The Egyptian Journal of Hospital Medicine (January 2024) Vol. 94, Page 1081-1092

Correction of Moderate to High Myopia: A Comparative Study

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ABSTRACT
Background: Myopia is a condition in which the eye's refraction (or ability to focus) is greater than what is required for good distant vision. For individuals with moderate to severe myopia, the two main surgical techniques for correcting their vision are excimer laser surgery and phakic intraocular lenses (IOLs).
Objectives: to evaluate the visual outcome between LASIK, transepithelial photorefractive keratectomy (trans-PRK) and implantable collamer lenses for correction of moderate to high myopia.
Patients and Methods: This study was conducted on forty-five patients with moderate to high myopia (-4 to -10 diopters). It was carried out at Ophthalmology Department at Menoufia University Hospital from April 2021 to October 2022. **Results:** 8 patients (53.33%) had operation on right eye and 7 patients (46.67%) had operationon left eye among transepithelial photorefractive keratectomy group. Also, 10 patients (66.67%) had operation on right eye and 5 patients (33.33%) had operation on left eye among implantable collamer lens group. Also, 10 patients (66.67%) had operation on right eye and 5 patients (33.33%) had operation on left eye among laser assisted in situ keratomileusis group,with no significant difference (P=0.685).
Conclusion: According to our study's findings, individuals with high myopia who had ICL implantation had somewhat higher postoperative visual quality than those who had LASIK, particularly if their corneal thickness was restricted and they had more refractive regression.
Keywords: ICL, LASIK, Myopia, Transepithelial photorefractive keratectomy (trans-PRK).

INTRODUCTION

When an eye's focusing power, or refraction, is higher than what is needed for sharp distant vision, it is referred to as myopia. For moderate to high myopia, there are two primary surgical corrective methods: excimer laser and phakic IOLs [1]. In order to reduce the cornea's refractive power and concentrate an object's image onto the retina rather than in front of it, excimer laser refractive surgery for myopia involves removing corneal stroma [2].

In order to concentrate the picture of an item being viewed onto the retina rather than in front of it, phakic IOLs for myopia treatment diverge light rays. They can be positioned in the posterior chamber of the eye, between the iris and the natural lens, or in the anterior chamber, in front of the iris [1].

It is commonly acknowledged that LASIK is a successful technique for treating moderate to high myopia. Under a hinged corneal flap, the deeper, parallel collagen lamellae of the middle stroma are ablated during LASIK, a lamellar treatment. Transepithelial photorefractive keratectomy, or trans-PRK, is a surface treatment that is commonly performed for mild myopia (<-4 diopters), and it is achieved by ablating Bowman's layer, the densely interwoven architecture of the anterior stroma, and removing the corneal epithelium [3].

With LASIK and PRK, there has been a significant improvement in both surgery safety and postoperative visual performance10–13. However, because of the possibility of keratectasia, LASIK and PRK may not be appropriate for thin corneas [4]. As an alternative to LASIK and PRK eye surgery, the implanted collamer lens (ICL), a posterior chamber phakic intraocular lens (pIOL), can be used to treat moderate to high myopia. ICL is inserted by a tiny corneal incision behind the iris and in front of the crystalline lens [5].

So, the aim of this study was to evaluate the visual outcome between LASIK, transepithelial photorefractive keratectomy (trans-PRK) and implantable collamer lenses for correction of moderate to high myopia.

PATIENTS AND METHODS

This study was conducted on forty-five patients with moderate to high myopia (-4 to -10diopters). It was carried out at Ophthalmology Department at Menoufia University Hospital .

All patients were subjected to the following:
Inclusion criteria: Age between 18 and 40 years, Spherical equivalent (-4 to -10) diopters, Discontinuing contact lens wear for at least two weeks and Central corneal thickness>480 micron.
Exclusion criteria: Clinical or topographic findings of keratoconus or keratoconus suspect, Corneal infection, trauma, or opacities, Active ocular disease, Dry eye and Systemic diseases, which were likely to affect corneal healing, e.g., connective tissue diseases.

A) **Preoperative examination: All patients were subjected to the following:** Visual acuity testing including UCVA and BCVA, Manifest and cycloplegic refraction, corneal topography and pachymetry, routine ophthalmologic examination; slit lamp biomicroscopy, applanation tonometry and fundus examination and high order aberration.
B) **Operative technique:** One third of patients were subjected to LASIK (group A), another third of

Received: 24/10/2023
Accepted: 24/12/2023

patients were subjected to transepithelial PRK (group B) and the last third of patients were subjected to implantation of ICL (group C).

C) **Postoperative follow-up: It included the following:** One day and one week postoperative (postop), one and three months postop and six months.

D) **Postoperative evaluation by:** Pentacam, high order aberration, visual acuity, contrast sensitivity and endothelial cell count.

Ethical approval:

Menoufia Medical Ethics Committee of the Menoufia Faculty of Medicine gave its approval to this study. All participants gave written consent after receiving all information. The Helsinki Declaration was followed throughout the study's conduct.

Statistical analysis

Microsoft Excel 2019 and the SPSS V.25 programme for Microsoft Windows 10 were the usual computer programmes used to tabulate and statistically analyse the results. Two kinds of analyses were conducted: A) Descriptive statistics were as follows: For quantitative data, the data were described as mean + SD and for qualitative data, the data were described as frequency and percentage. B) Analytical statistics, which comprised the subsequent tests: One-way ANOVA (F) and Chi-Squared (χ^2). Post Hoc tests: Tukey honestly significant difference (Tukey-HSD) test was used as a post hoc test to adjust for multiple comparisons. P values <0.05 was considered significant.

RESULTS

A CONSORT flow chart of the study population is shown in figure 1. Of the 58 patients who attended to Ophthalmology Department at Menoufia University Hospital, Shebin El-Kom. 13 patients were excluded from the study (5 patients declined consent and 8 patients did not meet the inclusion criteria, 45 patients were willing to participate in the study and consented for participation. Thus, 15 patients had T-PRK operation, 15 patients had ICL operation, and 15 patients had LASIK.

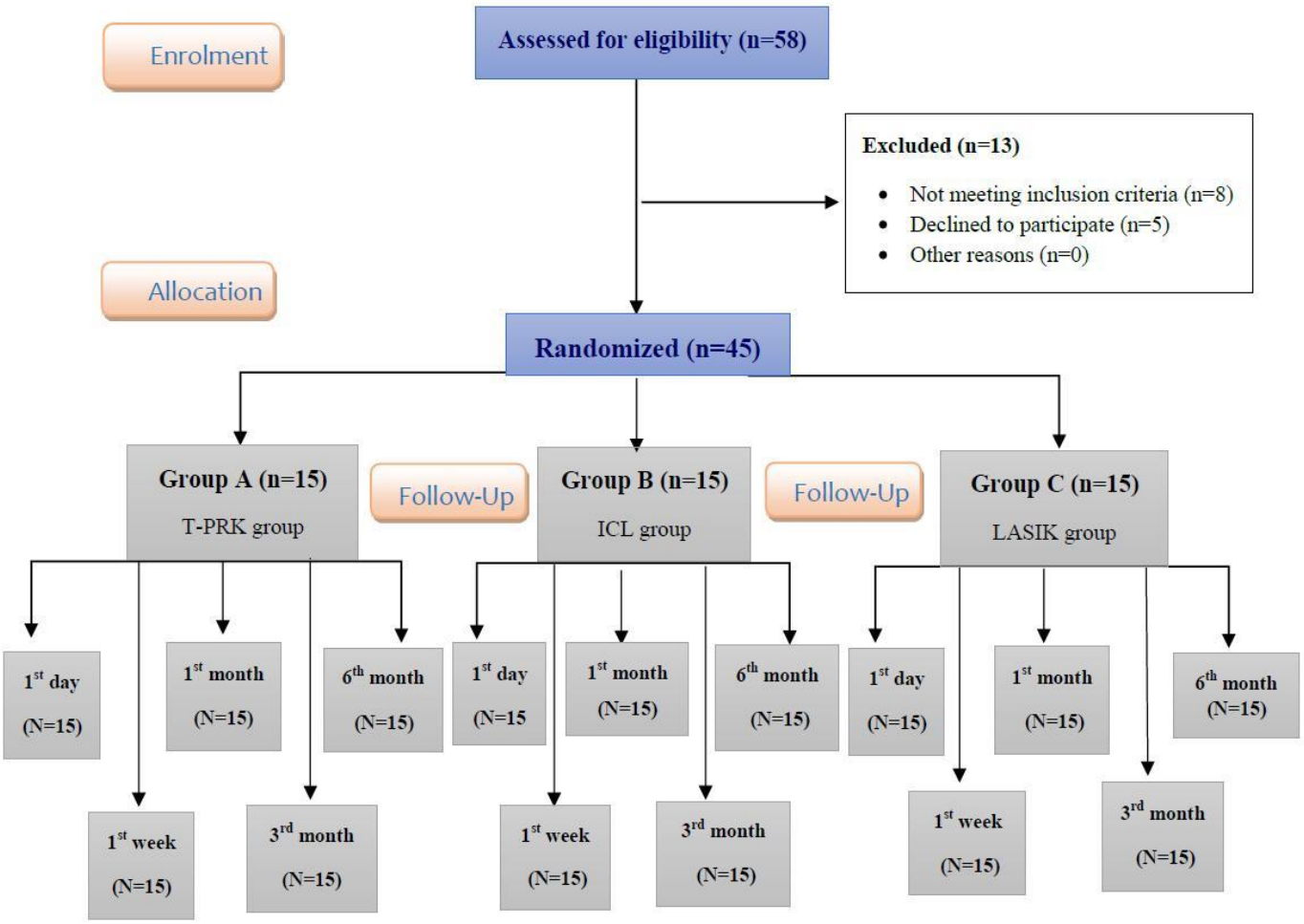

Figure (1): Flowchart of the studied patients.

The current study showed that refraction and central corneal thickness post 1st day, 1st week, 1st month, 3rd month and 6th month of operation were significantly increased among implantable collamer lens group than transepithelial photorefractive keratectomy and laser assisted in situ keratomileusis studied groups. While, central corneal thickness post 1st day of operation was significantly increased among laser assisted in situ keratomileusis group than transepithelial photorefractive keratectomy and implantable collamer lens studied groups **(Table 1)**.

Table (1): Refraction and central corneal thickness postoperative follow-up among T-PRK,ICL and LASIK studied groups (N=45).

Variables	T-PRK group (n=15)	ICL group (n=15)	LASIK group (n=15)	Total (n=45)	F	P value	95% CI	
							Lower	Upper
Refraction postoperative								
1st day Mean ±SDRange	-5.67±1.93 (-9.00)-(-4.00)	-7.33±1.41 (-8.75)-(-5.50)	-6.32±1.56 (-9.50)-(4.00)	-6.39±1.76 (-9.50)-(-4.00)	3.864	**0.029***	-6.97	-5.91
Post Hoc	**P1=0.009***, P2=0.291, P3=0.099							
1st week Mean ±SD Range	0.38±0.76 (-1.00)- 1.50	-0.83± 0.12 (-1.00)- (0.75)	-0.18± 0.64 (-1.00)- (0.50)	-0.20± 0.75 (-1.00)- (1.50)	16.532	**<0.001***	-0.44	0.02
Post Hoc	**P1<0.001*, P2=0.011*, P3=0.004***							
1st month Mean ±SD Range	0.25±0.66 (-1.00)-1.25	-1.25±0.21 (-1.50)-(-1.00)	-0.27±0.72 (-1.00)-(0.75)	-0.41±0.84 (-1.50)-(1.25)	26.254	**<0.001***	-0.68	-0.17
Post Hoc	**P1<0.001*, P2=0.018*, P3<0.001***							
3rd month Mean ±SD Range	0.25±0.66 (-1.00)-1.25	-1.25±0.21 (-1.50)-(-1.00)	-0.27±0.72 (-1.00)-(0.75)	-0.41±0.84 (-1.50)-(1.25)	26.254	**<0.001***	-0.68	-0.17
Post Hoc	**P1<0.001***, **P2=0.018***, **P3<0.001***							
6th month Mean ±SD Range	0.25±0.66 (-1.00)-(1.25)	-1.42±0.32 (-1.75)-(-1.00)	-0.27±0.72 (-1.00)-(0.75)	-0.46±0.91 (-1.75)-(1.25)	31.054	**<0.001***	-0.75	-0.20
Post Hoc	**P1<0.001***, P2=**0.022***, **P3<0.001***							
CCT postoperative								
1st day Mean ±SD Range	523.00±41.81 460.00-583.00	482.33±16.07 463.00-501.00	549.00±24.71 492.00-591.00	518.33±39.61 460.00-591.00	19.418	**<0.001***	506.09	530.14
Post Hoc	**P1=0 .001*, P2=0.020*, P3<0.001***							
1st week Mean ±SD Range	437.80±42.54 370.00-508.00	482.00±16.50 462.00-501.00	422.20±40.14 358.00-466.00	447.80±42.43 358.00-508.00	11.724	**<0.001***	434.48	460.19
Post Hoc	**P1=0.001*,** P2=0.230, **P3<0.001***							
1st month Mean ±SD Range	435.00±42.52 366.00- 505.00	482.33± 16.07 463.00-501.00	419.27± 40.97 355.00- 466.00	445.98± 43.50 355.00-505.00	12.950	**<0.001***	432.3	458.7
Post Hoc	**P1=0.001***, P2=0.229, **P3<0.001***							
3rd month Mean ±SD Range	433.00±42.44 361.00- 502.00	483.33± 16.09 465.00-503.00	416.53± 40.67 352.00- 463.00	444.72± 44.40 352.00-503.00	14.674	**<0.001***	430.83	457.75
Post Hoc	**P1<0.001***, P2=0.207, **P3<0.001***							
6th month Mean ±SD Range	433.00±42.44 361.00- 502.00	482.33± 16.57 464.00-503.00	416.53± 40.67 352.00- 463.00	444.39± 44.17 352.00-503.00	14.145	**<0.001***	430.57	457.34
Post Hoc	**P1<0.001*,** P2=0.208, **P3<0.001***							

T-PRK: Transepithelial photorefractive keratectomy. **ICL:** Implantable collamer lens. **LASIK:** Laser assisted in situ keratomileusis**. CCT:** Central corneal thickness. **F:** ANOVA F test. ***:** Significant. **CI:** Confidence interval for Mean. **P1:** T-PRK group compared to ICL group. **P2:** T-PRK group compared to LASIKgroup. **P3:** ICL group compared to LASIK group.

The present study noticed that K1 post 1st day, K2 post 1st day, 1st week, 1st month, 3rd month and 6th month of operation were significantly increased among implantable collamer lens group than transepithelial photorefractive keratectomy and laser assisted in situ keratomileusis studied groups. While, K1 post 1st month of operation was significantly increased among laser assisted in situ keratomileusis group than transepithelial photorefractive keratectomy and: Implantable collamer lens studied groups. On the other hand, there were no significant differences among the studied groups regarding K1 post 1st week, 3rd month and 6th month **(Table 2)**.

Table (2): Horizontal keratometry and vertical keratometry postoperative follow-up among T-PRK, ICL and LASIK studied groups (N=45).

Variables	T-PRK group (n=15)	ICL group (n=15)	LASIK group (n=15)	Total (n=45)	F	P value	95% CI	
							Lower	Upper
K1 postoperative								
1st day								
Mean ±SD	42.76±1.23	45.67± 2.81	42.64± 0.89	43.70± 2.27	12.945	**<0.001***	43.00	44.38
Range	40.07- 44.21	41.90- 48.20	40.70- 43.50	40.07- 48.20				
Post Hoc	**P1<0.001***, P2=0.856, **P3<0.001***							
1st week								
Mean ±SD	38.32±2.34	45.90± 2.48	84.73± 122.72	55.96± 71.47	1.851	0.170	34.61	78.02
Range	34.18- 41.75	42.60- 48.20	38.00- 387.00	34.18- 387.00				
Post Hoc	P1=0.771, P2=0.080, P3=0.141							
1st month								
Mean ±SD	38.27±2.33	45.97± 2.38	153.99±169.23	78.55± 108.34	6.577	**0.003***	46.54	112.28
Range	34.10- 41.70	42.80- 48.20	38.00- 386.00	34.10- 386.00				
Post Hoc	P1=0.830, **P2=0.002***, **P3=0.004***							
3rd month								
Mean ±SD	38.26±2.28	45.93± 2.29	84.87± 122.26	56.00± 71.24	1.879	0.165	34.72	77.99
Range	34.10- 41.40	42.90- 48.10	38.10- 386.00	34.10- 386.00				
Post Hoc	P1=0.767, P2=0.078, P3=0.138							
6th month								
Mean ±SD	38.26±2.28	45.93± 2.29	84.87± 122.26	56.00± 71.24	1.879	0.165	34.72	77.99
Range	34.10- 41.40	42.90- 48.10	38.10- 386.00	34.10- 386.00				
Post Hoc	P1=0.767, P2=0.078, P3=0.138							
K2 postoperative								
1st day								
Mean ±SD	44.11±1.53	46.83± 2.61	44.99± 1.22	45.31± 2.14	8.137	**0.001***	44.66	45.96
Range	40.67- 46.26	43.40- 49.40	42.10- 46.48	40.67- 49.40				
Post Hoc	**P1<0.001***, P2=0.212, **P3=0.010***							
1st week								
Mean ±SD	37.12±0.00	46.80± 2.66	38.83± 0.34	40.83± 4.51	167.095	**<0.001***	39.56	42.28
Range	37.12- 37.12	43.30- 49.40	38.35- 39.40	37.12- 49.40				
Post Hoc	**P1<0.001***, P2=**0.004*, P3<0.001***							
1st month								
Mean ±SD	39.52±2.66	46.80± 2.66	40.24± 3.53	42.15± 4.37	27.178	**<0.001***	40.86	43.51
Range	35.30- 43.50	43.30- 49.40	38.20- 48.90	35.30- 49.40				
Post Hoc	**P1<0.001***, P2=0.512, **P3<0.001***							
3rd month								
Mean ±SD	39.25±2.63	46.87± 2.59	38.89± 0.25	41.64± 4.22	66.516	**<0.001***	40.39	42.95
Range	35.10- 43.30	43.50- 49.50	38.50- 39.20	35.10- 49.50				
Post Hoc	**P1<0.001***, P2=0.647, **P3<0.001***							
6th month								
Mean ±SD	39.25±2.63	46.87± 2.59	38.89± 0.25	41.64± 4.22	66.516	**<0.001***	40.39	42.95
Range	35.10- 43.30	43.50- 49.50	38.50- 39.20	35.10- 49.50				
Post Hoc	**P1<0.001***, P2=0.647, **P3<0.001***							

T-PRK: Transepithelial photorefractive keratectomy. **ICL:** Implantable collamer lens. **LASIK:** Laser assisted in situ keratomileusis**. K1:** Horizontal keratometry. **K2:** Vertical keratometry. **F:** ANOVA F test. ***:** Significant. **CI:** Confidence interval for Mean. **P1:** T-PRK group compared to ICL group. **P2:** T-PRK group compared to LASIK group. **P3:** ICL group compared to LASIK group.

Regarding this study, high order post 1st month, 3rd month and 6th month of operation were significantly increased among implantable collamer lens group than transepithelial photorefractive keratectomy and laser assisted in situ keratomileusis studied groups. Also, visual acuity post 1st day, 1st week, 1st month, 3rd month and 6th month ofoperation were significantly increased among transepithelial photorefractive keratectomy group than implantable collamer lens and laser assisted in situ keratomileusis studied groups. While there were no significant differences among the studied groups regarding high order post 1st day and 1st week **(Table 3)**.

Table (3): High order postoperative and Visual acuity postoperative follow-up among T-PRK, ICL and LASIK studied groups (N=45).

Variables	T-PRK group (n=15)	ICL group (n=15)	LASIK group (n=15)	Total (n=45)	F	P value	95% CI	
							Lower	Upper
High order postoperative								
1st day								
Mean ±SD	0.43±0.06	0.44± 0.06	0.45± 0.04	0.44± 0.06	0.861	0.430	0.42	0.46
Range	0.33-0 .55	0.36-0 .51	0.40- 0.53	0.33-0 .55				
Post Hoc	P1=0.505, P2=0.197, P3=0.526							
1st week								
Mean ±SD	0.40±0.07	0.45± 0.04	4.89 ± 11.82	1.88± 6.92	2.143	0.130	-0.19	4.01
Range	0.30-0 .56	0.39- 0.48	0.32- 34.00	0.30- 34.00				
Post Hoc	P1=0.985, P2=0.079, P3=0.082							
1st month								
Mean ±SD	0.37±0.07	0.44± 0.04	0.39± 0.05	0.40± 0.06	7.303	**0.002***	0.38	0.42
Range	0.30- 0.50	0.38-0 .48	0 .33-0 .45	0.30- 0.50				
Post Hoc	**P1= 0.001***, P2=0.359, **P3=0.009***							
3rd month								
Mean ±SD	0.36±0.06	0.42±0.04	0.36±0.04	0.38±0.05	7.441	**0.002***	0.36	0.40
Range	0.30-0.48	0.37-0.45	0.30-0.42	0.30-0.48				
Post Hoc	**P1=0.001*,** P2=0.764, **P3=0.003***							
6th month								
Mean ±SD	0.36±0.06	0.42±0.04	0.36±0.04	0.38±0.05	7.441	**0.002***	0.36	0.40
Range	0.30-0.48	0.37-0.45	0.30-0.42	0.30-0.48				
Post Hoc	**P1=0.001***, P2=0.764**, P3=0.003***							
Visual acuity postoperative								
1st day								
Mean ±SD	0.09±0.04	0.03± 0.01	0.05± 0.04	0.06± 0.04	9.658	**<0.001***	0.05	0.07
Range	0.03-0 .17	0 .02-0 .05	0.02-0 .16	0.02-0 .17				
Post Hoc	**P1<0.001*, P2=0.009***, P3=0.111							
1st week								
Mean ±SD	0.84±0.20	0.53± 0.05	0.58± 0.16	0.66± 0.20	17.353	**<0.001***	0.59	0.71
Range	0.33- 1.00	0.50-0 .60	0 .30-0 .80	0 .30- 1.00				
Post Hoc	**P1<0.001*, P2<0.001***, P3=0.403							
1st month								
Mean ±SD	0.84±0.20	0.53± 0.05	0.61±0.17	0.67±0.20	15.556	**<0.001***	0.60	0.72
Range	0.33- 1.00	0.50-0 .60	0.40-0.80	0.33- 1.00				
Post Hoc	**P1<0.001*, P2<0.001***, P3=0.201							
3rd month								
Mean ±SD	0.84±0.20	0.53± 0.05	0.61±0.17	0.67±0.20	15.556	**<0.001***	0.60	0.72
Range	0.33- 1.00	0.50-0 .60	0.40-0.80	0.33- 1.00				
Post Hoc	**P1<0.001*, P2<0.001***, P3=0.201							
6th month								
Mean ±SD	0.84±0.20	0.53± 0.05	0.61±0.17	0.67±0.20	15.556	**<0.001***	0.60	0.72
Range	0.33- 1.00	0.50-0 .60	0.40-0.80	0.33- 1.00				
Post Hoc	**P1<0.001*, P2<0.001*,** P3=0.20							

T-PRK: Transepithelial photorefractive keratectomy. **ICL:** Implantable collamer lens. **LASIK:** Laser assisted in situ keratomileusis**. F:** ANOVA F test. ***:** Significant. **CI:** Confidence interval for Mean. **P1:** T- PRK group compared to ICL group. **P2:** T-PRK group compared to LASIK group. **P3:** ICL group compared to LASIK group.

Our study showed that contrast sensitivity post 1st day of operation was significantly decreased among transepithelial photorefractive keratectomy group than implantable collamer lens and laser assisted in situ keratomileusis studied groups. While**,** contrast sensitivity 1st week, 1st month, 3rd month and 6th month of operation were significantly increased among implantable collamer lens than transepithelial photorefractive keratectomy group and laser assisted in situ keratomileusis studied groups **(Table 4)**.

Table (4): Contrast sensitivity postoperative follow-up among T-PRK, ICL and LASIK studied groups (N=45).

Variables	T-PRK group (n=15)	ICL group (n=15)	LASIK group(n=15)	Total (n=45)	F	P value	95% CI	
							Lower	Upper
1st day								
Mean ±SD	1.93±0.11	2.00± 0.00	2.00± 0.00	1.98±0.07	5.091	**0.005***	1.96	2.00
Range	1.75- 2.00	2.00- 2.00	2.00- 2.00	1.75- 2.00				
Post Hoc	**P1=0.008*, P2=0.008***, P3=1.000							
1st week								
Mean ±SD	1.45±0.19	2.00± 0.00	1.32±0.11	1.59±0.32	116.694	**<0.001***	1.49	1.69
Range	1.25- 1.75	2.00- 2.00	1.25-1.50	1.25-2.00				
Post Hoc	**P1<0.001*, P2=0.007*, P3<0.001***							
1st month								
Mean ±SD	1.45±0.19	2.00± 0.00	1.32±0.11	1.59±0.32	116.694	**<0.001***	1.49	1.69
Range	1.25- 1.75	2.00- 2.00	1.25-1.50	1.25-2.00				
Post Hoc	**P1<0.001*, P2=0.007*, P3<0.001***							
3rd month								
Mean ±SD	1.63±0.13	2.00± 0.00	1.57±0.11	1.73±0.22	82.320	**<0.001***	1.67	1.80
Range	1.50-1.75	2.00- 2.00	1.50-1.75	1.50-2.00				
Post Hoc	**P1<0.001***, P2=0.074, **P3<0.001***							
6th month								
Mean ±SD	1.65±0.13	2.00± 0.00	1.57±0.11	1.73±0.22	81.571	**<0.001***	1.67	1.80
Range	1.50-1.75	2.00- 2.00	1.50-1.75	1.50-2.00				
Post Hoc	**P1<0.001*, P2=0.026*, P3<0.001***							

T-PRK: Transepithelial photorefractive keratectomy. **ICL:** Implantable collamer lens. **LASIK:** Laser assisted in situ keratomileusis**. F:** ANOVA F test. ***:** Significant. **CI:** Confidence interval for Mean. **P1:** T-PRK group compared to ICL group. **P2:** T-PRK group compared to LASIK group. **P3:** ICL group compared to LASIK group.

According to the side of the operation, there was no significant difference among the three groups **(Table 5)**.

Table (5): Eyes Postoperative follow-up among T-PRK, ICL and LASIK studied groups(N=45).

Variable	T-PRK group (n=15)		ICL group (n=15)		LASIK group (n=15)		Total (n=45)		X^2	P value
	No.	%	No.	%	No.	%	No.	%		
Eyes										
Right	8	53.33	10	66.67	10	66.67	28	60.87	0.756	0.685
Left	7	46.67	5	33.33	5	33.33	18	39.13		

T-PRK: Transepithelial photorefractive keratectomy. **ICL:** Implantable collamer lens. **LASIK:** Laserassisted in situ keratomileusis**. X^2:** Chi-square test. ***:** Significant. **CI:** Confidence interval for Mean.

The present study demonstrated that refraction, central corneal thickness, horizontalkeratometry, vertical keratometry, high order aberration, visual acuity and contrast sensitivity were increased among 1st day post-operative than 1st week, 1st month, 3rd month, 6th month postoperative **(Table 6)**.

Table (6): Refraction, CCT, K1, K2, high order aberration, visual acuity and contrast sensitivity postoperative follow-up among transepithelial photorefractive keratectomygroup (N=15).

Variables	T-PRK group(n=15)				
	1st day Mean ±SD	**1st week** Mean ±SD	**1st month** Mean ±SD	**3rd month** Mean ±SD	**6th month** Mean ±SD
Refraction	-5.67±1.93	0.38±0.76	0.25±0.66	0.25±0.66	0.25±0.66
P value (Mean diff.)	**P1 <0.001*(**-6.06±1.40**), P2 <0.001***(-5.92±1.55**), P3 <0.001***(-5.92±1.55**), P4 <0.001***(-5.92±1.55), **P5 =0.027***(0.13±0.21), **P6=0.027***(0.13±0.21), **P7=0.027***(0.13±0.21)				
CCT	523.00±41.81	437.80±42.54	435.00±42.52	433.00±42.44	433.00±42.44
P value (Mean diff.)	**P1 <0.001*(**85.20±27.69**), P2 <0.001***(88.00±27.84**),** **P3 <0.001***(90.00±28.23**), P4<0.001***(90.00±28.23), **P5 <0.001*** (2.80±0.86), **P6<0.001*(**4.80±1.93), **P7<0.001***(4.80±1.93), **P8<0.001***(2.00±1.36), **P9<0.001***(2.00±1.36)				
K1	42.76±1.23	38.32±2.34	38.27±2.33	38.26±2.28	38.26±2.28
P value (Mean diff.)	**P1 <0.001*(**4.45±1.97**), P2 <0.001***(4.50±1.95**), P3 <0.001***(4.50±1.93**), P4<0.001***(4.50±1.93), P5 =0.006 (0.05±0.06), P6=0.147(0.06±0.14), P7=0.147(0.06±0.14), P8=0.849 (0.01±0.13), P9=0.849 (0.01±0.13)				
K2	44.11±1.53	37.12±0.00	39.52±2.66	39.25±2.63	39.25±2.63
P value (Mean diff.)	**P1 <0.001*(**6.99±1.53**), P2 <0.001***(4.59±1.98**), P3 <0.001***(4.86±2.00**), P4 <0.001***(4.86±2.00), **P5 =0.004*** (-2.40±2.66), **P6=0.007*** (-2.13±2.63), **P7=0.007*** (-2.13±2.63), **P8<0.001*** (0.27±0.18), **P9<0.001*** (0.27±0.18)				
High order aberration	0.43±0.06	0.40±0.07	0.37±0.07	0.36±0.06	0.36±0.06
P value (Mean diff.)	P1 =0.105 **(**0.03±0.06**), P2= 0.002*** (0.06±0.06**), P3 <0.001***(0.07±0.06**), P4<0.001***(0.07±0.06), **P5 <0.001*** (0.03±0.02), **P6<0.001*** (0.04±0.02), **P7<0.001*** (0.04±0.02), **P8=0.004*** (0.01±0.01), **P9=0.004*** (0.01±0.01)				
Visual acuity	0.09±0.04	0.84±0.20	0.84±0.20	0.84±0.20	0.84±0.20
P value (Mean diff.)	**P1 <0.001* (**-0.74±0.19**), P2<0.001*** (-0.74±0.19**), P3 <0.001***(-0.74±0.19**), P4 <0.001***(-0.74±0.19).				
Contrast sensitivity	1.93±0.11	1.45±0.19	1.45±0.19	1.63±0.13	1.65±0.13
P value (Mean diff.)	**P1 <0.001* (**0.48±0.18**), P2<0.001*** (0.48±0.18**), P3 <0.001***(0.30±0.14**), P4 <0.001***(0.28±0.13), **P6 <0.001*** (-0.18±0.11), **P7<0.001*** (-0.20±0.14), **P8<0.001*** (-0.18±0.11), P9=0.334 (-0.20±0.14), P10=0.333 (-0.02±0.06)				

T-PRK: Transepithelial photorefractive keratectomy. **CCT:** Central corneal thickness. **K1:** Horizontal keratometry. **K2:** Vertical keratometry. **Diff:** difference. ***:** Significant. **P1:**1st day compared to 1st week. **P2:** 1st day compared to 1stmonth. **P3:** 1st day compared to 3rd month. **P4:** 1st day compared to 6th month. **P5:** 1st week compared to 1st month. **P6:** 1st week compared to 3rd month. **P7:** 1st week compared to 6th month. **P8:** 1st month compared to 3rd month. **P9:** 1st month compared to 6th month. **P10:** 3rd month compared to 6th month.

The current study showed that refraction and high order aberration were increased among 1st week postoperative than 1st day, 1st month, 3rd month, 6th month postoperative.While, central corneal thickness, vertical keratometry and were increased among 3rd monthpostoperative than 1st day, 1st week, 1st month, and 6th month postoperative. On the otherhand, horizontal keratometry and visual acuity were decreased among 1st day postoperativethan 1st week, 1st month, 3rd month, 6th month postoperative **(Table 7)**.

Table (7): Refraction, CCT, K1, K2, high order aberration, visual acuity and contrast sensitivity postoperative follow-up among implantable collamer lens group (N=15).

Variables	ICL group(n=15				
	1st day Mean ±SD	**1st week** Mean ±SD	**1st month** Mean ±SD	**3rd month** Mean ±SD	**6th month** Mean ±SD
Refraction	-7.33±1.41	-0.83± 0.12	-1.25±0.21	-1.25±0.21	-1.42±0.32
P value (Mean diff.)	**P1 <0.001*(**-6.50±1.32)**, P2 <0.001***(-6.08±1.36**), P3 <0.001***(-6.08±1.36)**, P4 <0.001***(-5.92±1.41), **P5 <0.001***(0.42±0.12), **P6<0.001***(0.42±0.12), **P7<0.001***(0.58±0.24), **P9<0.001***(0.17±0.12), **P10<0.001***(0.17±0.12)				
CCT	482.33±16.07	482.00±16.50	482.33± 16.07	483.33± 16.09	482.33± 16.57
P value (Mean diff.)	**P1=0.019***(0.33±0.49), **P3=0.019***(-1.00±1.46), P4=1.000(0.00±2.24), **P5=0.019***(-0.33±0.49), **P6=0.011***(-1.33±1.76), P7=0.605(-0.33±2.44), **P8=0.019***(-1.00±1.46), P9=1.000(0.00±2.24), **P10<0.001*(**1.00±0.85)				
K1	45.67± 2.81	45.90± 2.48	45.97± 2.38	45.93± 2.29	45.93± 2.29
P value (Mean diff.)	**P1=0.019***(-0.23±0.34), **P2=0.019***(-0.30±0.44), P3=0.075(-0.27±0.54), P4=0.075(-0.27±0.54), **P5=0.019***(-0.07±0.10), P6= 0.519(-0.03±0.20), P7= 0.519(-0.03±0.20), P8=0.207(0.03±0.10), P9=0.207(0.03±0.10),				
K2	46.83± 2.61	46.80± 2.66	46.80± 2.66	46.87± 2.59	46.87± 2.59
P value (Mean diff.)	**P1=0.019***(0.03±0.05), **P2=0.019***(0.03±0.05), P3=0.207(-0.03±0.10), P4=0.207(-0.03±0.10), P6= 0.065(-0.07±0.13), P7= 0.065(-0.07±0.13), P8= 0.065(-0.07±0.13), P9=0.065(-0.07±0.13)				
High order aberration	0.44± 0.06	0.45± 0.04	0.44± 0.04	0.42±0.04	0.42±0.04
P value (Mean diff.)	P1=0.462(-0.01±0.03), P2=1.000(0.00±0.04), **P3=0.023*(**0.02±0.03), **P4=0.023***(0.02±0.03), **P5<0.001*(**0.01±0.00), **P6<0.001*(**0.03±0.01), **P7<0.001*(**0.03±0.01), **P8<0.001*(**0.02±0.01), **P9<0.001*(**0.02±0.01)				
Visualacuity	0.03± 0.01	0.53± 0.05	0.53± 0.05	0.53± 0.05	0.53± 0.05
P value (Mean diff.)	**P1<0.001***(-0.50±0.05), **P2<0.001***(-0.50±0.05), **P3<0.001***(-0.50±0.05), **P4<0.001***(-0.50±0.05)				
Endothelial cell count	2716.67±106.35	2739.00±100.59	2759.67±104.03	2842.67±144.82	2878.33±159.82
P value (Mean diff.)	**P1<0.001***(-22.33±6.00), **P2<0.001***(-43.00±16.19), **P3<0.001***(-126.00±111.25), **P4<0.001***(-161.67±96.39), **P5<0.001***(-20.67±17.59), **P6=0.003***(-103.67±112.38), **P7<0.001***(-139.33±99.52), **P8=0.005*(**-83.00±95.17), **P9<0.001***(-118.67±82.23), **P10=0.004***(-35.67±39.79)				

ICL: Implantable collamer lens. **CCT:** Central corneal thickness. **K1:** Horizontal keratometry. **K2:** Verticalkeratometry. **Diff:** difference. ***:** Significant. **P1:**1st day compared to 1st week. **P2:** 1st day compared to 1st month. **P3:** 1st day compared to 3rd month. **P4:** 1st day compared to 6th month. **P5:** 1st week compared to 1st month. **P6:** 1st week compared to 3rd month. **P7:** 1st week compared to 6th month. **P8:** 1st month compared to 3rd month. **P9:** 1st month compared to 6th month. **P10:** 3rd month compared to 6th month.

Our study reported that central corneal thickness, vertical keratometry and contrast sensitivity were increased among 1st day postoperative than 1st week, 1st month, 3rd month,6th month postoperative. While, high order aberration was increased among 1st week postoperative than 1st day, 1st month, 3rd month and 6th month postoperative. On the otherhand, horizontal keratometry and visual acuity were decreased among 1st day postoperativethan 1st week, 1st month, 3rd month, 6th month postoperative **(Table 8)**.

Table (8): Refraction, CCT, K1, K2, high order aberration, visual acuity and contrastsensitivity postoperative follow-up among laser assisted in situ keratomileusis. (N=15).

Variables	LASIK group(n=15)				
	1st day Mean ±SD	**1st week** Mean ±SD	**1st month** Mean ±SD	**3rd month** Mean ±SD	**6th month** Mean ±SD
Refraction	-6.32±1.56	-0.18± 0.64	-0.27±0.72	-0.27±0.72	-0.27±0.72
P value (Mean diff.)	**P1 <0.001*(**-6.13±1.42**), P2 <0.001*(**-6.05±1.51**), P3 <0.001***(-6.05±1.51**), P4 <0.001***(-6.05±1.51), **P5=0.173(**0.08±0.22), P6=0.173(0.08±0.22), P7=0.173(0.08±0.22)				
CCT	549.00±24.71	422.20±40.14	419.27± 40.97	416.53± 40.67	416.53± 40.67
P value (Mean diff.)	**P1<0.001*(**126.80±26.81), **P2<0.001*(**129.73±27.01), **P3<0.001*(**132.47±26.83), **P4<0.001*(**132.47±26.83), **P5<0.001*(**2.93±1.67), **P6<0.001*(**5.67±2.02), **P7<0.001*(**5.67±2.02), **P8<0.001***(2.73±1.22), **P9**<**0.001*(**2.73±1.22)				
K1	42.64±0.89	84.73±122.72	153.99±169.23	84.87± 122.26	84.87± 122.26
P value (Mean diff.)	P1=0.206(-42.09±122.94), **P2=0.023***(-111.35±169.07), **P3=0.023***(-42.23±122.48), **P4=0.023***(-42.23±122.48), P5=0.084(-1.42±3.29), P6=0.317 (-0.14±0.52), P7=0.317 (-0.14±0.52), P8=0.084(69.12±143.97), P9=0.084(69.12±143.97)				
K2	44.99± 1.22	38.83± 0.34	40.24± 3.53	38.89± 0.25	38.89± 0.25
P value (Mean diff.)	**P1<0.001*(**6.16±1.20), **P2<0.001*(**4.74±3.78), **P3<0.001***(6.09±1.13), **P4<0.001*(**6.09±1.13), P5= 0.118(-1.42±3.29), P6=0.456(-0.07±0.34), P7=0.456(-0.07±0.34), P8=0.169(1.35±3.60), P9=0.169(1.35±3.60)				
High order aberration	0.45± 0.04	4.89 ± 11.82	0.39± 0.05	0.36±0.04	0.36±0.04
P value (Mean diff.)	**P1**=0.168(-4.44±11.81), **P2<0.001*(**0.07±0.04), **P3<0.001***(0.09±0.04), **P4<0.001*(**0.09±0.04), P5=0.163 **(**4.50±11.84), P6=0.161(4.53±11.84), P7=0.161(4.53±11.84), **P8<0.001*(**0.02±0.01), **P9<0.001*(**0.02±0.01)				
Visual acuity	0.05± 0.04	0.58± 0.16	0.61±0.17	0.61±0.17	0.61±0.17
P value (Mean diff.)	**P1<0.001***(-0.53±0.14), **P2<0.001***(-0.55±0.15), **P3<0.001***(-0.55±0.15), **P4<0.001***(-0.55±0.15), **P5=0.041***(-0.03±0.05), **P6=0.041***(-0.03±0.05), **P7=0.041***(-0.03±0.05)				
Contrast sensitivity	2.00± 0.00	1.32±0.11	1.32±0.11	1.57±0.11	1.57±0.11
P value (Mean diff.)	**P1<0.001***(0.68±0.11), **P2<0.001***(0.68±0.11), **P3<0.001***(0.43±0.11), **P4<0.001***(0.43±0.11)				

LASIK: Laser assisted in situ keratomileusis**. CCT:** Central corneal thickness. **K1:** Horizontalkeratometry. **K2:** Vertical keratometry. **Diff:** difference. ***:** Significant. **P1:**1st day compared to 1st week. **P2:** 1st day compared to 1st month. **P3:** 1st day compared to 3rd month. **P4:** 1st day compared to 6th month. **P5:** 1st week compared to 1st month. **P6:** 1st week compared to 3rd month. **P7:** 1st week compared to 6th month. **P8:** 1st month compared to 3rd month. **P9:** 1st month compared to 6th month. **P10:** 3rd month compared to 6th month.

DISCUSSION

Studies have shown that intraocular lens (IOL) implantation, photorefractive keratectomy (PRK), and laser-assisted in situ keratomileusis (LASIK) are effective treatments for high myopia ≥−6.00 D [6]. Numerous studies have shown these approaches to be safe, effective, and predictable [7,8].

The possibility of post-LASIK ectasia, which is thought to be decreased with femtosecond laser surgery (femto-LASIK), and the production of lower flap thickness SD in comparison to traditional LASIK are two issues with LASIK application for severely myopic patients. In contrast, femto-LASIK induces less higher order aberrations than the traditional method does [9]. So, the aim of this study was to evaluate the visual outcome between LASIK, transepithelial photorefractive keratectomy (trans-PRK) and implantable collamer lenses for correction of moderate to high myopia.

This study showed that, central corneal thickness post 1st day of operation was significantly increased among laser assisted in situ keratomileusis group (549.00±24.71) than transepithelial photorefractive keratectomy (523.00±41.81) and implantable collamer lens (482.33±16.07) studied groups (P<0.001). While, central corneal thickness post 1st week, 1st month, 3rd month and 6th month of operation were significantly increased amongimplantable collamer lens group than transepithelial photorefractive keratectomy and laser assisted in situ keratomileusis studied groups (P<0.001).

Our result was close to the result obtained by **Hjortdal *et al.*** [10] who found that, short-term corneal thickness reduction was greater in PRK eyes than in LASIK eyes; the likely cause is the existence of a thin and immature epithelial cell layer following PRK. Despite a significant disparity in corneal thickness, a similar refractive result was produced in both groups, which might be explained by edema of the LASIK flap edge. Following surgery, tonometry values dramatically dropped, especially in the LASIK group.

Also, **Hjortdal *et al.*** [10] reported that, the return of normal or potentially greater epithelial thickness or a stromal-healing response may have contributed to the medium-term considerable rise in corneal thickness in PRK eyes [11]. In LASIK eyes, corneal thickness did not dramatically rise, and the slight gain in optical power is consistent with the potential removal of peripheral flap edema. Over an extended period, both groups saw a minor but considerable increase in corneal thickness. If the thickening takes place throughout a sizable portion of the corneal surface, the rise in thickness without a matching increase in corneal power can be explained. Tonometry readings rose considerably in PRK eyes but did not alter in LASIK eyes.

Additionally, in a study by **Elmohamady and Abdelghaffar** [12] to study alterations in the anterior chamber due to appropriate IOP management and little to no surgical stress to the endothelium, a CCT scan revealed a nonsignificant change following implanted collamer lens implantation in extreme myopia using Pentacam.

In the current study, visual acuity post 1st day, 1st week, 1st month, 3rd month and 6th month of operation were significantly increased among transepithelial photorefractive keratectomy group than implantable collamer lens and laser assisted in situ keratomileusis studied groups (P<0.001).

Our results were partially compatible with the recent reported literature by **Sarhan *et al.*** [13] who found that, one day after surgery, patients in the FS-LASIK group showed much better VA than those in the ICL group; however, after one week, there was no difference (P > 0.05). In the third- and sixth-months following surgery, however, there was a substantial rise in VA in the ICL group relative to the FS-LASIK group. After FS-LASIK and ICL groups, VA was found to be steady, indicating that although the line in the ICL group tends to be more stable over time, eyes in the FS-LASIK group tend to regress with time. In fact, due to modest interface haze generation, the femtosecond LASIK procedure caused a temporary loss in optical quality as well as an increase in intraocular scattering in the early postoperative period [14].

Because of the higher-order aberrations and VA, the visual performance following FS- LASIK has been somewhat characterised [15]. According to **Kamiya *et al.*** [16], corneal scattering rather than higher-order aberrations from uneven surfaces is the reason for this recovery delay, and it is crucial for visual function following ICL.

In a similar vein, **Qin *et al.*** [17] reported that one week following surgery, the objective scatter index (OSI) rose considerably. Thus, they conjectured that the rise in OSI and higher-order aberrations in corneal morphological alterations and temporary haze were connected to the decline in VA one week following FS-LASIK. VA improved one month following surgery, and three months following surgery, it improved dramatically.

Possibly as a result of better visual quality brought about by the haze reduction, BCVA did not differ substantially before or after surgery. ICL implantation was shown in prior research by **Chung *et al.*** [18] to be a reliable, safe, and effective treatment for myopic regression in eyes that had previously undergone LVC. After ICL implantation, the mean UDVA and CDVA at three months after surgery greatly improved, and 97% of the eyes exhibited no change or gain in Snellen lines of CDVA. Furthermore, a SEQ within ±0.50 D was reached in 93% of the eyes.

In the current study, contrast sensitivity post 1st day of operation was significantly decreased among transepithelial photorefractive keratectomy group than implantable collamer lens and laser assisted in situ keratomileusis studied groups (P=0.015). While,

contrast sensitivity 1st week, 1st month, 3rd month and 6th month of operation were significantly increased among implantable collamer lens than transepithelial photorefractive keratectomy group and laser assisted in situ keratomileusis studied groups(P<0.001).

The effects of the two treatments on contrast were observed to differ significantly in research by **Saif and Mahdy [19],** as contrast sensitivity reduced one week after LASIK and restored to preoperative levels three months later. After one week and one month following the PRK treatment, it steadily reduced and improved, but after three months, it did not revert to the preoperative values.

The mean average contrast sensitivity in the LASIK group was 1.42 ± 0.1 prior to the surgery, 1.29 ± 0.07 one week after the treatment (P value <0.0001), and 1.35 ± 0.09 one month after the procedure (P value <0.0001). The measurement was 1.41 ± 0.11 with a P value of 0.017 three months after LASIK. The mean average contrast sensitivity in the PRK group was 1.44 ± 0.09 prior to the operation, 1.09 ± 0.04 one week after the surgery (P value <0.0001), and 1.2 ± 0.07 one month after the procedure (P value <0.0001). It was 1.34 ± 0.07 with a P value of 0.017 three months after PRK.

Our findings were almost exactly the same as those of other studies: 38 trial participants, or 76 eyes, were randomised to have LASIK (n = 18) or PRK (n = 20). In PRK patients, there was a statistically significant decrease in contrast sensitivity at all spatial frequencies in the first- and third-months following surgery, but by the sixth month, they had returned to preoperative levels. One month following surgery, there were lower contrast sensitivity levels in LASIK patients at all spatial frequencies. Contrast sensitivity returned after three months and did not deviate much from preoperative levels **[20].**

Also, in a study by **Ondategui *et al.*** **[21]** included 55 eyes treated with LASIK and 34 eyes treated with PRK. The findings showed that there were no appreciable variations in the reduction in retinal picture quality between PRK and LASIK. Three months after surgery, some PRK patients still exhibited a residual refractive defect that may have been caused by the corneal wound healing.

In the present study, 8 patients (53.33%) had an operation on right eye and 7 patients (46.67%) had operation on left eye among transepithelial photorefractive keratectomy group. Also, 10 patients (66.67%) had operation on right eye and 5 patients (33.33%) had operation on left eye among implantable collamer lens group. Also, 10 patients (66.67%) had an operation on right eye and 5 patients (33.33%) had operation on left eye among laser assisted in situ keratomileusis group, with no significant difference (P=0.685).

Castro-Luna *et al.* **[22]** discovered in a prior study that PRK surgery had a greater predictability than FS-LASIK surgery. There was a small decrease in safety and efficacy when compared to FS-LASIK surgery. They looked at the effectiveness and safety indices split into two patient groups—one that underwent retreatment and the other that did not—due to the large frequency of retreatments. In both the retreatment and non-retreatment groups, their findings indicated a statistically significant increase in safety for patients who underwent FS-LASIK surgery as opposed to those who underwent PRK surgery. There were statistically significant differences in the safety indices favouring the FS-LASIK approach between patient groups who had therapy and those that did not, with the exception of the 5-year follow-up following surgery. At the three-month, one-year, and two-year follow-up periods, there was a statistically significant difference in the efficacy rates for FS-LASIK operation. These discrepancies did not hold true five or ten years following the procedure; instead, the effectiveness outcomes were identical, with a little bias in favour of FS-LASIK surgery.

The same outcomes were also reported by **Sajjadi *et al.*** **[23],** however with a shorter follow-up period following surgery. Following a 6-month follow-up period, **Hashemi *et al.*** **[24]** found an effectiveness index of 1.01 ± 0.05 for PRK and 1.01 ± 0.14 for FS-LASIK.

CONCLUSIONS

In patients with extreme myopia, particularly if the corneal thickness is restricted and in individuals with more refractive regression, the postoperative visual quality following ICL implantation was marginally better than that following LASIK. ICL implantation is therefore a preferable first option, particularly for young people who require close vision. According to all findings, PRK and LASIK procedures are both long-term safe and successful. However, Trans PRK could be used safely and superior to LASIK in all cases and superior to LASIK in thin cornea and avoiding complications of flap.

- **Conflict of interest:** None.
- **Funding:** None.

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