# Overview of Scientific Work – Omid Kermani

Omid Kermani's scientific work spans approximately 37 years (1988–2025) and documents the development of laser-based ophthalmology, from the physical principles of excimer laser–tissue interaction to current topics such as artificial intelligence in corneal diagnostics, multifocal intraocular lenses, and immediate sequential bilateral cataract surgery. His principal areas of research include refractive corneal surgery, femtosecond and excimer laser technology, laser-based glaucoma surgery, and lens surgery.

## Early Phase: Laser–Tissue Interaction and the Fundamentals of Excimer Laser Technology (1988–1994)

Kermani's scientific career began with experimental studies of the photoablation of biological tissue at the University of Bonn (Dardenne Clinic), initially in collaboration with Hans-Joachim Koort and later with the physicist Holger Lubatschowski. One of his earliest publications, "Mass spectroscopic analysis of excimer laser ablated material from human corneal tissue" (J Cataract Refract Surg, 1988), analyzed the chemical composition of corneal constituents released during excimer laser photoablation and belongs to the pioneering phase of refractive excimer laser surgery. Concurrent studies investigated the use of the excimer laser in dentistry (Frentzen et al., 1989) and gynecology (Schmidt et al., 1989). These early publications were interdisciplinary and indicate that Kermani's focus extended beyond a narrowly defined clinical application to encompass the physical principles of laser–tissue interaction.

The studies "Struktur und Dynamik photoakustischer Schockwellen bei der 193 nm Excimerlaserphotoablation der Hornhaut" (Fortschr Ophthalmol, 1991) and "ArF-excimer laser-induced secondary radiation in photoablation of biological tissue" (Lasers Surg Med, 1994) contributed to the understanding of shock-wave dynamics and secondary radiation. Both topics were relevant to questions of safety and quality during the early development of LASIK and PRK and rank among the methodologically original works in the publication record.

This early phase also included the experimental study "XeCl excimer laser photoablation of human cataract lens" (Lasers and Light in Ophthalmology, Kugler & Ghedini, late 1980s/early 1990s; the journal is no longer available). It was the first to investigate the possibility of removing an opacified human lens by excimer laser photoablation and may therefore be regarded as a visionary precursor to contemporary, clinically established laser-assisted—particularly femtosecond laser–assisted—cataract surgery.

## Laser Surgery for Glaucoma (1992–1993)

During a brief but distinct phase of his work, Kermani established two lines of research in laser-based glaucoma treatment. The studies “Internal ablative sinostomy using a fiber delivered Q-switched CTE laser (2.69 µm)” (Int Ophthalmol, 1993) and “Q-switched CTE laser sclerostomies on human autopsy eyes” (Ger J Ophthalmol, 1993) document the independent development of a “cold-light” laser for photoablation. Unlike a free excimer laser beam, its radiation can be transmitted into the interior of the eye through an optical fiber, where it permits tissue-sparing ab interno photoablation. Conceptually, this represents foundational work on ab interno trabeculotomy, a technique that is now becoming increasingly established in minimally invasive glaucoma surgery using modern fiber- or excimer laser–based devices.

The study “Contact cw-Nd laser cyclophotocoagulation for treatment of refractory glaucoma” (Ger J Ophthalmol, 1992) marks the introduction of laser cyclophotocoagulation in Germany. Kermani established the procedure as a distinct treatment option at the Department of Ophthalmology of the University of Cologne, where it continues to be used for treatment-refractory glaucoma. Internationally, cyclophotocoagulation has since become an established component of the therapeutic armamentarium for advanced glaucoma; Kermani’s contribution thus lies in the early clinical implementation of an enduringly successful method.

## Refractive Excimer Laser Corneal Surgery (1998–2006)

With the establishment of LASIK in the 1990s, refractive excimer laser surgery became a principal focus. Together with Lubatschowski, Kermani published “A scanning and rotating slit ArF excimer laser delivery system for refractive surgery” (J Refract Surg, 1998), documenting the development of scanning-spot and scanning-slit systems. A second line of research comprised application and outcome studies involving the NIDEK platform: “Early results of NIDEK customized aspheric transition zones (CATz) in laser in situ keratomileusis” (J Refract Surg, 2003), “Hyperopic laser in situ keratomileusis with 5.5-, 6.5-, and 7.0-mm optical zones” (J Refract Surg, 2005), “Topographic- and wavefront-guided customized ablations with the NIDEK-EC5000CXII in LASIK for myopia” (Refract Surg, 2006), and “Outcomes of hyperopic LASIK with the NIDEK NAVEX platform centered on the visual axis or line of sight” (J Refract Surg, 2009). These studies received international attention because Kermani belonged to a small group of users who clinically validated the NIDEK platform at an early stage and published work combining topography- and wavefront-guided treatment. Particularly original was the use of large optical zones in hyperopic LASIK, which contributed to a relevant improvement in the stability of hyperopia correction.

The studies on centration strategies provide a conceptual framework: “Alignment in customized laser in situ keratomileusis” (J Refract Surg, 2004) and “Automated visual axis alignment for refractive excimer laser ablation” (J Refract Surg Suppl, 2006). They address the question of which reference point—the pupil center, visual axis, or line of sight—should be used to center the ablation. The 2006 study in particular is original and foundational: the automated alignment of the ablation with the visual axis described

therein subsequently became standard practice in the ophthalmic use of excimer lasers for refractive correction.

## Transition to Femtosecond Laser Surgery (2003–2023)

A central theme of the body of work is the pioneering use of femtosecond lasers in ophthalmology, pursued in close collaboration with the Laser Zentrum Hannover (Lubatschowski, Heisterkamp, Ripken, and Oberheide). “Intrastromal refractive surgery with ultrashort laser pulses: in vivo study on the rabbit eye” (Graefes Arch Clin Exp Ophthalmol, 2003) was among the early in vivo demonstrations of exclusively intrastromal, femtosecond laser–based refractive surgery. Conceptually, it anticipated both the lenticule extraction procedure now known as SMILE and current non-invasive intrastromal approaches.

The study “In-vitro- und In-vivo-Untersuchungen zur Presbyopiebehandlung mit Femtosekundenlasern” (Ophthalmologe, 2007) was the first published clinical study worldwide to investigate femtosecond laser–based restoration of accommodation. Although the anticipated clinical effect was not achieved, the study was historically and conceptually pioneering and addressed a topic that remains the subject of clinical development, including “lens softening” and femtosecond laser–based lens modification.

This line of research was systematically advanced to a prospective, controlled study design. “Clinical study on femtosecond laser restoration of accommodation” (Graefes Arch Clin Exp Ophthalmol, 2023; with Gerten, Oberheide, and Lubatschowski) reports an OCT-guided, prospective phase 2a study of femtosecond laser–based restoration of accommodation. The publication is significant in several respects: it demonstrates that Kermani’s group conducted not only retrospective case series but also prospectively designed, controlled studies, and it documents that this group was the first worldwide to perform and publish a clinical application of femtosecond laser treatment intended to restore accommodation in humans. Although the primary objective of achieving a clinically meaningful increase in accommodation was not fully attained—with no cataract formation over twelve months and an unexpected mean hyperopic shift of 1.0 D—the study established a conceptually unique field of treatment that remains distinctive to this day.

The studies “Real-time optical coherence tomography-guided femtosecond laser sub-Bowman keratomileusis on human donor eyes” (Am J Ophthalmol, 2008) and “Control of femtosecond thin-flap LASIK using OCT in human donor eyes” (J Refract Surg, 2010) are methodologically original because they integrate real-time OCT guidance with femtosecond laser incisions—an approach that was not widely implemented in commercial platforms until later. These two publications rank among the internationally recognized key contributions within the body of work.

## Lens Surgery: Phakic, Multifocal, and EDoF Intraocular Lenses (2009–2024)

In parallel with refractive corneal surgery, Kermani developed a second, long-standing line of work on intraocular lens surgery. “Dual intraocular lens implantation: Monofocal lens in the bag and additional diffractive multifocal lens in the sulcus” (J Cataract Refract Surg, 2009; with Gerten et al.) is conceptually distinct and describes a strategy now widely used in the form of add-on IOLs. “Rotation stability of the cachet angle-supported phakic intraocular lens” (J Refract Surg, 2013) contributes to the clinical evaluation of a phakic anterior chamber lens that was subsequently withdrawn from the market. It is therefore of value from the perspective of clinical documentation, although no longer directly applicable to current practice.

“Häufigkeit, Ursachen und Verlauf von Explantationen multifokaler Intraokularlinsen” (Klin Monbl Augenheilkd, 2016) is clinically relevant because it systematically examines the complication and dissatisfaction profiles associated with multifocal IOLs in a relatively large patient cohort, thereby contributing to a more realistic assessment of their indications. “The Vivity IOL: the European experience” (J Curr Ophthalmol Rep, 2022; with Cummings, Savini, Carones, and Ruiz-Mesa) summarizes the first European experience with a non-diffractive EDoF lens and may be classified as a consensus publication by a group of leading refractive surgeons. “Femto-masking: laser-generated apertures to extend depth of focus and reduce optical aberrations in intraocular lenses” (J Cataract Refract Surg, 2022; with Dick and Lubatschowski) is conceptually original. It proposes the postoperative creation of apertures in IOLs using a femtosecond laser to increase depth of focus and reduce aberrations. Situated at the interface between laser technology and lens optics, this contribution exemplifies the sustained effort to transfer concepts from laser technology to lens surgery.

The study “Custom-made anterior chamber intraocular lens for aphakia: a case report” (BMC Ophthalmology, 2026) represents the most independent development of this research line to date. It describes the development, design, and three-year outcome of a custom-made, foldable, angle-supported anterior chamber lens (VKL Type 37 F, designed by Kermani; Morcher GmbH), manufactured as a custom-made device under Article 2(3) of the Medical Device Regulation (MDR) for a young patient with aphakia in whom neither sulcus nor iris-claw fixation was feasible. This publication is discussed separately at the end of the overview.

## Monovision, Conductive Keratoplasty, Cross-Linking, and TLKP

Several German-language reviews and reports of clinical experience address procedures occupying a niche in refractive practice: “Monovision und konduktive Keratoplastie” (Z prakt Augenheilkd, 2010), “LASIK-Xtra: Standard-LASIK mit prophylaktischem CXL” (Augenspiegel, 2012), “Chirurgische Verfahren zur Monovision” (Augenspiegel, 2016), and “Oberflächlich, lamellär oder intrastromal? Die Zukunft der refraktiven Laserchirurgie” (Ophthalmologische Nachrichten, 2017). They summarize the German-language debate regarding indications, techniques, and risks; they do not claim international originality. They are nevertheless important in portraying a practice-oriented author who critically considers procedures even when they fail to gain

acceptance or remain controversial. “Excimerlaserbehandlung bei tiefer lamellärer Keratoplastik (TLKP) 100 µm über der Descemet” (Ophthalmologe, 2002; with Krumeich, Schöner, Lubatschowski, and Gerten) forms part of a methodologically distinct series of attempts to improve the precision of lamellar keratoplasty using an excimer laser. With the establishment of DSAEK and DMEK, however, the technique did not become a standard procedure.

## International Consortia on Corneal Biomechanics, Ectasia Detection, and Artificial Intelligence (2021–2022)

The character of the publications changed in 2021 and 2022, with Kermani appearing as a co-author of major international consortium studies, particularly those of the International Corneal and Ocular Biomechanics Study Group (Vinciguerra, Ambrósio, Hafezi, Roberts, et al.). “Optimized artificial intelligence for enhanced ectasia detection using Scheimpflug-based corneal tomography and biomechanical data” (Am J Ophthalmol, 2022) combines multimodal tomographic and biomechanical data in an AI model for the early detection of subclinical keratoconus. “Detection of post-laser vision correction ectasia with a new combined biomechanical index” (J Cataract Refract Surg, 2021) forms part of the validation series for the Corvis Biomechanical Index–Laser Vision Correction (CBI-LVC). In both instances, Kermani’s contribution consisted of providing clinical data and serving as a co-author; the principal methodological originality rests with the first authors. These publications mark a transition from working as a sole author or within small author teams to participating in international multicenter networks. The four educational reviews published in Ophthalmology Times Europe in 2022 on the “Pathophysiology and pathomorphology of corneal ectasia” (Stewart, with review contributions from Kermani, Ambrósio, Reinstein, Gatinel, Hafezi, and others) further demonstrate this integration.

The EUROCOVCAT publications—“Impact on refractive surgery due to increasing use of personal protection equipment” (Eur J Ophthalmol, 2021) and “COVID-19 outbreak and increased risk of amblyopia and epidemic myopia” (Eur J Ophthalmol, 2022)—are relevant as contemporary records and from a health-policy perspective. “The myopia pandemic” (J Cataract Refract Surg, 2021; with Cummings) is a concise position statement in the commentary genre.

## Most Recent Work (2024–2025)

“Simultane bilaterale Kataraktoperation. Eine kritische Betrachtung” (Z prakt Augenheilkd, 2025) reflects on immediate sequential bilateral cataract surgery (ISBCS), a practice that continues to be managed inconsistently in Germany, and should be read as a contribution to a current debate in health policy and medical law. Together with the publication on a customized anterior chamber IOL for aphakia, it brings the body of work full circle: both topics are situated at the margins of standard clinical care, where individualized solutions and critical reflection are required.

## Assessment: Originality and Significance

Overall, the body of work portrays an author whose principal original scientific contributions lie in the early and middle phases of his career: during the 1990s, as one of the co-founders of German research on excimer lasers and photoablation in Bonn and Cologne; during the 1990s and 2000s, as a pioneer of laser-based glaucoma and lens procedures; and during the 2000s, as a clinical pioneer of femtosecond laser–based corneal surgery in collaboration with the Laser Zentrum Hannover. At the same time, he was among the few users to publish substantial findings on the NIDEK platform in the international literature.

The following contributions appear particularly original and consequential within the specialist literature: (1) the laser-based glaucoma studies of the early 1990s, which introduced laser cyclophotocoagulation in Germany and, through fiber-based ab interno sinostomy, anticipated a concept in minimally invasive glaucoma surgery that has regained considerable relevance today; (2) the experimental study of XeCl excimer laser photoablation of the human lens as a visionary precursor to present-day laser-assisted cataract surgery; (3) the studies on real-time OCT guidance of the femtosecond laser (2008/2010); (4) the experimental work on intrastromal refractive surgery (2003) as a conceptual precursor to SMILE, as well as the first clinical study worldwide on femtosecond laser–based restoration of accommodation (2007); (5) “Automated visual axis alignment for refractive excimer laser ablation” (2006), the procedure described in which subsequently became standard in refractive excimer laser surgery; (6) dual IOL implantation (2009) as a precursor to today’s established add-on IOLs; and (7) the study on the explantation of multifocal IOLs (2016), which contributed to the critical clinical assessment of these lenses.

The NIDEK LASIK studies have been widely received in clinical practice, as have—through Kermani’s role as a co-author—the international consortium studies on AI-assisted ectasia detection and biomechanics following refractive surgery. In the latter studies, the originality cannot primarily be attributed to Kermani; his contribution lies in the provision of clinical data and participation in scientific networks. Excimer laser–assisted deep lamellar keratoplasty, by contrast, proved not to have a sustained clinical impact. The German-language reviews of monovision, conductive keratoplasty, and LASIK Xtra are educationally valuable but not internationally groundbreaking.

Across all phases of the work, the close integration of clinical practice and engineering-based laser technology is methodologically characteristic, as reflected in the recurring co-authorship with Lubatschowski (photonics, Hannover), Gerten (joint practice in Cologne), and Oberheide. A large proportion of the publications consist of retrospective case series, pilot studies in donor eyes, or initial clinical experience with new devices. These are complemented, however, by prospective and controlled investigations, particularly the phase 2a study of femtosecond laser–based restoration of accommodation (Graefes Arch, 2023), which demonstrates that the body of work is not limited to descriptive study formats. Against this background, Kermani’s scientific work may be characterized overall as practice-oriented, technology-focused, and well connected internationally, with its principal significance lying in the early evaluation and dissemination of laser-assisted procedures in refractive, lens, and glaucoma surgery.

## Outlook and Current Special Position: The Custom-Made Foldable Anterior Chamber Lens (2026)

The most recent publication, “Custom-made anterior chamber intraocular lens for aphakia: a case report” (BMC Ophthalmology, 2026), merits separate consideration. Although it currently marks the conclusion of the body of work, it occupies a distinct position because it brings together several characteristic themes of the oeuvre and translates them into a specific and unique innovation.

The study concerns the development and first implantation of a custom-made, foldable, angle-supported anterior chamber lens made of hydrophilic acrylate (VKL Type 37 F, designed by Kermani; Morcher GmbH). It was manufactured as a custom-made device under Article 2(3) MDR (EU 2017/745) for a young patient with aphakia in whom, following congenital cataract surgery, neither a sulcus-fixated posterior chamber lens nor a retropupillary iris-claw lens could be implanted. The lens can be injected through an incision of ≤2.6 mm, and the publication reports a complete three-year follow-up demonstrating stable centration, refractive predictability, normal intraocular pressure, and an endothelial cell loss of 7.6%, the majority of which occurred during the first postoperative year.

The significance of this study lies in its uniqueness. To current knowledge, it describes the world’s first foldable, injectable, angle-supported anterior chamber lens for which a three-year follow-up has been documented. The design principle that has dominated the field of angle-supported anterior chamber lenses since the US Food and Drug Administration approved the rigid Kelman Multiflex lens made of polymethyl methacrylate (PMMA) in 1980 is thereby challenged for the first time by a modern, biocompatible alternative suitable for small-incision surgery. Conceptually, the study directly follows Kermani’s earlier work on angle-supported phakic lenses (rotational stability of the Cachet lens, 2013) and combines the characteristic integration of clinical indication and engineering-oriented lens development seen throughout his work with a custom-made device subject to demanding regulatory requirements.

From a scientific perspective, it must be noted that this is a single case with three years of follow-up and therefore cannot yet provide evidence regarding long-term endothelial safety over several decades; the authors explicitly acknowledge this limitation. Against this background, however, the contribution should be assessed for what it is: the first clinical demonstration of the feasibility and medium-term tolerability of a novel lens concept that offers a minimally invasive alternative for carefully selected aphakic eyes in which established fixation techniques are unsuitable. Together with the first clinical study worldwide on femtosecond laser–based restoration of accommodation, it identifies two points at which Kermani’s body of work positions him not as a user of an existing technique, but as the first to describe a novel procedure.