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Refractive Error Correction in Bali, Indonesia: A Retrospective Cohort Study of ReLEx SMILE and Femto-LASIK Outcomes

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A B S T R A C T

Introduction: Technological advances have driven progress in surgical techniques for refractive problems, including the use of laser-assisted in situ keratomileusis (LASIK) through the ReLEx SMILE and Femto-LASIK methods. While Bali Mandara Eye Hospital pioneered LASIK procedures in Bali Province, there has been no research to date evaluating the outcomes of these procedures. **Methods:** This retrospective cohort study analyzed medical record data from patients with refractive disorders who underwent LASIK surgery at Bali Mandara Eye Hospital between January and December 2023. The data collected included patient demographics, pre-and post-operative visual acuity, and the type of LASIK surgery performed. **Results:** The study included 151 eyes. The majority of patients were male (52.3%), aged 17-29 years, had a college education (60.3%), worked in the private sector (38%), resided in Bali (86%), and underwent the ReLEx SMILE procedure (60.3%). Both Femto-LASIK and ReLEx SMILE procedures yielded excellent visual outcomes and were considered safe. Post-operative uncorrected visual acuity (UCVA) improved to the level of pre-operative best-corrected visual acuity (BCVA) in 137 eyes (90.73%). **Conclusion:** The ReLEx SMILE and Femto-LASIK methods are both safe and effective procedures for correcting refractive errors, particularly mild myopia. There was no significant difference in visual outcomes between the two methods.

1. Introduction

Refractive errors, encompassing myopia (nearsightedness), hyperopia (farsightedness), and astigmatism, stand as a prevalent cause of vision impairment on a global scale. The World Health Organization (WHO) identifies refractive errors as the primary contributor to vision impairment and the second leading cause of vision loss worldwide, accounting for 43% of all vision impairment cases. In Indonesia, the 2013 Basic Health Research (Riskesdas) revealed a 42% prevalence of refractive errors as a major cause of blindness.[1,2] Traditionally, the management of refractive errors has relied on eyeglasses, contact lenses, and surgical interventions. Among these, Laser-Assisted in situ Keratomileusis (LASIK) has emerged as a well-established surgical technique employed to correct myopia, hyperopia, and astigmatism by reshaping the cornea. This procedure has gained considerable popularity due to its high success rates, minimally invasive nature, and rapid visual recovery.[3,4] Advancements in technology have paved the way for the development of two innovative LASIK techniques: ReLEx SMILE and Femto-LASIK. ReLEx SMILE (Refractive Lenticule Extraction, Small Incision Lenticule Extraction) is a flapless procedure that utilizes a femtosecond laser to create a small incision and extract a lenticule of corneal tissue, effectively correcting the refractive error. Femto-LASIK, conversely, involves the creation of a corneal flap using a femtosecond laser, followed by excimer

laser ablation to reshape the cornea.[5-7]

Several studies have been conducted to compare the safety, efficacy, and predictability of ReLEx SMILE and Femto-LASIK in correcting refractive errors, particularly myopic astigmatism. While some studies have indicated differences in post-operative outcomes between the two methods, others have found no significant difference in visual acuity.[8-10] This study aims to evaluate the demographics, outcomes, and safety of LASIK procedures performed using the ReLEx SMILE and Femto-LASIK methods at Bali Mandara Eye Hospital. The findings of this study will contribute to the existing body of knowledge on refractive surgery and assist in guiding clinical decision-making for the management of refractive errors.

2. Methods

This retrospective cohort study meticulously examined medical records belonging to patients with refractive disorders who underwent LASIK surgery at Bali Mandara Eye Hospital. The study period spanned from January 1st to December 31st, 2023. Ethical approval for this research was granted by the hospital's ethics committee, ensuring adherence to ethical guidelines and patient confidentiality. The study population encompassed all patients who underwent LASIK surgery during the specified study period. Data extraction from medical records was conducted with precision, focusing on the following key variables; Age: Recorded in years, capturing the age of the patient at the time of surgery; Gender: Categorized as male or female; Education Level: Classified into distinct levels, such as primary, secondary, and tertiary education, providing insights into the patients' educational backgrounds; Occupation: Documented to understand the patients' professional fields and potential implications for visual demands; Domicile: Recorded to assess geographical distribution and potential environmental influences on refractive errors; Type of LASIK Surgery: Categorized as either ReLEx SMILE or Femto-LASIK, distinguishing between the two surgical techniques under investigation; Pre-operative Uncorrected Visual Acuity (UCVA): Measured without any visual aids, representing the baseline visual acuity before surgery; Post-operative UCVA: Measured without visual aids at a designated follow-up period, reflecting the visual acuity achieved after surgery; Pre-operative Best-Corrected Visual Acuity (BCVA): Measured with the optimal refractive correction, representing the best possible visual acuity with glasses or contact lenses before surgery.

Stringent inclusion and exclusion criteria were applied to ensure the selection of an appropriate study sample. Patients were included if they met the following criteria; Diagnosis: A confirmed diagnosis of myopia, hyperopia, or astigmatism, the refractive errors targeted by LASIK surgery; Surgical Intervention: Underwent LASIK surgery at Bali Mandara Eye Hospital within the specified study period. Conversely, patients were excluded if they met any of the following criteria; Incomplete Medical Records: Cases with missing or insufficient data that could compromise the analysis were excluded; Neurological or Systemic Disorders: Patients with neurological or systemic conditions that could potentially affect visual acuity or surgical outcomes were excluded to minimize confounding factors; Ocular Diseases: Patients with ocular diseases other than refractive errors, such as glaucoma or cataracts, were excluded to maintain the focus on refractive error correction.

Visual acuity, a crucial outcome measure in this study, was assessed using the Snellen chart, a standardized tool for measuring visual acuity. The Snellen chart displays letters of progressively decreasing sizes, and the patient's visual acuity is determined by the smallest line of letters they can read accurately from a standardized distance. The visual acuity measurements were then converted to LogMAR (logarithm of the minimum angle of resolution) scores for statistical analysis. LogMAR is a logarithmic scale that provides a more precise and linear representation of visual acuity compared to the traditional Snellen fraction; Uncorrected Visual Acuity (UCVA): This measure represents the patient's visual acuity without

any corrective lenses or surgical intervention. It reflects the baseline visual function before any treatment; Best-Corrected Visual Acuity (BCVA): This measure represents the patient's best possible visual acuity with the optimal refractive correction, achieved through glasses or contact lenses. It reflects the potential visual acuity that could be achieved with ideal correction.

The two LASIK surgical techniques employed in this study, ReLEx SMILE and Femto-LASIK, represent advanced approaches to refractive error correction. Both techniques utilize sophisticated laser technology to reshape the cornea and improve visual acuity. ReLEx SMILE is a flapless technique that distinguishes it from traditional LASIK. It involves the following steps; Femtosecond Laser Application: A femtosecond laser, a high-precision laser emitting ultrashort pulses, is employed to create a small incision in the cornea, typically ranging from 2 to 4 millimeters; Lenticule Creation: The femtosecond laser is then used to create a refractive lenticule, a disc-shaped piece of corneal tissue, within the cornea. The lenticule's shape and size are precisely calculated based on the patient's refractive error; Lenticule Extraction: The surgeon extracts the lenticule through the small incision, reshaping the cornea and correcting the refractive error. Femto-LASIK, while also utilizing a femtosecond laser, differs from ReLEx SMILE by creating a corneal flap. The procedure involves the following steps; Flap Creation: A femtosecond laser is used to create a thin, hinged flap in the cornea; Flap Lifting: The surgeon carefully lifts the corneal flap, exposing the underlying corneal tissue; Excimer Laser Ablation: An excimer laser, a different type of laser that removes microscopic layers of corneal tissue, is then applied to reshape the cornea and correct the refractive error; Flap Repositioning: The corneal flap is repositioned and smoothed down to cover the treated area.

The data collected in this study were meticulously analyzed using statistical software, specifically Microsoft Excel 2019 and SPSS version 27.0. These software packages provide a comprehensive suite of statistical tools for data management, analysis, and visualization. Descriptive statistics were employed to summarize and characterize the study population and visual acuity outcomes. These statistics included; Measures of Central Tendency: Mean, median, and mode were used to describe the typical or central values of the data; Measures of Dispersion: Standard deviation, range, and interquartile range were used to describe the variability or spread of the data; Frequency Distributions: Frequency tables and histograms were used to display the distribution of data across different categories or values.

Inferential statistics were employed to draw conclusions about the study population based on the sample data. The specific statistical tests used included; Mann-Whitney U Test: This non-parametric test was used to compare the efficacy of ReLEx SMILE and Femto-LASIK in improving visual acuity. It assesses whether there is a statistically significant difference in the distribution of visual acuity outcomes between the two groups; Wilcoxon Signed Ranks Test: This non-parametric test was used to compare pre-operative BCVA and post-operative UCVA within each group. It assesses whether there is a statistically significant difference in the distribution of visual acuity before and after surgery. The significance level, denoted by alpha (α), was set at 0.05 for all statistical tests. This signifies that a p-value of less than 0.05 was considered statistically significant, indicating that the observed results were unlikely to have occurred by chance alone.

3. Results

Table 1 presents the demographic and clinical characteristics of the 151 patients who underwent LASIK surgery at the Bali Mandara Eye Hospital. The average age of patients was 28.8 years, with the majority falling within the 17-29 year age bracket. This aligns with the general trend of younger individuals seeking refractive correction for lifestyle and professional reasons. There was a near-equal distribution between males (52.3%) and females (47.7%), suggesting that both genders are equally

likely to undergo LASIK surgery. A significant proportion of patients worked in the private sector (37.7%) and had a college education (58.9%). This may reflect a greater awareness and affordability of LASIK surgery among this demographic. Most patients were from Bali (85.4%), which is expected given the hospital's location. However, the presence of patients from outside Bali (14.6%) indicates the hospital's reputation and reach beyond the immediate vicinity. A greater number of patients opted for the ReLEx SMILE procedure (60.3%) compared to Femto-LASIK (39.7%). This could be attributed to the potential advantages of ReLEx SMILE, such as faster recovery and reduced dry eye symptoms, though further investigation is needed to confirm this.

Table 1. Demographic and clinical characteristics of the study population.

Characteristic	**ReLEx SMILE (n=91)**	**Femto-LASIK (n=60)**	**Total (n=151)**
Age (years)			
Mean ± SD	28.5 ± 7.2	29.3 ± 8.1	28.8 ± 7.6
Range	18-45	19-48	18-48
Gender			
Male	49 (53.8%)	30 (50.0%)	79 (52.3%)
Female	42 (46.2%)	30 (50.0%)	72 (47.7%)
Occupation			
Private sector	36 (39.6%)	21 (35.0%)	57 (37.7%)
Government employee	22 (24.2%)	15 (25.0%)	37 (24.5%)
Student	18 (19.8%)	12 (20.0%)	30 (19.9%)
Others	15 (16.5%)	12 (20.0%)	27 (17.9%)
Education level			
High school	30 (33.0%)	21 (35.0%)	51 (33.8%)
College	55 (60.4%)	34 (56.7%)	89 (58.9%)
Others	6 (6.6%)	5 (8.3%)	11 (7.3%)
Place of residence			
Bali	78 (85.7%)	51 (85.0%)	129 (85.4%)
Outside Bali	13 (14.3%)	9 (15.0%)	22 (14.6%)

Table 2 provides a comparative analysis of pre-and post-operative visual acuity between the ReLEx SMILE and Femto-LASIK groups. Both groups exhibited similar levels of visual acuity before surgery, with no statistically significant difference in BCVA (p=0.87) or UCVA (p=0.42). This indicates that the groups were comparable in terms of their baseline visual function. Both ReLEx SMILE and Femto-LASIK led to significant improvements in UCVA at all follow-up time points (day 1, week 1, and month 1). The lack of statistically significant differences in post-operative UCVA between the groups ($p>0.05$ for all time points) suggests that both techniques are equally effective in enhancing visual acuity. The substantial improvement in UCVA from pre-operative levels to all post-operative assessments highlights the effectiveness of both ReLEx SMILE and Femto-LASIK in correcting refractive errors.

Table 2. Comparison of pre-and post-operative visual acuity between ReLEx SMILE and Femto-LASIK groups.

Variable	ReLEx SMILE (n=91)	Femto-LASIK (n=60)	p-value
Pre-operative BCVA (LogMAR)	0.12 ± 0.08	0.11 ± 0.07	0.87
Pre-operative UCVA (LogMAR)	0.75 ± 0.21	0.78 ± 0.23	0.42
Post-operative UCVA (LogMAR) - Day 1	0.15 ± 0.11	0.16 ± 0.12	0.63
Post-operative UCVA (LogMAR) - Week 1	0.08 ± 0.06	0.09 ± 0.07	0.38
Post-operative UCVA (LogMAR) - Month 1	0.05 ± 0.04	0.06 ± 0.05	0.21

Table 3 presents the potential complications observed following ReLEx SMILE and Femto-LASIK procedures. The total complication rate was 13.2%, with no significant difference between ReLEx SMILE (13.2%) and Femto-LASIK (13.3%). This suggests that both techniques have a similar safety profile. Dry eye syndrome was the most common complication, occurring in 2.0% of patients. Although slightly more frequent in the ReLEx SMILE group, the difference was not statistically significant. DLK and Epithelial Ingrowth complications were rare, each occurring in only 0.7% of patients. Transient Light Sensitivity was the second most common complication, affecting 5.3% of patients. The similar occurrence in both groups indicates that this is a general post-operative effect rather than technique-specific. Undercorrection/Overcorrection refractive complications occurred in a small percentage of patients (3.3% and 1.3%, respectively), highlighting the precision of both techniques.

Table 3. Potential complications.

Complication	ReLEx SMILE (n=91)	Femto-LASIK (n=60)	Total (n=151)
Dry eye syndrome	2 (2.2%)	1 (1.7%)	3 (2.0%)
Diffuse lamellar keratitis (DLK)	0 (0%)	1 (1.7%)	1 (0.7%)
Epithelial Ingrowth	1 (1.1%)	0 (0%)	1 (0.7%)
Transient light sensitivity	5 (5.5%)	3 (5.0%)	8 (5.3%)
Undercorrection	3 (3.3%)	2 (3.3%)	5 (3.3%)
Overcorrection	1 (1.1%)	1 (1.7%)	2 (1.3%)
Total	12 (13.2%)	8 (13.3%)	20 (13.2%)

Table 4 displays the comparison between post-operative uncorrected visual acuity (UCVA) at 1 week and pre-operative best-corrected visual acuity (BCVA), categorized by the type of LASIK procedure (ReLEx SMILE or Femto-LASIK). A high percentage of patients in both the ReLEx SMILE (91.2%) and Femto-LASIK (90.0%) groups achieved post-operative UCVA comparable to their pre-operative BCVA. This indicates that both procedures effectively corrected refractive errors to the desired target vision. A small proportion of patients in both groups (4.0% overall) experienced post-operative UCVA that was even better than their pre-operative BCVA. This suggests that in some cases, LASIK can lead to visual acuity exceeding the best possible correction with glasses or contact lenses. A small percentage of patients (5.3% overall) had post-operative UCVA that did not reach their pre-operative BCVA. This highlights that while LASIK is highly effective, it may not achieve the desired visual outcome in all cases.

Table 4. The comparison between post-operative UCVA at 1 week and pre-operative BCVA, categorized by the type of LASIK procedure.

Comparison	ReLEx SMILE (n=91)	Femto-LASIK (n=60)	Total (n=151)
UCVA comparable to pre-op BCVA	83 (91.2%)	54 (90.0%)	137 (90.7%)
UCVA better than pre-op BCVA	3 (3.3%)	3 (5.0%)	6 (4.0%)
UCVA worse than pre-op BCVA	5 (5.5%)	3 (5.0%)	8 (5.3%)

4. Discussion

The study population predominantly comprised young adults, college-educated individuals working in the private sector, and residing in Bali. This demographic profile aligns with observations from other studies on LASIK surgery. The prevalence of LASIK surgery among young adults can be attributed to their desire to enhance their quality of life and reduce reliance on glasses or contact lenses, particularly in a world increasingly dominated by digital screens and visual demands. The higher proportion of college-educated individuals and those employed in the private sector may reflect greater awareness and affordability of LASIK surgery within this demographic. This observation underscores the importance of continued efforts to raise awareness and improve access to refractive surgery across all socioeconomic strata. The predominance of young adults seeking LASIK surgery is not surprising, considering the numerous benefits this procedure offers to this demographic. Young adults are often highly motivated to achieve optimal vision without the need for corrective eyewear. Freedom from glasses and contact lenses can significantly enhance participation in sports, travel, and other activities that may be hindered by corrective eyewear. For instance, individuals who enjoy swimming, contact sports, or outdoor adventures may find glasses or contact lenses cumbersome or impractical. LASIK surgery offers the freedom to engage in these activities without the limitations imposed by corrective eyewear. Moreover, traveling without the need to pack and care for glasses or contact lenses can be liberating and convenient. Many young adults perceive glasses or contact lenses as a cosmetic burden, and LASIK provides an opportunity to improve their appearance and self-confidence. In today's image-conscious society, physical appearance plays a significant role in self-esteem and social interactions. Some individuals may feel that glasses or contact lenses detract from their desired appearance or make them feel self-conscious. LASIK surgery can address these concerns by eliminating the need for corrective eyewear, allowing individuals to embrace their natural appearance and boost their self-confidence. In today's competitive job market, optimal vision without reliance on corrective aids can be perceived as a professional advantage. Certain professions, such as aviation, law enforcement, and healthcare, have strict vision requirements. LASIK surgery can help individuals meet these requirements and pursue their desired career paths without limitations. Moreover, even in professions without strict vision requirements, optimal vision can enhance productivity, performance, and overall professional success. The overrepresentation of college-educated individuals and those employed in the private sector raises important considerations regarding access and equity in refractive surgery. While LASIK technology has advanced significantly, cost remains a barrier for many individuals. The higher prevalence among those with greater financial resources highlights the need for strategies to improve affordability and access to refractive surgery for all. The socioeconomic disparities in LASIK access reflect broader inequalities in healthcare access and affordability. Individuals with lower incomes and limited access to private health insurance may face significant financial barriers to undergoing LASIK surgery. This disparity can perpetuate existing inequalities, as those with greater financial resources are more likely to benefit from the latest advancements in vision correction technology. Educating the public

about the benefits and affordability of refractive surgery can increase awareness and encourage individuals to seek treatment. Public awareness campaigns can dispel misconceptions about LASIK surgery, such as its safety and cost, and highlight its potential to improve quality of life. These campaigns can utilize various media channels, including television, radio, print media, and social media, to reach a broad audience. Offering flexible financing plans and payment options can make LASIK more accessible to those with limited financial resources. Many LASIK providers offer financing plans with low monthly payments or deferred interest options. These plans can make LASIK surgery more manageable for individuals who may not be able to afford the upfront cost. In some countries, government subsidies or insurance coverage can help reduce the cost of refractive surgery for eligible individuals. Government intervention can play a significant role in improving access to refractive surgery. Subsidies or insurance coverage can help alleviate the financial burden for low-income individuals and make LASIK surgery more affordable. Non-profit organizations and charitable foundations can play a role in providing financial assistance to those who cannot afford refractive surgery. Charitable organizations can offer grants or scholarships to individuals who meet certain criteria, such as income level or visual impairment severity. These initiatives can help bridge the affordability gap and make LASIK surgery accessible to a wider population. Technological advancements continue to drive down the cost of LASIK surgery, making it more accessible to a wider population. The development of more efficient lasers and streamlined surgical techniques has contributed to lower procedure costs. As technology continues to advance, we can expect further reductions in the cost of LASIK surgery, making it more affordable for a greater number of individuals. Furthermore, the emergence of new refractive correction options, such as implantable collamer lenses (ICLs) and small incision lenticule extraction (SMILE), provides alternatives for individuals who may not be suitable candidates for traditional LASIK. These alternative procedures may offer advantages in terms of safety, efficacy, or cost-effectiveness for specific patient populations.[11,12]

Both ReLEx SMILE and Femto-LASIK procedures demonstrated significant improvements in visual acuity, with no statistically significant difference between the two methods. This finding supports previous research indicating that both techniques are equally effective in correcting refractive errors. The choice between ReLEx SMILE and Femto-LASIK should be individualized, considering factors such as corneal thickness, refractive error, lifestyle preferences, and the patient's risk tolerance. ReLEx SMILE, being a flapless procedure, may be favored in individuals with thinner corneas or those engaged in contact sports or occupations with a higher risk of eye trauma. Femto-LASIK, on the other hand, may be preferred in cases with higher refractive errors or when customization of the flap is desired. To further understand the comparable efficacy observed in this study, let's delve deeper into the nuances of ReLEx SMILE and Femto-LASIK, exploring their mechanisms, advantages, and limitations. ReLEx SMILE (Refractive Lenticule Extraction, Small Incision Lenticule Extraction) represents a paradigm shift in refractive surgery, offering a flapless alternative to traditional LASIK. This innovative technique utilizes a femtosecond laser, a high-precision laser emitting ultrashort pulses of light, to create a small lenticule, a lens-shaped piece of corneal tissue, within the cornea. This lenticule is then extracted through a tiny incision, typically 2-4mm, resulting in the desired refractive correction. One of the most common complications associated with LASIK is dry eye syndrome, characterized by a gritty sensation, burning, and blurred vision. This complication arises from the disruption of corneal nerves during flap creation. SMILE's flapless approach minimizes disruption to these nerves, potentially leading to a lower incidence of dry eye syndrome. Studies have shown that SMILE may indeed be associated with less severe and less frequent dry eye symptoms compared to Femto-LASIK. Patients undergoing SMILE often experience rapid

visual recovery due to the less invasive nature of the procedure. The smaller incision and minimal disruption to the corneal structure contribute to faster healing and quicker return to optimal vision. Many patients report significant improvement in their vision within the first 24 hours after SMILE surgery, allowing them to resume their daily activities sooner. The cornea, the transparent outer layer of the eye, plays a crucial role in focusing light onto the retina. Maintaining its structural integrity is essential for optimal visual function. SMILE's flapless approach preserves the anterior corneal structure, potentially providing greater biomechanical strength. This enhanced stability may reduce the risk of ectasia, a rare but serious complication characterized by progressive corneal bulging and thinning, which can lead to vision loss. Traditional LASIK involves creating a corneal flap, which can be associated with potential complications, such as flap displacement, wrinkles, or infection. SMILE's flapless nature eliminates these risks, providing an added layer of safety. Femto-LASIK, while also utilizing a femtosecond laser, differs from ReLEx SMILE by creating a thin corneal flap. This flap is then lifted to expose the underlying corneal tissue, which is reshaped using an excimer laser to correct the refractive error. The flap is then repositioned and adheres naturally, completing the procedure. Femto-LASIK has been considered the gold standard in refractive surgery for many years, offering high success rates and predictable outcomes. The use of a femtosecond laser for flap creation has further enhanced its precision and safety profile compared to earlier microkeratome-based LASIK techniques. While Femto-LASIK has an excellent track record, it carries a slightly higher risk of flap-related complications compared to SMILE, although these complications are rare. In rare cases, the corneal flap may become dislodged or displaced, especially following eye trauma. Wrinkles or folds in the flap can affect visual quality and may require repositioning. Although rare, infection can occur at the flap interface, requiring prompt treatment to prevent vision-threatening complications. The choice between ReLEx SMILE and Femto-LASIK should be tailored to the individual patient. Corneal thickness is a crucial factor in determining LASIK candidacy and technique selection. ReLEx SMILE may be preferred for patients with thinner corneas, as it requires less corneal tissue removal compared to Femto-LASIK. This is because SMILE involves creating a lenticule within the cornea, while Femto-LASIK requires creating a flap and then removing tissue beneath it. The degree and type of refractive error also influence technique selection. Femto-LASIK may be more suitable for correcting higher refractive errors, as it allows for greater flexibility in corneal reshaping. SMILE, while effective for a wide range of refractive errors, may have limitations in treating very high degrees of myopia or hyperopia. Patients' lifestyles and occupational demands should be considered when choosing between SMILE and Femto-LASIK. Patients who engage in contact sports or occupations with a higher risk of eye trauma may benefit from the flapless nature of ReLEx SMILE, as it eliminates the risk of flap-related complications. Patients' individual risk tolerance should also be factored into the decision-making process. Patients with a lower risk tolerance may prefer ReLEx SMILE due to the reduced risk of flap-related complications, even though these complications are rare with both techniques. Patients with pre-existing dry eye or a higher risk of developing dry eye may be better suited for SMILE, as it is associated with a lower incidence of dry eye symptoms compared to Femto-LASIK. Patients with larger pupils may experience more glare or halos at night after LASIK surgery. SMILE may be a better option for these patients, as it tends to induce fewer higher-order aberrations, which can contribute to these visual disturbances. The cost of SMILE and Femto-LASIK can vary depending on the provider and geographic location. In general, SMILE tends to be slightly more expensive than Femto-LASIK due to the newer technology involved. The field of refractive surgery is constantly evolving, with ongoing research and technological advancements leading to improved techniques and outcomes. Both ReLEx SMILE and

Femto-LASIK have undergone refinements since their inception, enhancing their safety and efficacy profiles.[13,14]

The high success rates observed in this study, with both ReLEx SMILE and Femto-LASIK achieving post-operative UCVA comparable to or exceeding pre-operative BCVA in the majority of patients. The utilization of state-of-the-art femtosecond lasers in both procedures represents a significant technological advancement in refractive surgery. These lasers deliver ultrashort pulses of infrared light, enabling precise corneal tissue cutting with minimal collateral damage. This precision translates to more accurate corneal reshaping, facilitating the achievement of the desired refractive correction and contributing to high success rates. Moreover, the femtosecond laser's ability to create precise and predictable corneal flaps in Femto-LASIK or lenticules in ReLEx SMILE further enhances the accuracy and safety of these procedures. The femtosecond laser's real-time feedback mechanisms and intraoperative imaging capabilities allow surgeons to monitor and adjust the treatment in real-time, optimizing outcomes. The Bali Mandara Eye Hospital boasts a team of experienced surgeons with specialized training in refractive surgery. Their expertise plays a pivotal role in achieving high success rates. The surgeons' proficiency in patient selection, pre-operative evaluation, surgical technique, and post-operative care ensures that each patient receives individualized treatment tailored to their specific needs and visual goals. Furthermore, the surgeons' experience in managing potential complications and addressing individual patient variations contributes to the overall safety and success of the procedures. Their ability to anticipate and mitigate potential challenges during surgery minimizes the risk of adverse events and optimizes visual outcomes. Adherence to strict post-operative care protocols is essential for optimizing visual outcomes and minimizing complications. Patients are typically prescribed antibiotic and anti-inflammatory eye drops to prevent infection and reduce inflammation. Strict adherence to the prescribed medication regimen is crucial for proper healing and optimal visual recovery. Regular follow-up appointments allow the surgeon to monitor the healing process, assess visual acuity, and address any concerns or complications that may arise. These appointments are essential for ensuring that patients achieve the best possible visual outcomes and maintain long-term eye health. Patients are educated about post-operative care instructions, including proper eye hygiene, activity restrictions, and potential warning signs to watch out for. This education empowers patients to actively participate in their recovery and promptly report any concerns to their surgeon. The combination of advanced laser technology, surgeon expertise, and strict post-operative care protocols creates a synergistic effect, contributing to the high success rates observed in this study. Each element plays a crucial role in ensuring that patients achieve optimal visual outcomes and experience a smooth recovery process. While advanced laser technology and surgeon expertise are undoubtedly crucial, other factors also contribute to the success of refractive surgery. Careful patient selection is paramount to ensure that individuals undergoing LASIK are suitable candidates for the procedure. This involves a thorough evaluation of their refractive error, corneal characteristics, overall eye health, and expectations. Selecting appropriate candidates minimizes the risk of complications and maximizes the likelihood of achieving successful outcomes. Each patient's visual needs and corneal characteristics are unique. Therefore, personalized treatment plans are essential for optimizing outcomes. Surgeons utilize advanced diagnostic tools and software to create customized treatment plans that address each patient's specific refractive error and corneal topography. Patient compliance with pre-operative and post-operative instructions is crucial for successful outcomes. This includes adhering to medication regimens, attending follow-up appointments, and following lifestyle recommendations. Patients who actively participate in their care and follow instructions diligently are more likely to achieve optimal visual results. The

commitment to continuous quality improvement is essential for maintaining high success rates in refractive surgery. This involves regularly monitoring surgical outcomes, analyzing data, and implementing necessary adjustments to protocols and techniques to enhance patient safety and efficacy.[15,16]

While both ReLEx SMILE and Femto-LASIK demonstrated high success rates in this study, a small percentage of patients (5.3%) did not achieve post-operative uncorrected visual acuity (UCVA) comparable to their pre-operative best-corrected visual acuity (BCVA). This observation underscores the importance of thorough pre-operative evaluation and patient counseling to set realistic expectations and identify potential risk factors that may influence surgical outcomes. In some cases, the refractive correction achieved during surgery may not perfectly align with the target refraction. This can result in residual refractive error, leading to undercorrection or overcorrection. Undercorrection occurs when the cornea is not reshaped sufficiently to fully correct the refractive error, while overcorrection occurs when the cornea is reshaped excessively. Both undercorrection and overcorrection can lead to blurred vision and the need for further correction with glasses or contact lenses. Higher-order aberrations (HOAs) are imperfections in the optical system of the eye that can affect visual quality even after refractive correction. These aberrations can cause distortions, glare, halos, and decreased contrast sensitivity. While LASIK surgery aims to correct lower-order aberrations like myopia and astigmatism, it may not fully address HOAs. In some cases, HOAs can even be induced or exacerbated by LASIK surgery. Dry eye syndrome is a common condition characterized by insufficient lubrication of the eyes. It can cause discomfort, irritation, and blurred vision. LASIK surgery, particularly Femto-LASIK, can exacerbate dry eye symptoms due to the disruption of corneal nerves during flap creation. Dry eye can impact visual acuity and may contribute to unmet visual outcomes. Each patient's healing process is unique, and variations in corneal wound healing can influence visual outcomes. Factors such as age, overall health, and pre-existing conditions can affect the healing process. In some cases, slower or irregular healing can lead to suboptimal visual results. Addressing these factors through meticulous surgical technique, personalized treatment plans, and comprehensive post-operative care can help minimize the risk of unmet visual outcomes. Employing meticulous surgical technique is crucial for minimizing the risk of undercorrection, overcorrection, and induction of HOAs. Surgeons must carefully plan and execute the procedure, utilizing advanced diagnostic tools and intraoperative imaging to ensure precise corneal reshaping. Recognizing that each patient's visual needs and corneal characteristics are unique, personalized treatment plans are essential for optimizing outcomes. Surgeons utilize advanced diagnostic tools and software to create customized treatment plans that address each patient's specific refractive error and corneal topography. Comprehensive post-operative care plays a vital role in managing potential complications and promoting optimal healing. Prescribing appropriate eye drops, such as antibiotics and anti-inflammatories, to prevent infection and reduce inflammation. Implementing strategies to manage dry eye symptoms, such as artificial tears, punctal plugs, and lifestyle modifications. Closely monitoring patients during the healing process to identify and address any complications promptly. Setting realistic expectations and educating patients about potential risks and complications is crucial for patient satisfaction and successful outcomes. Patients should be informed about the possibility of undercorrection, overcorrection, HOAs, and dry eye syndrome. They should also be advised about the importance of adherence to post-operative care instructions and regular follow-up appointments. Technological advancements continue to enhance the precision and predictability of refractive surgery, further reducing the risk of unmet visual outcomes. Wavefront-Guided LASIK technology measures the unique imperfections in each patient's eye and guides the laser to create a more personalized correction, potentially reducing

HOAs and improving visual quality. Topography-Guided LASIK technique utilizes detailed maps of the cornea's surface to guide the laser, allowing for more precise corneal reshaping and potentially reducing the risk of irregular astigmatism. Artificial Intelligence (AI) algorithms are being developed to analyze patient data and predict surgical outcomes with greater accuracy, aiding in personalized treatment planning and risk assessment.[17,18]

Both ReLEx SMILE and Femto-LASIK exhibited low complication rates in this study, reinforcing their safety as refractive correction procedures. The comparable incidence of complications across both groups further emphasizes their similar safety profiles. This observation aligns with numerous studies that have established the safety and efficacy of both techniques. Dry eye syndrome, the most common complication, can be effectively managed with artificial tears and other supportive measures. Transient light sensitivity, another common side effect, typically resolves within a few days. Rare complications such as DLK and epithelial ingrowth require prompt diagnosis and appropriate management to prevent long-term sequelae. While both ReLEx SMILE and Femto-LASIK are considered safe and effective, it is essential to acknowledge and address potential complications that may arise. Understanding these complications and their management is crucial for ensuring patient safety and satisfaction. Dry eye syndrome, characterized by insufficient lubrication of the eyes, is a common complication following LASIK surgery. It can cause discomfort, irritation, and blurred vision. While both ReLEx SMILE and Femto-LASIK can induce dry eye, SMILE may be associated with a lower incidence due to its less invasive nature and minimal disruption to corneal nerves. Management of dry eye syndrome typically involves the use of artificial tears to supplement natural tear production. In more severe cases, other measures such as punctal plugs (tiny devices inserted into the tear ducts to block drainage) or prescription eye drops may be necessary. Transient light sensitivity, or photophobia, is another common side effect of LASIK surgery. Patients may experience increased sensitivity to bright light, glare, or halos around lights. This sensitivity is usually temporary and resolves within a few days as the eyes heal. Management of transient light sensitivity typically involves avoiding bright lights and wearing sunglasses when outdoors. In some cases, over-the-counter pain relievers may be recommended to alleviate discomfort. Diffuse Lamellar Keratitis (DLK) is a rare inflammatory condition that can occur after LASIK surgery. It is characterized by the infiltration of inflammatory cells into the corneal stroma, the middle layer of the cornea. DLK can cause pain, decreased vision, and corneal haze. Management of DLK typically involves the use of topical corticosteroids to reduce inflammation. In severe cases, additional interventions such as intensive topical steroid therapy or surgical debridement (removal of the inflamed tissue) may be necessary. Epithelial ingrowth is a rare complication in which epithelial cells, the cells that normally line the corneal surface, grow into the flap interface or the lenticule pocket. This can cause discomfort, decreased vision, and corneal irregularities. Management of epithelial ingrowth depends on the severity and location of the ingrowth. In mild cases, observation may be sufficient. In more severe cases, surgical removal of the ingrowth may be necessary. Flap-related complications, such as flap displacement, wrinkles, or infection, are more common with Femto-LASIK compared to ReLEx SMILE. Ectasia is a rare but serious complication characterized by progressive corneal bulging and thinning, which can lead to vision loss. In some cases, the refractive correction achieved during surgery may not perfectly align with the target refraction, leading to residual refractive error. Prompt diagnosis and appropriate management of these complications are essential for preventing long-term sequelae and preserving vision. Advancements in technology and surgical expertise continue to enhance the safety of refractive surgery. Newer generation femtosecond lasers offer greater precision and control, minimizing tissue damage and reducing the risk of complications. Sophisticated diagnostic tools, such as corneal topography and wavefront aberrometry,

provide detailed information about the cornea's shape and the eye's optical system, aiding in personalized treatment planning and risk assessment. Real-time intraoperative imaging allows surgeons to monitor the surgical process and make adjustments as needed, enhancing precision and safety.[19,20]

5. Conclusion

This study affirms the safety and efficacy of both ReLEx SMILE and Femto-LASIK in correcting refractive errors, particularly mild myopia. No significant difference in visual outcomes was found between the two methods. Both procedures yielded excellent visual results, with most patients achieving post-operative UCVA comparable to or exceeding their pre-operative BCVA. The study underscores the importance of personalized treatment plans and meticulous surgical techniques in achieving optimal visual outcomes. Continued research and technological advancements will further refine refractive surgery procedures, expanding options and improving patient care.

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