–created CCIs are associated with a lower incidence of DMD during the intraoperative and early postoperative periods compared with manual keratome incisions. Although the degree of risk reduction varied across studies and statistical significance was not uniformly achieved, the direction of effect was consistent, supporting a meaningful association between incision construction technique and posterior corneal stability.

Interpretation of the main findings

Across the included studies, incision-site DMD was detected more frequently in manual incision groups, particularly when high-resolution AS-OCT was employed early after surgery. This observation was most evident during intraoperative or postoperative day 1 imaging, whereas later follow-up demonstrated a marked decline in DMD prevalence in both groups. These temporal patterns suggest that DMD is predominantly an early mechanical phenomenon, arising from stresses imposed on the posterior corneal layers during incision creation and initial intraocular manipulation.

Importantly, the higher early incidence of DMD in manual incision groups does not appear to be a random finding. Rather, it reflects systematic differences in incision architecture and wound reproducibility between the two techniques. Manual keratome incisions, even when performed by experienced surgeons, inherently involve variability in tunnel geometry, internal wound smoothness, and posterior lip configuration.[6] These subtle inconsistencies may not be clinically apparent at the slit lamp but become evident when assessed with OCT-based imaging modalities.[3,4]

Mechanistic rationale for reduced DMD with femtosecond laser incisions

The reduced incidence of DMD observed with femtosecond laser–created CCIs is biologically plausible and supported by morphologic and biomechanical evidence. Femtosecond laser incisions are generated through photo disruption, allowing precise separation of corneal tissue along preprogrammed planes with minimal collateral trauma. This contrasts with manual keratomes, which rely on mechanical cutting forces that may induce localized stress at the stromal–Descemet interface.[7,8]

Imaging studies have consistently demonstrated that femtosecond laser incisions produce smoother internal wound surfaces, more consistent tunnel length, and improved alignment of the internal and external wound lips.[8,9] These characteristics likely reduce shear forces acting on the Descemet membrane during phacoemulsification, irrigation–aspiration, and intraocular lens implantation. In addition, improved posterior wound apposition may limit fluid ingress into the potential space between Descemet membrane and posterior stroma, further reducing the likelihood of detachment.[5]

Another potential mechanism relates to endothelial preservation. Experimental and clinical data suggest that femtosecond laser energy, when appropriately applied, may result in less endothelial traction at the incision site compared with mechanical blade entry.[13] Given the critical role of endothelial integrity in maintaining stromal–Descemet adhesion, even modest reductions in endothelial trauma could contribute to improved posterior corneal stability.

Contextualization within existing literature

Previous literature evaluating femtosecond laser–assisted cataract surgery has largely emphasized refractive precision, surgically induced astigmatism, endothelial cell loss, and global complication rates.[14–16] While several studies have described improved incision architecture with femtosecond laser technology,[7–9,17] DMD has rarely been examined as a dedicated outcome. When reported, it has often been treated as a minor or incidental finding rather than a clinically relevant endpoint.

The present systematic review addresses this gap by isolating incision-site DMD as a specific outcome of interest. By incorporating studies that employed intraoperative or early postoperative OCT assessment, this analysis captures both clinically apparent and subclinical detachments. In doing so, the findings complement rather than contradict prior meta-analyses of femtosecond laser–assisted cataract surgery, which may have overlooked incision-related posterior corneal changes due to broader outcome definitions.[15,16]

Notably, the present findings suggest that femtosecond laser–assisted cataract surgery may provide selective advantages in terms of incision-related outcomes, even if overall complication rates or visual outcomes are comparable to manual surgery. This nuanced interpretation aligns with the growing recognition that surgical quality should not be assessed solely on final visual acuity but also on tissue-level integrity and reproducibility.

Clinical significance and practical implications

From a clinical perspective, the largely subclinical and self-resolving nature of most incision-site DMDs must be carefully considered. Longitudinal imaging studies indicate that the majority of small detachments reattach spontaneously within weeks, without the need for

intervention or adverse visual consequences.[3,5] As such, the findings of this review should not be interpreted as evidence that femtosecond laser–assisted cataract surgery is required to prevent clinically significant DMD.

However, the presence of early DMD may serve as a surrogate marker of incision quality and posterior wound integrity. In this context, a lower incidence of DMD with femtosecond laser–created incisions suggests improved surgical consistency and reduced microtrauma at the corneal incision site. These factors may be particularly relevant in eyes with compromised corneal endothelium, shallow anterior chambers, or increased susceptibility to wound-related complications.

Moreover, as OCT-based assessment becomes increasingly integrated into routine postoperative evaluation, the ability to minimize subclinical corneal alterations may assume greater importance in surgical benchmarking and quality assurance.

Limitations of evidence

The present analysis is subject to several limitations that warrant consideration. First, the included studies were predominantly non-randomized and observational in nature, introducing potential selection bias and confounding. Second, sample sizes were generally modest, limiting statistical power and precision of pooled estimates. Third, heterogeneity existed with respect to laser platforms, incision parameters, surgeon experience, and OCT imaging protocols.

In addition, definitions of DMD varied across studies, and standardized thresholds for clinically meaningful detachment were lacking. The timing of DMD assessment also differed, with some studies focusing on intraoperative detection and others emphasizing early postoperative imaging. These factors may have contributed to heterogeneity and limit direct comparability.

Finally, the analysis focused primarily on early DMD incidence. The long-term clinical relevance of subclinical DMD, including its potential association with endothelial cell loss or delayed corneal recovery, remains insufficiently explored.

Future research directions

Future investigations should prioritize prospective randomized controlled trials specifically designed to evaluate incision-related outcomes, including DMD, using standardized OCT protocols and predefined assessment time points. Studies correlating OCT-detected DMD with endothelial cell density, corneal thickness changes, visual recovery, and patient-reported outcomes would further clarify the clinical implications of these findings.

Additionally, comparative evaluations of different femtosecond laser platforms,

incision geometries, and energy settings may help identify optimal parameters for minimizing posterior corneal trauma. As femtosecond laser technology continues to evolve, such data will be essential for refining surgical techniques and maximizing the benefits of precision incision construction.

Conclusion

This systematic review demonstrates that femtosecond laser–created CCIs are associated with a lower incidence of early incision-site DMD compared with manual keratome incisions. While most detected detachments are subclinical and self-resolving, the findings highlight the importance of incision architecture in posterior corneal stability. Future well-designed prospective studies are required to better elucidate the clinical significance of subclinical DMD and to define the role of femtosecond laser technology in optimizing corneal wound integrity.

Conflicts of Interest

The authors confirm that the research was carried out independently and declare no conflict of interest.

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