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SELECTED LASER TECHNOLOGIES USED IN OPHTHALMOLOGY: A NARRATIVE REVIEW OF CORNEAL REFRACTIVE PROCEDURES, Nd:YAG LASER APPLICATIONS, AND THEIR CLINICAL SIGNIFICANCE

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ABSTRACT

Laser technologies constitute a fundamental component of contemporary ophthalmology, permitting precise and minimally invasive treatment of refractive errors and selected ocular conditions. The aim of this review is to discuss the most important applications of laser refractive procedures and the Nd:YAG laser. The section on refractive surgery examines photorefractive keratectomy (PRK), laser-assisted in situ keratomileusis (LASIK), and small-incision lenticule extraction (SMILE), with particular emphasis on their mechanisms of action, indications, advantages, limitations, and potential complications. PRK remains a significant method of superficial ablation, especially for patients with thinner corneas or an elevated risk of complications related to flap creation. LASIK provides rapid visual improvement but necessitates a thorough assessment of corneal biomechanics and ocular surface status. SMILE offers a flapless alternative, particularly for correcting myopia and myopic astigmatism. The review also addresses the clinical applications of the Nd:YAG laser, including posterior capsulotomy, peripheral iridotomy, and vitreolysis. The analysis indicates that the effectiveness of laser treatment in ophthalmology is determined not only by technological sophistication but also by appropriate patient selection, outcome assessment, and the surgeon's expertise.

KEYWORDS

Laser Ophthalmology, Refractive Surgery, LASIK, PRK, Nd:YAG Laser, Laser Iridotomy

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1. Introduction

The origins of laser technology date back to the early twentieth century and the work of two pioneering physicists. In 1900, Max Planck showed that energy is not released or absorbed in a continuous flow, but in small, fixed amounts he called “quanta”, with each quantum directly linked to the frequency of radiation. Nearly two decades later, in 1917, Albert Einstein proposed the idea of stimulated emission- the process by which a photon passing near an excited atom can cause it to release a second photon identical to the first in frequency, phase, polarisation, and direction [1]. These ideas, however, remained purely theoretical for a long time. It took until May 16, 1960, for Theodore Maiman to build the first working laser of 693.3 nm wavelength, producing a focused beam of light from a ruby rod powered by a flashlamp. This moment signified the true beginning of the laser age [2]. Just one year after the ruby laser was invented, it began to be used in medicine, specifically in ophthalmology, when the first eye surgeries were performed using this type of laser. In the same year, Javan and Bennett launched the first gas laser, and Snitzer built a prototype Nd:YAG [3].

Various types of lasers, particularly CO₂ and Nd:YAG lasers, are widely employed across numerous medical disciplines, including general surgery, neurosurgery, dermatology, otolaryngology, gastroenterology, gynecology, and urology. However, ophthalmology is recognised as the medical specialty that utilises laser technologies most extensively and comprehensively, occupying a unique position in this regard among clinical fields [4].

Laser technologies are used both in advanced diagnostic imaging of ocular structures and in a broad range of therapeutic procedures. The introduction of ophthalmic lasers has fundamentally revolutionised the field of refractive surgery by supporting precise correction of refractive errors, including myopia, hyperopia, and astigmatism [5].

This review presents selected laser technologies used in ophthalmic procedures, with particular emphasis on their applications in refractive surgery. Refractive surgical techniques are classified according to both the treatment method and the laser technology employed, including photorefractive keratectomy (PRK), laser-assisted in situ keratomileusis (LASIK), and small-incision lenticule extraction (SMILE). Additionally, the review discusses the clinical applications of the Nd:YAG laser in the management of three distinct ophthalmic disorders.

2. Methodology

This narrative literature review is based on publications retrieved from databases including PubMed, Scopus, Google Scholar, and Web of Science. Relevant articles were identified using keywords related to laser technologies in ophthalmology, such as refractive surgery, Nd:YAG, and laser iridotomy. Selection criteria focused on relevance to commonly used clinical procedures, and the data were analysed qualitatively without the application of a formal systematic review protocol.

3. Results

Corneal refractive laser procedures

Laser refractive surgery involves correcting vision defects by reshaping the cornea using high-energy ophthalmic lasers. Advances in this field have been driven primarily by the introduction of the excimer laser, followed by the femtosecond laser, which have enabled refractive procedures to be performed with increasing precision and in a less invasive manner [5,6,8].

One of the first widely used methods was PRK (Photorefractive Keratectomy), introduced into clinical practice in the late 1980s. This technique utilises an excimer laser emitting ultraviolet radiation at a wavelength of 193 nm, permitting precise photoablation of the cornea [7]. A further development of this method was LASIK (Laser-Assisted in Situ Keratomileusis), which, in addition to the excimer laser, utilised the creation of a corneal flap. This shortened the recovery time, reduced post-operative discomfort and minimised corneal haze [5]. The next stage in the development of refractive surgery was the introduction of procedures using a femtosecond laser, which generates ultrashort pulses of light, affording precise intracorneal cuts whilst minimising damage to surrounding tissues. This is utilised in the SMILE (Small Incision Lenticule Extraction) method, considered one of the latest techniques in laser vision correction [8].

Modern refractive surgery systems also utilise advanced diagnostic methods and eye-tracking systems, which allow for greater precision during procedures and reduce the possibility of complications [5]. Despite the high efficacy of laser procedures, adverse effects may occur, including tear film disorders and dry eye syndrome [7]. For this reason, appropriate patient selection and the choice of the correct surgical technique are of paramount importance, as the latest and most advanced laser technique is not necessarily, in itself, the most appropriate method of vision correction for all patients.

For this reason, a detailed discussion of the methods mentioned above- namely PRK and trans-PRK, LASIK and SMILE- is provided below, together with a description of the laser technologies used in each.

Photorefractive Keratectomy (PRK) and trans-PRK

Photorefractive keratectomy is a superficial corneal ablation technique and was the first laser refractive correction technique to be introduced into clinical practice. In this procedure, following the removal of the epithelium, ablation of the anterior part of the corneal stroma is performed using an excimer laser, which leads to a change in the curvature of the cornea and correction of the refractive error [7,10]. In classic PRK, the epithelium is removed mechanically, with alcohol or using a rotating brush, whereas in trans-PRK (transepithelial photorefractive keratectomy), both the epithelium and the corneal stroma are removed exclusively using an excimer laser. The trans-PRK technique is referred to as a 'no-touch' procedure, as it eliminates contact between surgical instruments and the corneal surface [9].

PRK and trans-PRK are primarily used to correct mild to moderate myopia and astigmatism. The range of correction with PRK covers myopia up to approximately -12.0 D, hyperopia up to $+5.0$ D and astigmatism up to 6.0 D; however, as the depth of ablation increases, so does the risk of regression of the refractive effect and corneal haze [6].

According to a study conducted on patients who underwent trans-PRK surgery for hyperopia, 91% of eyes were within ± 0.50 D of the target refraction at 12 months; however, the authors emphasised that results were less predictable at higher levels of hyperopia [10].

A key advantage of superficial ablation techniques is that they do not require the creation of a corneal flap. The minimum residual stromal thickness following ablation should be at least $250\text{--}300\text{ }\mu\text{m}$ in order to

reduce the risk of post-operative corneal ectasia. For this reason, PRK and trans-PRK are often chosen for patients with a thin cornea, corneal surface irregularities, and those at risk of eye injury, including contact sports players or soldiers [7].

Contraindications include keratoconus, suspected ectasia identified in topographic or tomographic examinations, unstable refractive error, active ocular surface diseases, and severe dry eye syndrome. Active autoimmune diseases and connective tissue diseases are also considered contraindications due to the potential for impaired corneal healing [6]. Patients for whom this method is not suitable include those with astigmatism exceeding 3.0 D, glaucoma, retinal pathologies, and those with conditions that may affect refractive stability [11].

A meta-analysis conducted by Alasbali, which included 12 studies involving a total of 1,711 eyes, found no significant differences between conventional PRK and trans-PRK in terms of final visual acuity, refractive outcome and safety [12]. The differences mainly concerned the early postoperative period, as the lasers currently used in the trans-PRK method employ ablation profiles that consider variations in epithelial thickness throughout different parts of the cornea, permitting more uniform tissue removal. This reduces mechanical trauma to the ocular surface, resulting in faster re-epithelialisation and less severe postoperative pain. Compared with conventional PRK, the epithelial healing time following trans-PRK was typically 2–3 days, whereas with conventional PRK, complete re-epithelialisation was more commonly observed after 3–5 days [7,10].

The most common side effects of both procedures relate to the healing of the corneal surface following the removal of the epithelium. According to data presented by Gurnani et al., pain and discomfort occur in up to 90% of patients within the first 72 hours after surgery. Typical symptoms include photophobia, tearing, a burning sensation and a foreign body sensation. Later complications include dry eye, regression of the refractive effect, undercorrection or overcorrection, halos, glare and subepithelial corneal haze. Gurnani et al. report an incidence of haze at around 15%, regression at around 7%, and dry eye symptoms in up to 50% of cases. Rare but potentially serious complications include infectious keratitis, scarring and postoperative corneal ectasia [6].

Laser-Assisted in Situ Keratomileusis (LASIK)

LASIK (Laser-Assisted in Situ Keratomileusis) is a refractive procedure in which the corrective effect is obtained by excimer-laser ablation of the corneal stroma after creation of a corneal flap. The flap includes the epithelium, Bowman's membrane and the anterior stromal layer; after it is lifted, the laser reshapes the stromal bed. In myopia, the central cornea is flattened, in hyperopia, the more peripheral cornea is ablated to increase central curvature, and in astigmatism, ablation is planned according to the meridians requiring correction [13].

The flap may be created with a mechanical microkeratome or with a femtosecond laser. The femtosecond technique provides more predictable flap thickness and reduces selected mechanical complications, but the essential distinction from PRK is that LASIK preserves most of the epithelium and therefore usually produces less early postoperative pain and faster visual recovery [6,13]. For this reason, the method is commonly selected for mild to moderate myopia, hyperopia and astigmatism, particularly when corneal thickness and topography are favourable [13].

Eligibility for LASIK requires stable refraction, normal corneal topography and tomography, sufficient residual stromal thickness after ablation, and careful assessment of the ocular surface. Contraindications include keratoconus or suspected ectasia, abnormal topography, active ocular infection or inflammation, severe dry eye disease, advanced glaucoma and systemic conditions that may impair healing, including uncontrolled autoimmune disease. Pregnancy, breastfeeding, uncontrolled diabetes, corneal dystrophies, a history of corneal herpes and unrealistic expectations also require particular caution [13].

Clinical outcomes are generally favourable, especially in lower and moderate myopia and astigmatism. LASIK is often associated with very rapid functional visual recovery, and patient satisfaction is reported as high in many studies. However, in hyperopia, the predictability is lower than in myopia, particularly at higher corrections. A meta-analysis comparing LASIK and PRK in hyperopia did not show a significant final advantage of LASIK in safety or efficacy, although LASIK was associated with less early postoperative corneal haze [15].

The main limitation of LASIK is related to flap creation and corneal nerve disruption. Flap-specific complications include microstriae, macrostriae, incomplete or displaced flap, epithelial ingrowth and diffuse lamellar keratitis. Dry eye is also frequent in the early postoperative period because flap formation and stromal ablation interrupt corneal nerve fibres, reduce corneal sensation and destabilise the tear film. Management is

stepwise and may include preservative-free artificial tears, treatment of meibomian gland dysfunction, short-term anti-inflammatory therapy, cyclosporine or lifitegrast, punctal plugs, autologous serum or scleral lenses in more severe cases [13,14].

In summary, LASIK offers fast visual rehabilitation and reduced early discomfort compared with surface ablation, but it requires stricter assessment of corneal biomechanics and the ocular surface. The choice between LASIK and PRK should therefore be based not only on the magnitude of the refractive error, but also on corneal thickness, topography, tear-film status, occupational risk of eye trauma and individual healing factors [6,13,14].

Small Incision Lenticule Extraction (SMILE)

SMILE (Small Incision Lenticule Extraction) is a flapless refractive procedure performed with a femtosecond laser. The laser creates an intrastromal lenticule and a small corneal incision, through which the lenticule is manually removed. This changes the corneal curvature without creating a large flap and without using excimer-laser stromal ablation [9,17].

The method is used primarily for the correction of myopia and myopic astigmatism. Its main theoretical and clinical advantages are preservation of the anterior corneal surface architecture, smaller incision size, reduced disruption of corneal nerves and potentially lower impact on tear-film stability compared with flap-based procedures. Visual recovery is usually favourable, although the earliest postoperative improvement may be slower than after LASIK [6,9,17].

Patient selection for SMILE requires stable refraction, appropriate corneal thickness, normal corneal tomography and exclusion of ectatic disease. The procedure is not suitable when there is keratoconus, suspicious topography, active ocular surface disease, uncontrolled dry eye, insufficient residual stromal thickness or unstable refraction. As with other refractive techniques, systemic diseases that impair wound healing and unrealistic expectations should be considered during qualification [9,17].

Published clinical data indicate good efficacy and safety in properly selected patients. Initial clinical experience and subsequent reviews describe high rates of corrected visual acuity improvement and predictable refractive outcomes in myopia [16,17]. A meta-analysis focused on high astigmatism also supports the efficacy of SMILE in astigmatic correction, although results depend on preoperative cylinder, nomogram accuracy and centration [18].

The adverse-effect profile differs from LASIK because there is no corneal flap. Flap displacement and epithelial ingrowth are therefore avoided, but complications such as difficult lenticule dissection, residual refractive error, interface inflammation, dry eye symptoms, halos, glare, and, rarely, ectasia may still occur. In clinical decision-making, SMILE should be considered an important alternative to LASIK and PRK, particularly when preservation of corneal nerves and avoidance of a flap are desirable [6,9,17].

Neodymium-doped yttrium aluminum garnet (Nd:YAG) laser procedures in ophthalmology

The neodymium-doped yttrium aluminium garnet (Nd:YAG) laser is one of the most commonly used lasers in surgical ophthalmology. Unlike excimer lasers, used for corneal photoablation in PRK and LASIK, and femtosecond lasers used, for example, in the SMILE procedure, it is not used for routine reshaping of the corneal curvature. Its significance stems primarily from its ability to very precisely disrupt selected structures in the anterior and posterior segments of the eye. The active medium is a yttrium-aluminium garnet crystal doped with neodymium ions, which emits radiation at a wavelength of 1064 nm in the near-infrared range [19].

The mechanism of action of the Nd:YAG laser is based on photodisruption. A short, high-energy pulse causes ionisation of the tissue at the beam focus, the formation of plasma, followed by rapid expansion and a shock wave. This allows the targeted structure to be cut or disrupted without the need for a conventional surgical incision [19,20]. In practice, it is crucial to position the laser focus very precisely, as even a slight deviation can alter the energy distribution and increase the risk of damage to adjacent structures of the eye [21].

For this reason, the Nd:YAG laser is routinely used to treat posterior capsular opacification following cataract surgery, for laser iridotomy in patients with angle-closure glaucoma and, in selected cases, for vitreolysis of vitreous opacities [19]. These applications are discussed in the following subsections.

Treatment of posterior capsule opacification (secondary cataract).

Posterior capsule opacification (PCO), often referred to as secondary cataract, is the most common late complication following cataract surgery. It arises as a result of the proliferation, migration and metaplasia of residual lens epithelial cells, which gradually impairs the transparency of the optical axis. Patients usually report a decrease in visual acuity, reduced contrast sensitivity, glare, halos and difficulty seeing in low light [22,26].

In symptomatic PCO, the treatment of choice is Nd:YAG posterior capsulotomy. The procedure involves creating an opening in the central part of the opacified posterior lens capsule. The concentrated laser energy causes localised photodisruption of the tissue, thereby allowing the optical axis to be re-exposed without surgically opening the eyeball [22]. Capsulotomy is performed on an outpatient basis, usually following topical anaesthesia, and an improvement in vision may occur within the first few hours or days following the procedure [22,24].

The efficacy of capsulotomy is high. In a study by Lighthizer et al., an improvement in visual acuity was achieved in the vast majority of patients, and complications were rare. When performed correctly, the procedure usually yields rapid and predictable functional results [24].

The technique used to perform the capsulotomy is also of great importance. Borkenstein and Borkenstein point out that precise shaping of the opening, whilst minimising unnecessary damage to the capsule, can influence the quality of vision following the procedure [26]. In practice, therefore, the aim is to create a central opening sufficient to expose the optical axis, but without excessive exposure of the tissues to laser energy [22,26].

Although capsulotomy is a highly predictable procedure, it is not entirely risk-free. The most commonly reported complications include a temporary increase in intraocular pressure, inflammatory reaction in the anterior chamber, damage to the intraocular lens caused by the laser beam, macular oedema, and transient visual disturbances associated with the presence of capsular fragments in the vitreous [22]. Haemorrhages, retinal detachment or dislocation of the intraocular lens are observed less frequently [22].

For many years, retinal detachment was considered one of the most serious potential complications of capsulotomy. However, a study by Elbaz et al., involving a large group of patients who had undergone phacoemulsification, found no increased risk of retinal detachment following capsulotomy [25]. The authors concluded that the procedure itself is not an independent risk factor for retinal detachment, and that classic predisposing factors, such as younger age, axial myopia or previous retinal pathologies, are of greater significance [25].

As a result, posterior capsulotomy remains the gold standard for the symptomatic treatment of PCO. This is mostly because of its high efficacy, low invasiveness and relatively predictable outcomes, as well as the rare occurrence of complications and, consequently, its safety for the patient [22,23].

Laser iridotomy in angle- closure glaucoma

Laser peripheral iridotomy (LPI) using an Nd:YAG laser is one of the primary methods of treatment and prevention of primary angle-closure glaucoma, particularly when pupillary block is the main mechanism [27,30]. During the procedure, a small opening is made in the peripheral part of the iris. This allows aqueous humour to flow between the posterior and anterior chambers of the eye, equalises the pressure difference on either side of the iris and promotes the widening of the drainage angle [27,28]. Due to photodisruption, this can be achieved without surgically opening the eyeball [27].

The primary indication for LPI is the spectrum of primary angle-closure disease (PACD), which includes suspected primary angle closure, primary angle closure and primary angle-closure glaucoma. The procedure is performed prophylactically in individuals at risk of angle closure, as well as therapeutically following the resolution of an acute glaucoma attack [27,30]. Its aim is to remove the pupillary block, which is one of the main mechanisms responsible for the rise in intraocular pressure in this group of patients [27].

In a study by Kavitha et al., significant anatomical changes were observed in the anterior segment of the eye following LPI: flattening of the iris, increased anterior chamber depth, and widening of the drainage angle [27]. This confirms the procedure's effectiveness in resolving pupillary block. The authors note, however, that the effect may be less pronounced if other anatomical mechanisms are also responsible for the narrowing of the angle [27].

The efficacy of iridotomy has also been confirmed in the treatment of acute angle-closure glaucoma. In a study by Gray et al., iridotomy restored communication between the eye's chambers and controlled

intraocular pressure in the majority of patients with an acute glaucoma attack [28]. Current clinical guidelines continue to recommend LPI as one of the primary treatment methods in cases where a pupillary block component is present [30].

Although LPI is highly effective, it can cause side effects. The most common of these are: a temporary increase in intraocular pressure, minor bleeding from the iris, a short-lived inflammatory reaction in the anterior chamber, photophobia, and transient visual disturbances [27]. Some patients also experience symptoms of dysphotopsia associated with the presence of an opening in the iris. Relevant complications are rare [27,29].

An important issue is the effect of iridotomy on the corneal endothelium. A five-year follow-up study conducted by Mishima et al. found a gradual decrease in corneal endothelial cell density following prophylactic iridotomy in patients with narrow-angle glaucoma [29]. Although the changes observed did not usually lead to clinically significant corneal decompensation, the results suggest a need for long-term follow-up of patients who have undergone the procedure, particularly in cases of concomitant corneal diseases [29].

Peripheral laser iridotomy, therefore, remains an important component of the treatment and prevention of angle-closure glaucoma, particularly when pupillary block is the predominant factor. Its advantages include minimal invasiveness, the ability to be performed on an outpatient basis, and a low incidence of serious complications. However, the effectiveness of the procedure should always be assessed in the context of the anatomy of the drainage angle and any additional mechanisms contributing to its closure [27,28,30].

Vitreolysis for vitreous floaters

Vitreous floaters are a common cause of subjective deterioration in visual quality, particularly in people with posterior vitreous detachment (PVD). They arise as a result of the aggregation of collagen fibres or other structural changes in the vitreous humour. They cast a shadow on the retina, which is why the patient sees them as moving dots, threads or specks in their field of vision [31,34]. They do not usually cause a significant reduction in visual acuity, but in some patients, they make reading, driving and everyday activities noticeably more difficult [32,33,35].

Laser vitreolysis may be considered in selected patients with symptomatic vitreous opacities. Compared with observation alone, it may relieve symptoms more rapidly, and compared with vitrectomy, it is a less invasive method [31,32,35]. However, it is not a suitable option for every patient, as its effectiveness depends on the size, shape and location of the opacities. During the procedure, photodisruption causes the opacities to fragment or vaporise. For safety reasons, opacities located at a sufficient distance from the retina and the lens are primarily suitable for treatment [31,32].

The best results are usually achieved in patients with well-defined opacities following posterior vitreous detachment, particularly of the Weiss ring type [32,34,35]. In cases of multiple, diffuse or poorly visible opacities, efficacy is lower. Therefore, patient selection should include an assessment of the location, size and mobility of the opacities, as well as a realistic discussion with the patient regarding the expected benefits [31,32].

Clinical studies suggest that laser vitreolysis may reduce the severity of symptoms in appropriately selected patients. In a study by Goh et al. on opacities associated with PVD, symptomatic improvement was observed in the majority of treated patients, with a good safety profile [34]. The results of a randomised study by Shah and Heier, involving patients with symptomatic Weiss's ring, showed greater improvement in the vitreolysis group than in the sham group, although the authors emphasised the need for further studies with larger sample sizes and longer follow-up periods [35].

Data on long-term outcomes are promising, although still more modest than those for capsulotomy or iridotomy. Nunes et al. demonstrated sustained symptomatic improvement in the majority of patients following vitreolysis, without significant late complications associated with the procedure. The authors emphasised that appropriate patient selection is essential for the success of treatment [32].

A 2025 study by Liu et al. involving patients with physiological vitreous opacities demonstrated a subjective improvement in vision-related quality of life and a reduction in symptom severity following vitreolysis, whilst maintaining a favourable safety profile [31]. These results support the use of the procedure in selected patients, but do not justify treating it as a universal method for all types of opacities [31,35].

Although vitreolysis is a minimally invasive procedure, it is not entirely without risk. The most commonly reported adverse effects include temporary blurred vision, a slight increase in intraocular pressure, and the persistence of some symptoms despite treatment [31–34]. Lens damage, retinal damage, vitreous

haemorrhage and macular oedema have been reported less frequently; however, these complications mainly occur when patients are incorrectly selected, or the laser focus is incorrectly positioned [32,34]. For this reason, it is particularly important to accurately assess the location of opacities and to maintain a safe distance from the retina and lens during the procedure [31].

Compared with capsulotomy and iridotomy, vitreolysis has more selective indications. Its effectiveness depends largely on the characteristics of the opacities, the patient's condition and the stage of the disease. In carefully selected patients, however, it can significantly improve visual comfort and offer a less invasive alternative to vitrectomy [31–35].

The Nd:YAG laser has established itself in ophthalmology as it allows for the precise photodisruption of specific structures within the eye without the need for conventional surgery. Posterior capsulotomy remains the gold standard for the symptomatic treatment of PCO following cataract surgery, whilst peripheral iridotomy is an important method for the treatment and prevention of angle-closure glaucoma when pupillary block is present. Vitreolysis, on the other hand, can help certain patients with symptomatic vitreous opacities, but requires particularly careful screening and assessment of their condition.

Although the clinical indications described vary, the common element in all these procedures is photodisruption. It is this that allows for localised and selective treatment of specific structures within the eye. These procedures generally have a favourable safety profile and can be performed on an outpatient basis; however, the actual risk of complications depends on the patient's suitability, the surgical technique and the surgeon's experience.

4. Discussion

The review indicates that laser technologies currently play a very broad and diverse role in modern ophthalmology. The procedures in question differ in their mechanism of action, indications and the eye structures they affect, but they share one key feature: their effectiveness does not depend solely on the technical parameters of the device. Equally important are the correct patient selection, precise planning of the procedure and a realistic assessment of the achievable outcomes.

In refractive surgery, the evolution from superficial ablation techniques such as PRK, through LASIK, to SMILE reflects the drive to shorten recovery times, reduce post-operative discomfort and minimise the risk of complications. This does not, however, mean that newer methods automatically replace older ones. PRK remains an important option for selected patients, particularly when preserving corneal biomechanics is essential or when creating a corneal flap is undesirable. LASIK offers rapid improvement in vision and a high level of patient satisfaction, but carries a risk of flap-related complications and has a greater impact on corneal innervation. The SMILE technique mitigates some of these issues as it does not require the creation of a flap; however, its suitability depends on the type and extent of the refractive error, corneal parameters and the surgeon's experience. For this reason, the choice between PRK, LASIK and SMILE should be based on an individual clinical assessment, rather than on the assumption that the latest technique is always the best option.

A similar principle applies to procedures performed using the Nd:YAG laser, although their clinical context is different. Unlike refractive procedures, treatments using the Nd:YAG laser are primarily therapeutic in nature and are used to treat specific ophthalmic conditions. Posterior capsulotomy is a well-established and effective method for the symptomatic treatment of posterior capsule opacification following cataract surgery. Peripheral laser iridotomy remains a key component of the treatment and prevention of angle-closure glaucoma, particularly when pupillary block is the predominant mechanism. Vitreolysis, on the other hand, has a more selective application. This procedure brings about a significant improvement in visual comfort for patients, particularly in those with well-defined opacities, such as Weiss's ring. Consequently, the effectiveness of this method depends to a much greater extent on the location and morphology of the opacities; therefore, accurately assessing the patient's condition is a crucial pre-treatment step.

The literature review also suggests that laser procedures should not be assessed solely in terms of efficacy, as measured by improvements in visual acuity or a reduction in symptoms. Safety, the predictability of outcomes, the healing process, post-operative discomfort and the patient's subjective assessment of visual quality are also of significant importance. For example, a method that offers very good refractive accuracy may not be the best option for a patient with significant corneal surface abnormalities, a thin cornea or an increased risk of dry eye syndrome. Similarly, although Nd:YAG laser treatments are minimally invasive, they require an in-depth assessment of anatomical relationships, appropriate selection of laser energy, and post-

treatment monitoring, particularly in patients at risk of increased intraocular pressure, retinal complications or damage to the corneal endothelium.

The available data suggest that not all of the procedures in question are supported by the same level of clinical evidence. Posterior capsulotomy and peripheral laser iridotomy are well-established methods with clearly defined indications. Vitreolysis, however, remains a procedure that is more dependent on patient selection and requires further high-quality research, including studies on long-term efficacy, safety and patient-reported outcomes. In refractive surgery, future research needs to focus not only on uncorrected visual acuity, but also on visual quality, tear film parameters, corneal biomechanics and long-term stability of the outcome.

The importance of laser technologies in ophthalmology is therefore not limited to their technical sophistication. Their true clinical value depends on their appropriate application in specific situations. Future developments are likely to include improved imaging, more effective eye-tracking systems, greater personalisation of treatment parameters, and further refinements in how the laser interacts with tissue.

5. Conclusions

Selected laser technologies have become an integral part of contemporary ophthalmology, both in the correction of refractive errors and in the treatment of specific ocular disorders. The procedures discussed in this review demonstrate that the clinical value of laser treatment depends not only on the type of laser used, but also on the indication, anatomical conditions, expected visual outcome, and individual risk profile of the patient. Corneal refractive procedures and Nd:YAG laser applications differ in their mechanisms and clinical purposes, yet both require careful qualification and precise execution. PRK, LASIK and SMILE should therefore be regarded as complementary rather than competing techniques, while Nd:YAG laser procedures remain important therapeutic options in well-defined clinical settings. Further technological development may improve safety, accuracy and patient comfort; however, the choice of treatment should ultimately be guided by the anatomy of the eye, the type of condition, the patient's expectations and risk profile, rather than by the mere availability of a particular technology or the assumption that newer methods are always superior.

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