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The use of femtosecond laser in surgery assisted cataract

O uso do laser de femtosegundo na cirurgia da catarata assistida

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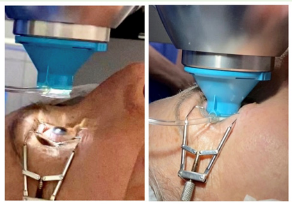
ABSTRACT
Introduction: There are several techniques for treating cataracts that have been used for many decades. The femtosecond laser emerged more recently, but there are few studies on its use.
Objective: Review over published results to better positioning their indications and use.
Method: Narrative review carried out on virtual platforms in Portuguese and English, using SciELO, Google Scholar, Pubmed and Scopus with the following descriptors "cataract, phacoemulsification, femtosecond laser" with AND or OR search.
Result: At the end, 37 articles were included.
Conclusion: Despite the high cost and lack of experience with the platforms, it is believed to be important for ophthalmologists in training to develop knowledge and skills regarding technological innovations such as FLACS.
KEYWORDS: Cataract. Phacoemulsification. Femtosecond laser.

RESUMO
Introdução: Existem várias técnicas para o tratamento da catarata e usadas há muitos décadas. Mais moderanemnte surgiu o laser de femtosegundo, mas existem poucos estudos com seu uso.
Objetivo: Revisar dos resultados publicados para posicionar melhor suas indicações e uso.
Método: Revisão narrativa feita em plataformas virtuais em português e inglês, utilizando SciELO, Google Scholar, Pubmed e Scopus com os seguintes descritores "catarata, facoemulsificação, laser de femtosegundo" com busca AND ou OR.
Resultado: Ao final incluíram-se 37 artigos.
Conclusão: Apesar do alto custo e falta de experiência com as plataformas, acredita-se ser importante para oftalmologistas em formação desenvolverem conhecimentos e habilidades acerca de inovações tecnológicas como a FLACS.
PALAVRAS-CHAVE: Catarata. Facoemulsificação. Laser de femtosegundo.



Femtosecond laser: Patient Interface (PI) coupling in vacuum formation (docking)

Central Message

The constant evolution of medicine and the greater demand of patients demand the need to adapt to new technologies, and to know when and how much they bring benefits. There are several techniques for the treatment and used for many decades and more recently the femtosecond laser has emerged. There are few studies with its use and so review of the results is appropriate.

Perspective

Despite the difficulties of educational institutions with the high cost and lack of experience with the platforms, it is believed to be important for ophthalmologists in training to develop knowledge and skills about technological innovations, such as FLACS. Likewise, it is imperative that institutions have teaching protocols in surgery in order to standardize routine and allow analyzing failures that can be improved over time.

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INTRODUCTION

The constant evolution of medicine and the greater demand of patients demand the need to adapt to new technologies, and to know when and how much they bring benefits. Therefore, it is important that physicians in subspecialization have access to state-of-the-art technologies and guidance on how to use them in order to obtain security when starting or improving their professional ophthalmological career, following the progression of medicine. There are several techniques for the treatment and used for many decades and more moderately the femtosecond laser has emerged. There are few studies with its use and so review of the results is appropriate.

METHOD

This is a narrative review of the literature made by collecting information published on virtual platforms in Portuguese and English. The analysis was carried out on the SciELO, Google Scholar, Pubmed, and Scopus platforms. First, a search was carried out for descriptors related to the theme with the following terms: "Cataract. Phacoemulsification. Femtosecond laser" with AND or OR OR search, considering the title and/or abstract. Secondly, those that were more related to the theme were separated for the full reading of the texts. In the end, 37 articles were included.

DISCUSSION

Faceectomy is the most performed intraocular procedure in the world and also one of the oldest. In its early days, the lens and the capsular sac were dislocated to the vitreous (couching technique) or removed through a large incision in the cornea (intracapsular technique), both without intraocular lens (IOL) implantation and with greater chances of complications such as glaucoma and retinal detachment. The emergence of the extracapsular technique allowed the vitreous humor not to migrate to the anterior segment, reducing surgical complications and creating capsular support, since in this technique only the lens was removed, preserving the capsular sac. This support would later be used to assist in the positioning of the IOL.[1,2]

In 1940, Harold Ridley developed the first polymethylmethacrylate IOL, with the aim of reducing the weight of the glasses that were necessary to provide vision to the operated patient.[3] Thirty years after the invention, the IOL had its importance recognized and, since then, new technologies have been studied with the objective of not only restoring vision, but delivering greater accuracy for various focal lengths without the need to wear glasses.[4]

Phacoemulsification emerged in 1967 with Charles Kelman and revolutionized cataract surgery. Over the decades, it has remained in constant improvement and has become the most used technique since then. Through it, it is possible to perform the operation by microincision in the cornea, without the need for suturing and with low complication rates.[5] Traditional phacoemulsification consists of making a main microincision in the cornea (≥1.[8] mm) and an accessory microincision (around 1 mm), both made with millimeter scalpel blades. Once the anterior chamber is accessed, it is filled with viscoelastic, a transparent and viscous substance that allows the anterior chamber not to stick with the exit of the aqueous humor through the incisions. With the pupil dilated, the capsular bag is opened manually through surgical forceps, where the confection of a perfect circle with a diameter of around 5 mm is planned. This step is called capsulotomy or capsulorrhexis and requires extremely precise and delicate manual movement over the thin capsular membrane, where any carelessness can make the capsulorhexis discontinuous, compromising the safety of the procedure. With access to the lens, hydrodissection is performed so that it detaches from the capsular sac. The next step is the fragmentation and aspiration of the lens, through pulsed ultrasound waves and the irrigation and aspiration system generated by the phacoemulsification device.[2,4,5]

There are techniques for the lens to be fragmented efficiently,2 among them the "Divide and Conquer".[6,7] The most taught technique in teaching services, especially in the initial operations, is it,8,9 where 2 grooves forming a cross are sculpted in the cataract by ultrasonic energy from the phacofragation pen, allowing the division into 4 quadrants and aspiration of the parts individually.[6] The increase in temperature and the vibrations emitted by ultrasound in the phacoemulsification process dissipate heat and energy, which can be harmful to corneal endothelial cells. The measurement of this energy is presented during operation by the device, in the acronym CDE (cumulative dissipated energy), where low values are aimed at reducing cellular aggression. The denser the cataratous nucleus, in general, the larger the CDE.[10-12] With the capsular bag empty, it is possible to implant the IOL inside it. This has haptics that are fixed inside the capsular sac, without the need for sutures.[13] After IOL implantation, the viscoelastic is aspirated and the incisions are hydrated for self-sealing. The operation is considered fast and the only surgeon may be able to perform 1,000 to 2,000 operations per year, in high-demand services.[8]

Femtosecond laser-assisted cataract surgery (FLACS) began in the United States of America in 2009,14 and is considered one of the greatest technological advances in surgical ophthalmology in the last decade.[15] The association of laser in conventional surgery has brought benefits to the surgeon and the patient, increasing the precision of steps that were previously done manually, making them reproducible.[14-17]

The femtosecond laser is an Nd:glass laser that can generate ultrashort pulses in the time span of femtoseconds (10-15 s), which allows cutting tissues with reduced energy compared to other pulsed lasers such as the Nd:YAG, excimer and argon laser. This reduced energy allows you to cut only the treatment site, with minimal collateral damage to adjacent tissues. Its cutting is done by photodisruption, a process in which electron-free plasma and ionized molecules are generated that rapidly expand and collapse to produce microcavitation bubbles and acoustic shock waves, resulting in incision and separation of tissues.[18]

In cataract surgery, the laser is used to make incisions in the cornea, capsulotomy and fragmentation of the lens nucleus. The device bases its reading on an optical coherence tomography system, which scans the ocular anatomy during the execution of the procedure. The FLACS technique, due to its high precision, would bring benefits such as: improvement of the architecture of corneal incisions, improving their sealing at the end of opeaction16,19,20, reproducibility in the size and position of the capsulotomy.[10,13-17,20] For experienced surgeons, the manual technique tends to generate variable patterns,18 which can lead to IOL decentralization13,20 and a reduction in the amount of CDE during phacoemulsification. This may occur because the energy dissipated by the laser in the lens sections is less than that carried out by ultrasound, leading to less endothelial loss.[11,12,14,18,19,21-24]

From the above, it is concluded that the safety margin of the surgical procedure increases and the results improve.[14,16,20,21,25] However, the benefits of using laser in cataract surgeries are controversial in the literature.

Despite the advantages described, the safety and visual results may not be superior to the conventional phacoemulsification technique.[17,25-29] Among the factors that hinder the use of laser in ophthalmology services worldwide, the main ones are the high cost of equipment, the lack of scientific proof of results that justify the investment, and the lack of experience of surgeons with the new surgical technique.[16,25,26,30,31]

FLACS consists of 2 steps: the application of the laser in the femtosecond device, and the aspiration of the cataract in the phacoemulsification device.[10,15,17,20]

In the laser stage of the LenSx® device (Alcon Laboratories, Inc., Fort Worth, TX, USA), it is fed with patient identification and surgical planning data, entered manually. The incision in the cornea can be adjusted in its angle, size, and shape; capsulotomy in its diameter; and the fractures of the lens in number, shape and depth. The patient is then laid on the stretcher in the supine position, where he is positioned under the LenSx® obturator. Sedatives can be applied, but the patient must remain conscious. A specific contact lens (SoftFit PI) is attached to a disposable piece that will be fixed to the patient interface (PI), which will make contact with the patient's eye, allowing gripping by induced vacuum, stabilizing the eye for the surgical procedure (Figure 1).[32]

The coupling of the PI and any step where the vacuum is driven is called docking. This step is crucial, because if it is not possible to adequately centralize the eye in the IP, the vacuum may be lost during the procedure or the internal structures may be left out of position, usually tilted or tilted, which may make the application of the laser unfeasible. Part of the good positioning of the PI depends on the patient's collaboration in fixing on the internal light of the shutter and not moving the head.[18,20,33] After touching the cornea, the PI is pressed against the eye in order to remove the air between it and the corneal surface, and then a vacuum is applied. The presence of air in the treatment areas can prevent the application of the laser at the planned location. With the vacuum formed, the patient's eye can be viewed in real time on the device's monitor, with the image of the surgical planning superimposed on it. In the first mesh, it is possible to position the corneal incisions in a radial direction, away from or near the limbus, center the capsulorhexis as well as adjust its size, and adjust the diameter of the crystalline sections (Figure 2).

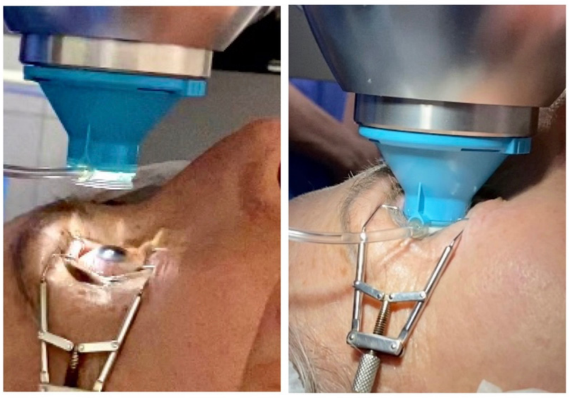

FIGURE 1 — Coupling of the Patient Interface (PI) to the eye for vacuum formation (docking step)

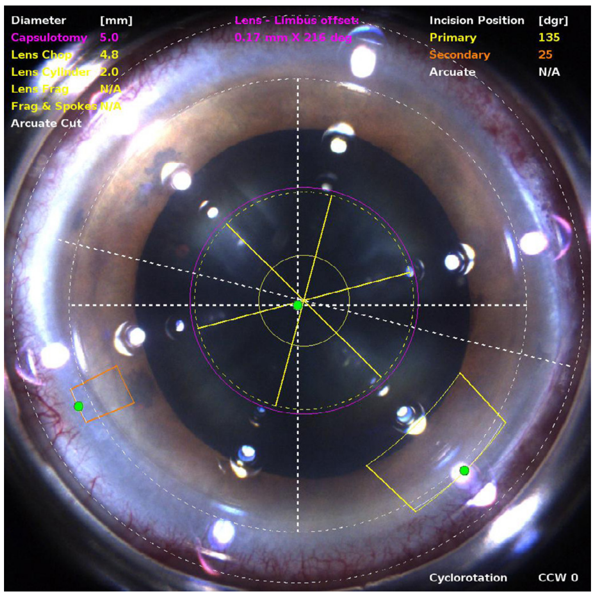

FIGURE 2 — Intraoperative planning of the position of the main and accessory cornea incisions, capsulotomy and crystalline chops

On the next screen, the crystalline tilt is verified through the OCT (optical coherence tomography) image in real time on the device. Here, the anterior capsule of the lens should be as close as possible to a straight line, and an "S" pattern with slightly accentuated curves is also acceptable32 (Figure 3A). If the tilt is moderate or sharp, you should redo the docking.[18] The depth of the crystalline cut is also adjusted by the OCT screen, so as to encompass its entire core, respecting the safety limit for the posterior capsule shown by the device (Figure 3B).

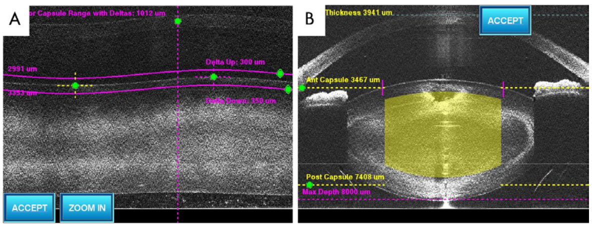

FIGURE 3 — Visibility in intraoperative OCT: A) the entire capsulotomy area; B) depth of treatment in cataract

The next screen will show the location and shape of the corneal incisions on the monitor.[32] The main incision is usually bi- or triplanar, with the epithelial opening located in the clear cornea or in the limbal region, depending on the planning18 (Figure 4).

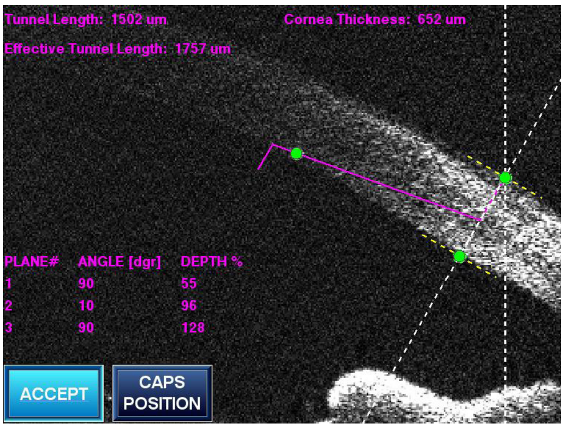

FIGURE 4 — OCT of the main corneal incision, showing its architecture and extension

The limbus is recognized on OCT imaging by the transition from the cornea - dark area - to the eslera - light area. After checking that all the steps are correct, the laser is released, and its application is performed by pressing the pedal. After the laser is finished, the vacuum is released and the PI removed.[32] The next step is in the phacoemulsification device, where it follows a pattern similar to the conventional operation, with the advantages of more delicate steps having already been performed by the laser.[14-16,20,25]

Bali et al.[33] described the presence of capsulorhexis adhesions (tags) in 10.[5%] of the cases, leading to 4% of previous ruptures, the same incidence of ruptures as Nagy Z et al.[14] in 2009. Han SB et al.[18] in a 2020 review article, states that tags can still occur when there are difficulties in positioning the PI during docking, leading to lens tilt and cut at different depths in the anterior segment, forming capsular tags and incomplete capsulotomies. These complications diminish with the learning curve. The femtosecond laser's "grid" pattern for core fragmentation can reduce the need for ultrasonic energy for its aspiration.[22]

Studies show that the learning curve in FLACS presents more frequent complications in the first 200 operations, even when performed by surgeons already experienced in conventional cataract surgeries, while in traditional phacoemulsifications the complications decrease after an average of 80 surgeries. However, when taught and supervised by preceptors in educational institutions, FLACS are safe, with complication rates similar to conventional surgery.[14,33-36] Popayales et al.[37] noted that for both experienced and non-experienced surgeons, the rates of suction loss and vacuum time have progressively reduced with the increasing volume of surgeries on the Catalys® platform. Vacuum time reduced from 137s to 99s, and the number of complications also reduced with increasing surgical volume. The report of the apprentice's surgical experience to his preceptor is important for him to provide guidance on specific points, so that the difficulties can be alleviated. In the present study, the 2 phacorrefractive surgeons performed more than 10 surgeries. Despite the orientations of the preceptors based on the difficulties reported and on direct observation of the stages, there were no signs of evolution after the 10th surgery. This suggests that a larger surgical volume is necessary for there to be a significant favorable change in the variables analyzed. At the same time, as described, we obtained results similar to those in the literature, where most studies analyze experienced surgeons and not in learning. Therefore, the existence of a protocol may have favored us.

Of the bibliographic references found, most of the studies that analyze FLACS results do not evaluate the operations during the ophthalmological subspecialization phase,31 and few describe variables about the laser stage. In general, the complications of FLACS reported are from the phacoemulsification step, and not from the laser application, stating that the learning curve seems to stabilize after 200 operations.[21,33]

CONCLUSION

Despite the difficulties of educational institutions with the high cost and lack of experience with the platforms, it is believed to be important for ophthalmologists in training to develop knowledge and skills about technological innovations such as FLACS. Likewise, it is imperative that institutions have teaching protocols in surgery in order to standardize routine and allow analyzing failures that can be improved over time.

Authors' contributions

Conceptualization: Felipe Roberto Exterhotter Branco
Investigation: Hamilton Moreira
Methodology: Felipe Roberto Exterhotter Branco, Hamilton Moreira
Writing (original draft): All authors
Writing (proofreading and editing):All authors

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