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Review Article

LASIK X SMILE: Option in Refractive Surgery Correction

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Abstract

Introduction: In Brazil, between 11 and 36% of people have myopia, which is one of the most frequent refractive errors that affects vision from afar, occurring due to the visual image not being focused directly on the retina, but ahead of it. Astigmatism, in addition to being a common optical problem, is associated, in most cases, with other refractive problems, such as myopia or hyperopia. Ophthalmology stands out for being the first specialty in medicine to use laser for therapeutic purposes, as well as for its accelerated and constant development. Corneal refractive surgery, also called subtraction surgery, was the first procedure adopted using the laser, being currently the most used surgery to correct refractive errors.

Objectives: The general objective of this article is to discuss the importance of using the laser in ophthalmology, since the control of the making of the cut with the laser reduces the risk of complications that can occur when creating the flap, such as lamella perforation (buttom hole), irregular cut and incomplete cut. The specific objective is to compare the SMILE (Small Incision Lenticule Extraction) and LASIK (Laser In-Situ Keratomileusis) techniques, for the purpose of verifying which method is the most efficient for correcting refractive errors.

Conclusion: When compared to other surgical techniques, SMILE is considered more efficient, since the incision is up to 80% smaller, which reduces the risk of dry eye by 99%.

Keywords: Ophthalmology; Corneal Refractive Surgery; Laser; SMILE; LASIK

Introduction

Visual perception begins with the capture of electromagnetic energy in the visible spectrum of the human being (400 to 700 nanometers) by the photoreceptor cells of the retina. In the retina, the light energy is transformed into an electrical response, which, in turn, is modulated and propagated through the optical pathways to the occipital cortex, where it is perceived as a visual sensation. Visual perception includes the sense of form, chromatic and luminous. The sense of shape, which is a function of the macular region located on the retina, depends on optical mechanisms that allow us to obtain a good morphological perception [1]. Such an ideal condition is called emetropy and occurs when parallel rays strike the eye and are refracted, converging on the retina. The opposite condition, very common, is ametropia. In it, the parallel rays do not exactly focus on the retina. Ametropia contemplates three main types of refractive errors: myopia, hyperopia and astigmatism.

Refractive surgery comprises procedures that aim to decrease and, if possible, eliminate refractive errors [2,3]. The types of refractive surgery can be classified according to the place of performance: corneal surgery, which is subdivided into surgery for addition, subtraction, tissue contraction and relaxing incision; intraocular surgery, which includes phakic implants and lens exchange (facorefractive); and scleral surgery, which includes the relaxing incision and expansion implants.

For at least two decades, in the clinical practice of ophthalmology professionals, refractive surgeries have been present. With the emergence of the excimer laser, as well as with the increase in the efficiency and safety levels of surgical procedures, this technique has become reliable and predictable. In the United States, it is estimated that around 60 million people choose to perform refractive surgery, and in the country, only 10% of the market is explored.

There is a shortage, however, in the national literature on practices and preferences among refractive surgeons. There are indications, however, that LASIK (Laser In-Situ Keratomileusis) would be the surgical technique of choice for refractive surgeons.

Therefore, there is a need to discuss the importance of using the laser in ophthalmology, due to the necessary control of making the cut with the laser, reducing the risk of complications that can occur when creating the flap, such as perforation of the lamella (buttom hole), irregular cut and incomplete cut.

This article aims to compare the SMILE (Small Incision Lenticule Extraction) and LASIK (Laser In-Situ Keratomileusis) techniques, for the purpose of verifying which method is the most efficient for correcting refractive errors.

Laser in ophthalmology

Amplification by Stimulated Emission of Radiation Light), thus understood the amplification of light through the stimulated emission of radiation, was developed by the American physicist Theodore H. Maiman, in 1960, using ruby Crystal.

Ophthalmology stands out for being the first specialty in medicine to use laser for therapeutic purposes, as well as for its accelerated and constant development. Corneal refractive surgery (subtraction surgery) was the first procedure adopted using the laser, being currently the most used surgery to correct refractive errors. It currently consists of 2 main techniques: Surface ablation techniques that include photorefractive keratectomy (PRK), subepithelial laser keratectomy (LASEK), photorefractive keratectomy (PRK) with mitomycin C, Epi - laser assisted in situ keratectomy (Epi - LASIK); and Lamellar surgery which is the keratomileuse in situ better known as LASIK.

In fact, the term "laser" has a connotation of advanced and futuristic technology. But it is necessary to understand that, like computers, lasers are in a constant and rapid evolution, which makes diagnostic and therapeutic applications increasingly accurate and effective. Several types of laser such as argon, krypton, carbon dioxide, neodymium-YAG (yttrium aluminum garnet [Nd: YAG]) and excimer have been developed for several applications in ophthalmology. Thus, in the 1940s, the bases of corneal refractive surgery were introduced, which culminated in radial keratotomy. In the 1990s, the excimer laser was finally introduced in refractive eye surgery, now considered the main modality of refractive surgery.

The different lasers are characterized by the wavelength within the electromagnetic spectrum of the light. This is determined by the laser source and the active medium, being defined by the distance the photon travels while the electric field completes an oscillation. The characteristics and forms of laser-tissue interaction, photocoagulation, photodisruption, photoablation or photochemistry are determined by the wavelength, together with the exposure time, power density and energy density. Such characteristics determine the absorption of energy, which is different between each tissue of the organism.

While the transparent refractive media of the eye, cornea, crystalline and vitreous do not absorb magnetic radiation in the visible spectrum of light, at higher energy densities, absorption with plasma formation occurs, a phenomenon called tissue photodisruption. This phenomenon occurs especially at wavelengths in the near-infrared range (NIR near infra-red). The first practical application of NIR lasers in ophthalmology was with Nd: Yag laser, introduced by Aron-Rosa in the early 1980s.

The Nd: Yag laser is widely used for opening the posterior capsule (capsulotomy) and iris (iridotomy), as well as for lysis of vitreous beams and hyaloid rupture in cases of pre-retinal hemorrhage. All of these applications determined a significant reduction in the need for intraocular interventions that are unquestionably more traumatic and at greater risk.

The Nd: YAG laser produces tissue photodisruption at its point of focus, resulting in a rapidly expanding cloud of free electrons and ionized molecules (plasma). Typically, the Nd: YAG laser lasts for a pulse in the nanosecond range (10-9 of the second). In this exposure range, acoustic shock waves are formed, which dissipate to the surrounding tissues, typically with a 100 μm (0.1 mm) tissue damage zone. This fact can be easily perceived when the laser beam reaches the intraocular lens during the performance of posterior capsulotomy, which is undesirable, but it generates few side effects for the patient. However, such a volume of collateral tissue damage made the use of Nd: Yag laser in corneal surgeries impractical, as these demand precision dozens of times greater. By reducing the duration of laser pulses with this wavelength (NIR) for the femtosecond range (10-15 seconds), it is possible to concentrate the energy in an area 100 times smaller or submicron, which significantly increases the control, allowing corneal surgery.

The first observation of the interaction of a femtosecond (fs) NIR laser with the cornea was made by Ronald Kurtz, in 1992, while still residing at the University of Michigan (Kellogg Eye Center). Kurtz observed a clean and perfectly shaped cut in the cornea of a scientist, who had had an accidental injury with a laser that was being studied for the auto industry. Together with Hungarian engineers Tibor Juhasz and French Gerard Mourou, Kurtz began studies for the application of femtosecond laser in ophthalmology at CUOS (Center for Ultrafast Optical Science), University of Michigan, in order to found the Intralase corporation in 1979.

The first femtosecond NIR laser devices, which operated at a frequency below 10 kHz, were tested in Hungary. Intralase was the first NIR femtosecond laser to be approved by the American FDA (Food and Drug Adminsitration) to perform the lamellar cut of LASIK in 2000 with 510k exemption, that is, without the need for studies because it is comparable to the microkeratome. Intralase (Abbot Medical Optics) became available to the international market in 2001, with a growing and rapid acceptance in the refractive surgery market. Quickly, other femtosecond lasers were introduced in a fast growing and competitive market, in which all the major companies linked to Ophthalmology are well represented. The control of the making of the cut with the laser reduces the risk of complications that can occur when creating the flap, such as perforation of the lamella (buttom hole), irregular cut and incomplete cut.

The planar geometry of the flap and the greater consistency in controlling the thickness of the cut significantly reduce the risk of deeper cuts, which are associated with an increased risk of biomechanical destabilization and evolution to ectasia. The greater post-operative stability of the flap created by the femtosecond is also related to its more perfect fit in the bed. Additionally, the impact of LASIK assisted by femtosecond laser is lower than that performed by the microkeratome on the ocular surface, with a lower incidence of dry eye and neurotrophic epitheliopathy.

Laser techniques used in refractive surgery

The term amblyopia is derived from the Greek amblyopia, which means weak, dull, and ops, which means action to see, vision. It is, therefore, "weak vision" or "vague eye". It consists of a decrease in visual acuity produced by abnormal visual development at an early age, which cannot be directly or exclusively attributed to anomalies of the eye or of the optical pathways. In amblyopia, there is inadequate stimulation of the visual cortex (abnormal or insufficient visual stimulation), being considered the most frequent cause of low vision in childhood, with a prevalence of 2-4%. The underlying cause of all amblyopia is the inability of the visual system to comfortably handle different images from both eyes as a result of abnormal binocular interactions. If there are differences in sharpness in the images (refractive errors), different images (strabismus), totally degraded images (cataracts), or occlusion (ptosis), during childhood, the result is a form of amblyopia.

It is a flaw in the development of visual function that degrades spatial vision and steriopsy, and is usually associated with strabismus, anisometropia or visual deprivation in the early stages of vision development. The abnormal development of central vision as a cause of amblyopia was proven in 1981 by authors David H. Hubel and Torsten Wiesel. The experience carried out by them through direct examination of cats with visual deprivation earned them the Nobel Prize in Medicine.

For Heekeren, Marrett and Ungerleider 15, amblyopia does not only cause a cortical anatomical reduction of the ocular dominance columns of the amblyopic eye, with a major reduction in binocular cells, studies show that visual functions such as contrast sensitivity are reduced not only at high spatial frequencies such as also in the medium and low. Asymmetries in temporo-nasal processing of visual stimuli remain immature in adults with amblyopia and other abilities such as satisfactorily performing spatial alignments, detecting phases of, and peripheral vision are also altered in these individuals.

In adults, amblyopia is usually diagnosed by means of a significant drop in visual acuity, which cannot be corrected with the use of optical compensation.

These are the three major groups for the classification of ambiopia

- Refractive amblyopia, which can be uni or bilateral. In it, the clearest image is always the predominant one. When amblyopia occurs bilaterally, due to high myopia or hyperopia, it is referred to as ametropic amblyopia. Uncorrected astigmatism, where the image is more blurred on one of the two axes, causes southern amblyopia. The significant refractive difference between the two eyes causes anisometropic amblyopia. Anisometropic patients should first try their optical correction before determining whether or not occlusion therapy is necessary. Thus, in refractive amblyopia, the image has a poor resolution and decreased sensitivity to contrast; and
- Strabic amblyopia, which, in children, is revealed as an ocular deviation, which creates two images of the same object in different positions of space. To avoid double vision, the brain will suppress the image with the weakest quality. In adults, diplopia occurs due to poor brain plasticity. Many young patients alternate vision between the two eyes to develop the same visual quality, however, if there is a strong prevalence for deviation of one eye, amblyopia may occur. Strabic amblyopia is always unilateral, being more frequent in cases of endotropy. All amblyopic patients with strabismus require some type of therapy for amblyopia16. In strabic amblyopia, therefore, in addition to the image presenting low resolution, with reduced contrast sensitivity, as occurs in refractive amblyopia, there are also difficulties in spatial location, which can induce monocular adaptation, or an abnormal retinal correspondence;
- Amblyopia due to stimulation deprivation. In this type of amblyopia, conditions such as congenital or acquired cataracts, ptosis or corneal opacity can cause unilateral or bilateral amblyopia. Such conditions involve ocular refractive media and can cause more severe amblyopia. Amblyopia due to deprivation may require optical correction before any amblyopia therapy.

The effects of amblyopia and strabismus have merited some reflection on self-esteem and interpersonal relationships. Amblyopia treatments can range from surgery (in the case of strabismus or opacities), to refractive correction (in cases of accommodative strabismus or anisometropias), including occlusion, as a complement to the treatment. Sometimes, complete correction with glasses is not possible, and it is necessary to decrease the degree of the amblyopic eye to ease anisekonia, or the use of contact lenses. However, some anisometropic amblyopes do not adapt with hypocorrection, nor with the use of lenses. For these patients, refractive surgery appears as a viable alternative.

The duration of treatment is very variable. In some cases it can go up to 6 months, while in others, with greater depth of the problem, such as deprivation amblyopia, children can continue with the occlusion for a longer period. However, many children with amblyopia continue to wear glasses to correct their refractive error, even after specific treatment for amblyopia - occlusion or penalty.

Most children undergoing treatment for amblyopia report that they feel embarrassed due to the application of the occlusion or even with the use of glasses, and this feeling is increased when they are used simultaneously. In adults, refractive surgery with excimer laser to correct myopia, astigmatism and hyperopia has been used successfully. The experience of doctors using excimer laser increases every day, and so do the indications for its use. Such findings allow us to affirm that refractive surgery for anisometropes may become an indication, based on the positive results reported in the literature.

The successful refractive surgery brings very positive changes in the quality of life of most patients, being a method considered safe for the treatment of amblyopia in adults, however, it can present some complications, such as the presence of halos, “glare”, hypo or overcorrections and corneal infections.

Three types of refractive surgeries for laser visual correction are used to reduce amblyopia: PRK, LASIK and SMILE. It is also possible to consider the use of such procedures in special cases of children, in which there is no possibility of carrying out traditional treatment with glasses, contact lenses or occlusion. However, the real need must be considered, since the effectiveness and safety of these procedures were verified with a maximum follow-up of 47 months, with no reports with longer follow-up periods.

PRK was the first surgical technique associated with the excimer laser to correct ametropias. However, it had limitations related to the corneal healing process. Its success was obscured by the advent of LASIK, which fulfilled the requirement of patients to obtain a good visual result in comfort and in a short period of time.

One of the pioneers in personalized refractive surgery was Theo Seiler who, in June 1999, performed the first personalized LASIK, using a Tscherning aberrometer and the Allegretto excimer laser (WaveLight Technologie AG, Germany). The first revised and published results were from Mrochen., *et al*. (2000), from the Seiler team, and were very promising. Three cases have been reported with stroke better than 20/15 at 6 months after surgery. Two eyes gained two lines of MAVC and there was an average reduction of 27% in HOAs. Subsequent publications showed that the advantages of treatment guided by aberrometry included improved visual resolution, contrast sensitivity and also a lower frequency of nocturnal visual complaints.

One of the fundamental factors for personalized results was the nomogram used. In the study by Nuijits., *et al*. (2002), the refractive result was satisfactory, with improvement of the spherical equivalent (EE) from -5.28 ± 2.12D to -0.66 ± 0.40D, with the target correction based on the result measured by the aberrometry. However, 92% of the eyes had EE between ± 0.50D at 6 months PO, with two eyes hypocorrected at -1.00D and -0.88D. These results corroborate the findings of a study conducted by Mrochen., *et al*. Who identified a systematic hypocorrection of 0.67D of the spherical component (EC) in ablation based on Tscherning-type aberrometry.

Regarding HOAs, there was not a reduction in preoperative HOAs, but a tendency towards less induction compared to conventional treatments. In a study involving 140 eyes with myopia up to -7D, the customized ablation of the LADARWave CustomCornea platform showed significantly less induction than conventional ablation.

Studies of the physiology involved in post-PRK corneal healing have shown greater epithelial hyperplasia and stromal remodeling in relation to eyes subjected to LASIK. Epithelial hyperplasia results from an attempt to restore the original shape of the cornea, as well as to restore its surface regularity. Stromal remodeling occurs with the production of keratocytes and reorganization of collagen fibers. Their uniformity and perfect spacing between them are essential for greater corneal translucency.

However, the surgical trauma represented by PRK leads to profound anatomical disorganization. In addition to cellular aggression and anatomical changes, important corneal physiological barriers are broken, leading to the activation of different cellular repair mechanisms.

The procedure called SMILE (Small Incision Lenticule Extraction) was proposed by Sekundo with Visumax (Zeiss-Meditec). It is the most modern technique when it comes to refractive surgery, with a prognosis that, after 24 hours, most patients already have good enough vision to perform their usual activities.

The measurement of the central corneal thickness is essential both for tracking ectasic diseases, as well as for deciding which type of treatment is safer for a given patient, and subsequently planning for laser visual correction surgery. Ultrasound pachymetry is classically considered the gold standard for this measurement, but optical coherence tomography (OCT), Scheimpflug technology or slit scanning are techniques that can provide accurate measurement without the need for contact. In addition, the tomographic approach allows reconstruction of the pachymetry map, with evidence that this approach is more effective in determining the value of the thinnest point using the pachymetry map, as well as for the diagnosis of ectatic diseases. However, the need to perform tomography before laser visual correction surgery can be determined by the surgeon according to each case, assessing whether central pachymetry with ultrasound is suficiente.

SMILE (small incision lenticule extraction (smile) versus laser in-situ keratomileusis (LASIK)

In Brazil, about 40% of people have myopia, which is one of the most frequent refractive errors that affects vision from afar and occurs because the visual image is not focused directly on the retina, but in front of it. Astigmatism, in addition to being a common optical problem, is associated, in most cases, with other refractive problems, such as myopia or hyperopia.

The main concerns for those who are thinking about undergoing the procedure are the recovery time, safety during the surgery, fear of feeling pre and postoperative pain and, for those who know someone who has had the surgery or has already researched the subject, the displacement of “flap”, the layer of the cornea that is partially raised during surgery.

The surgery performed by LASIK consists of applying the excimer laser to reshape the cornea under a "flap", which can be cut with a microkeratome blade or femtosecond laser. In the case of surface ablation or PRK, there is no need to flap. The superficial layer of cells (epithelium) is removed by the surgeon to apply the excimer laser. In addition to making the flap at LASIK, other applications for corneal surgery have increased the applicability of the femtosecond laser. We highlight the tunneling for stromal ring segment implants, corneal biopsy, incisional keratotomy for astigmatism, lamellar and penetrating keratoplasty. The femtosecond laser can create cuts for extraction of lenticles, in the same way as aceratomileusis in situ described by prof. José I. Barraquer in the 50s. The procedure called SMILE (small incision lenticule extraction) was proposed by Sekundo with Visumax (Zeiss-Meditec).

The SMILE (Small Incision Lenticule Extraction) technique is considered more accurate than previous generation equipment. In the SMILE technique, there is no flap or removal of the epithelium. The femtosecond laser VisuMax (ZEISS) performs treatment to create an internal lenticle in the cornea, which is removed by a small incision, 7 times smaller than that performed by the LASIK technique. Compared to these well-known and used operations, the SMILE technique corrects the refractive error of the eye more safely, preserving the biomechanical structure of the cornea and reducing the impact on the production of tears. When compared to other surgical techniques, SMILE is considered more efficient, since the incision is up to 80% smaller, which reduces the risk of dry eye by 99%.

The method is the most modern in the world when it comes to refractive surgery. It provides cutting accuracy, unsurpassed speed, excellent visual control and treatment technique. With a less invasive incision, the intervention is done in just one step and reduces the risk of infections and problems, such as dry eye syndrome and epithelial growth, since healing occurs more quickly. "Among the existing techniques, this is the one that least changes the structure of the cornea, which facilitates post-operative care, which is reduced to the use of eye drops and there is still no risk of displacement or wrinkling of the "flap".

For the same corneal thickness, SMILE is biomechanically 10% stronger than PRK and 25% greater than LASIK. In SMILE, the interactive forces increase when the lenthicle gets deeper, being able to safely treat patients with high myopia. Another great advantage of the Smile technique is the much lower incidence of Dry Eye compared to PRK and LASIK, with the Lenticular Extraction technique, sensitive fibers are spared. The SMILE technique offers precision, reproducibility and safety.

Dry eye disease is considered common and plays an important role in patients' eye comfort and visual performance. Dry eye is often seen after refractive surgery, becoming an increasing challenge for refractive surgeons.

The dry eye occurs after refractive surgery including exacerbation of pre-existing eye disease, the interaction between the ocular surface and the eyelids being an important factor in maintaining the production and flow of tears. Lasik is a popular refractive surgical option, however half of the patients have reported dry eye symptoms after the procedure. The introduction of the femtosecond laser has made the FS-LASIK a more accurate and safer surgical option.

There was an advance in refractive surgery with small incision lenticular extraction - SMILE, and a procedure without a flap was established. The main difference between FS-LASIK and SMILE is the fact that FS-LASIK affects the epithelium and the anterior stroma, resulting in greater resection of the nerves and Smile affects the posterior stromal bed with preservation of the corneal nervous plexus [4-35].

Conclusion

Refractive surgery comprises procedures that aim to decrease and, if possible, eliminate refractive errors (myopia, hyperopia and astigmatism). Several types of lasers have been developed for several applications in ophthalmology, including LASIK and SMILE.

The surgery performed by LASIK consists of applying the excimer laser to reshape the cornea under a "flap", which can be cut with a microkeratome blade or femtosecond laser.

In the SMILE technique, there is no flap or removal of the epithelium. The femtosecond laser VisuMax (ZEISS) performs treatment to create an internal lenticle in the cornea, which is removed by a small incision, but 7 times smaller than that performed by the LASIK technique. In addition, the SMILE technique corrects the refractive error of the eye more safely, preserving the biomechanical structure of the cornea and reducing the impact on the production of tears. Consider, further, that, for the same corneal thickness, SMILE is biomechanically 10% stronger than PRK and 25% greater than LASIK. In SMILE, interactive forces increase when the lenthicle gets deeper, which makes it possible to safely treat patients with high myopia.

Thus, when compared to LASIK and other refractive surgical techniques, SMILE has been considered to be the most efficient, considering that the incision is up to 80% smaller, thereby reducing the risk of dry eye by 99%, in addition to presenting greater biomechanical strength for the same corneal thickness, being also a safe treatment to be used in patients with high myopia.

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