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Femtosecond laser-assisted implantation of Ferrara versus Myo rings for keratoconus Correction

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Abstract

Aims: To compare Ferrara ring versus MYO ring to demonstrate the most appropriate solution for keratoconus to avoid penetrating keratoplasty. Keratoconus is a serious medical and communal dispute that perturbs the character of life, evolved to be the first indication of penetrating keratoplasty in young people, which has many drawbacks as rejection for example. Intracorneal ring segments help to avoid keratoplasty. **Study design**: This research was accomplished as a retrospective, randomized trial. It was conducted between January 2018 and July 2020. **Materials and methods**: Fifty eyes of keratoconus, divided into, group (I): 29 eyes underwent Ferrara Ring implantation and group (II): 21 eyes underwent Myo Ring implantation for correction of keratoconus and high myopia **Results**: Statistical analysis revealed, there was statistically significant improvement in group B (MYO ring group) in comparison to group A (Ferrara ring group) with Un Aided Visual Acuity (UAVA) after implantation by 1 month ($p = 0.027$), also there was statistically significant increase in group B in comparison to group A with subjective refraction after 3 months ($p = 0.035$), there was statistically significant decrease in keratometry readings in MYO group in comparison to Ferrara group with 1 month ($p = 0.011$) and after 6 months ($p = 0.011$). **Conclusions**: Ferrara and MYO Intracorneal rings are considered very effective treatments in the management of keratoconic patients, with superiority for MYO ring in unaided visual acuity and keratometry modification.

Keywords: MYO ring; Ferrara; ICRS; Femtosecond; laser; keratoconus

Introduction

Keratoconus is a non-inflammatory advancing corneal thinning of unsettled etiology outlined by steepening, conical protruding and eccentric thinning and attenuation, producing irregular astigmatism, high myopia and bad visual acuity [1-2]. Keratoconus usually happens during puberty and may seriously annoy the patient's life [3], In keratoconus, corneal deteriorations promoted variable decrease in the best-corrected visual acuity (BCVA) as a result of malignant myopia, regular or irregular astigmatism, moreover apical scarring in end stage cases. Even though, intensive clinical and laboratory investigations, its precise etiology is unknown [4-5], this corneal aberrationbecomes the imperious urgency for corneal transplantation in young patients. Till the end of previous century, keratoplasty was the only treat for this pathology, though its endless complications. In the beginning of current millennium, intracorneal ring segments implantation was prospective as a therapeutic choice for treating keratoconus patients. The optimum refractive surgery hoped to be harmless, reproducible, achieving and reversible [6-7]. Intra Corneal Ring Segments (ICRS); preside the hopes for keratoconus patients. It is a harmless and a reversible procedure, repairing topographical problems influencing refraction, so enhance vision and welfare of patients. Theoutcome's steadiness will rely on the pathway of the disease at time of the surgery; therefore, non progressive keratoconus cases have stable succeeded treatment by rings [8]. Intrastromal corneal ring segments affect by an "arc-shortening element" on the corneal tissue to regularize the central defect. The most aim of rings is to reshape the odd curve of cornea and thus decrease astigmatism. Efficiency of rings in refraction repair appeared obviously with early detection and intervention, mastering a prohibition against complications [9]. Corneal re-modification by rings with aid of the Femtosecond laser is a powerful technique for keratoconus prevention with lightening High order Aberrations (HOA) in cornea of eyes with coma polynomials 3.5 m. application of Myo Ring implantation has endorsed to be an beneficial and reproducible act for vision recovery in high nearsightedness and keratoconus [10]. If the expected achievement by a program is 80% for the initial performance, it only takes an easy, rapid and secured steps for more advancement in the following proceed to reach a competence rate of nearby 100%. This is mainly the theory of the Myo Ring effect. Myo Ring implantation was found to be the procedure of least intervention for advancing vision and refraction in the most keratoconus. Myo Ring could be considered a flexible tool for KC remodeling, as it can be carefully mixed with other rings, achieving successful adds [11]. Ferrara rings achieved safe and a reasonable successful substitute for keratoconus surgery principally with un-satisfaction for contact lenses [12]. So the question now, what is the most valuable for keratoconus, the complete ring (MYO) or the segmented rings (Ferrara)? this will be answered in this thesis.

Subjects and methods

Study lay out

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This research was accomplished as a retrospective, randomized trial. It was conducted between January 2018 and September 2019.

Participants

A collection of 50 eyes of 30 patients were recruited from the national laser institute, Giza, Egypt, Inclusion criteria were, aged 25 years or older suffering from mild to moderate keratoconus, Cases that had more than 400 microns at the thinnest area and that was available for follow-up after an operation more than one year, Exclusion criteria were patients with some eye diseases (corneal Pellucid marginal degeneration, with chronic corneal herpes, with hopeless retinal diseases), with mental abnormality, had special jobs as asbestos workers, cases of high myopia only and could be corrected by glasses, Patients refuse to be included, pregnant and lactating.

Randomization

Each participant was informed about the aim, idea, nature, and benefits of the trial, the right to refuse or withdraw at any time, and the confidentiality of any obtained data. Keratoconus eyes were randomly assigned into 2 groups (A and B) with the use of a randomization program. No dropping out of subjects from the study was reported after randomization, the patients were blinded to their allocation.

Interventions

Group A was composed of 29 eyes with Keratoconus and underwent Ferrara rings implantation. Group B consisted of 21 eyes with Keratoconus and underwent Myo rings implantation, with follow up for 1, 3 and 6 months.

Instrumentation

1- Ferrara ring (Ferrarah Ophthalmic Corporation, Belo Horizonte city, Brazil): Ingredients Polymethyl Methacrylate (PMMA) with a natural filter for blue light, Arc 90° to 210°, Thickness 0.15 to 0.35 mm
2- Myo Ring (DIOPTEX GmbH, Austria): dimensions: based on the Myo Ring nomogram with theoretical calculation extracted by an observational attempt on a corneal model 27, 28, 29, and 30. This nomogrambuilt on mean central keratometry and corneal thickness at the thinnest point.

Evaluation procedure

The evaluation procedure was performed for all patients in the 2 groups before starting the program and after rings implantation by 1, 3 and 6 months.

Vision and refraction assessment

Vision degree (unaided and best corrected visual acuity) was identified by using Log Mar scale, refraction problems, objective one calculated by an autorefractometer and subjective also evaluated by log mar, anterior segment examination by a slit lamp, fund us examination using a + 20 dioptres lens for indirect ophthalmoscope, a + 90 dioptres lens for a slit lamp fund us bio microscopy and IOP determined by the Goldman application tonometer.

Assessment of corneal thickness

Corneal thickness was assessed by a keratometry before rings implantation and following it by 1, 3 and 6 months.

Assessment for corneal curvature and astigmatism by

I- Automated Kerato-Refractometer: Objective refraction using the Topcon Auto Kerato-Refractometer KR-800.

II- OPD-Scan: Nidek OPD-Scan 3measures auto refraction, keratometry, topography, wave front, and pupillometry enabling precise and approved details of corneal aberration comparing Root Mean Square (R.M.S.) and total High Order Aberrations among eyes.

III- Pentacam: Pentacam was used to assess patients' corneal topography, keratometry and pachymetry. The value of K1, K2 and Kmax were calculated together with the size, site and centralization of the corneal cone. The amount of corneal astigmatism, The thickness of cornea is measured and thinnest locations are determined, Zernike polynomials with focusing on coma aberration, anterior elevations and posterior elevations determined with periodic comparisons were done.

Treatment procedure

Group I: 29 eyes underwent Ferrara Ring implantation. Anesthesia: (Benoxinate HCL drops) put three times with 1 minute apart as a start, Corneal stromal tunnels for segments were done by IntraLase Femtosecond assisted (Abbott Medical Optics company, Santa Ana, CA, USA), tunnel depth and incision of (65-70 percent) of entire corneal thickness at the thinnest point of the ring, the inner diameter is 5.0 mm while, the outeroneis 6.0 mm, the length of entry cut is 1.2 mm, the inlet cut thickness equal 1 μm, the inlet cut energy

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is equal to 1.3 mJ, the ring bed formation energy is 1.3 mJ. Rings were pushed into their channels, at the end; a supporting contact lens was fixed.

The postoperative treatment was as followed

All eyes were had Fluorometholone 0.1%+ sod, Cromoglycate 2% (Fluca, Jamjoom, K.S.A) each 8 hours a day for 7 days, Moxifloxacin 0.5% (Vigamox, Alcon, U.S.A) each 4 hours a day for 7 days, and non-preserved artificial tear (Artelac) (Baush and Lomb, France) each 6 hours a day for 45 days.

Group II: This part of the study included 21 eyes underwent Myo Ring implantation. Anesthesia: the same as the Ferrara ring procedure.

Operative details: The central point of the site of Intrastromal corneal ring implantation was marked by sterilized specialized pen under the operation microscope (OMS- 800, TOPCON, and Tokyo, Japan).

A tunnel was set up in the most central 9 mm in cornea deep by 300 microns using Femtosecond laser (Victus, Bausch and Lomb, New York, USA).

Using a spatula, a space was slowly done via the lateral open between the closed flap and stroma. After that, the suitable Myo Ring picked affiliated with nomogram was put into this corneal tunnel through outside opening.

The ring was inserted by a particular tool through the tunnel, then ring was repositioned to be half way on the cornea reflection, by handling the ring with a sins key hook applied via the nasal incision. Then Based Balanced Saline was pushed to get rid of bubbles, followed by moxifloxacin (Vigamox, Alcon, U.S.A) was injected, Then a contact lens was put.

Postoperative medication: the same as the Ferrara ring procedure.

Postoperative Follow-up

Patients were monitored for the minimum of 6 months postoperatively. This was done at first month, third month and at sixthmonth after surgery.

Statistical study:

Data and investigations were collected, revised, coded, and preceded for the Statistical Package for Social Science (IBM SPSS) version 20. The data were entered as numbers and percentages for the qualitative data, mean, standard deviations and ranges for the quantitative data with parametric distribution and median with inter quartile range (IQR) for the quantitative data with the non-parametric distribution. Independent t-test was utilized in the differentiation between two classes with quantitative data and parametric distribution and Mann-Whitney test was utilized in the differentiation between two groups with quantitative data and non-parametric dissemination.

$P < 0.01$: High significant (HS), $P > 0.05$: Non significant (NS), $P < 0.05$ Significant (S).

Results

There was no statistically significant difference in central thickness B (before implantation), after1month, after 3 months and after 6 months in comparison between MYO group and Ferrara group (P value > 0.05).

Table (1): Discrimination between MYO group & Ferrara group as regards central thickness

	MYO group		Ferrara group		Independent T test	
	Mean	SD	Mean	SD	T	p value
Central thickness B	475.86	37.94	454.96	50.78	1.582	0.102
After 1 month	475.76	39.41	455.89	35.98	1.582	0.123
After 3 months	482.38	40.30	461.53	38.75	1.801	0.078
After 6 months	470.53	57.20	462.54	43.12	0.424	0.674

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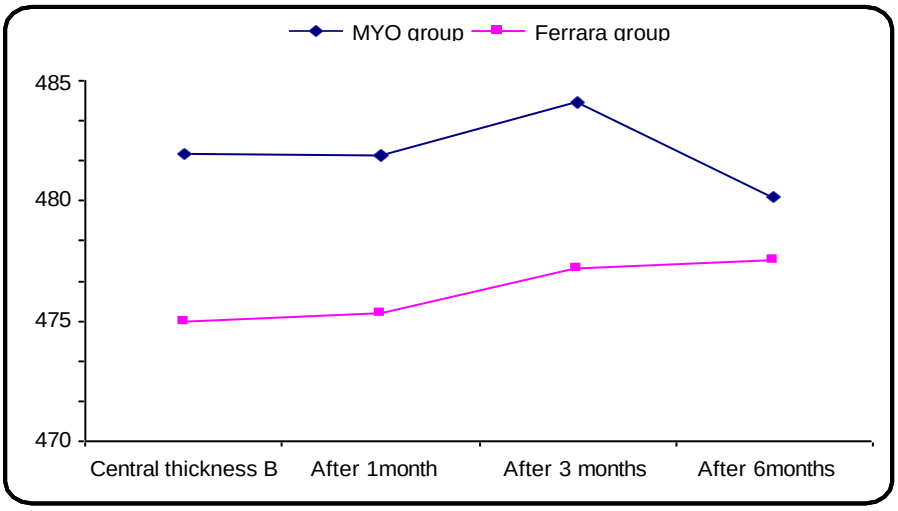

Figure (1): Thickness among studied groups

In unaided visual acuity (UAVA), a statistically significant increase was noted in MYO group compared to Ferrara 1 month post operation (P value: 0.027), as shown in table (2).

Table (2): Comparison MYO group & Ferrara group as regards UAVA

	MYO group		Ferrara group		Independent T test	
	Mean	SD	Mean	SD	t	p value
UAVA B	0.82	0.49	0.67	0.78	0.703	0.486
After 1 month	0.40	0.14	0.28	0.22	2.289	0.027
After 3 months	0.38	0.19	0.30	0.24	1.257	0.215
After 6 months	0.46	0.22	0.40	0.73	0.330	0.743

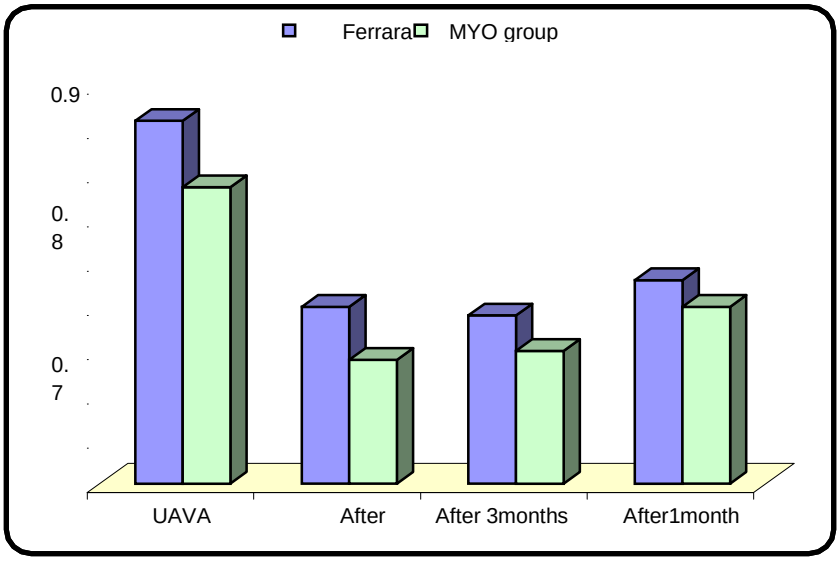

Figure (2): UAVA among studied groups

A statistically significant difference was not found in BCVA B, after 3months and after 6 months in comparison between MYO group and Ferrara group (P value>0.05).

Table (3): Comparison MYO group & Ferrara group as regards BCVA

	MYO group		Ferrara group		Independent T test	
	Mean	SD	Mean	SD	T	p value
BCVA B	1.10	3.88	0.89	2.86	0.222	0.825
After 3 months	0.24	0.17	0.16	0.11	1.932	0.059
After 6 months	0.22	0.07	0.16	0.12	1.992	0.052

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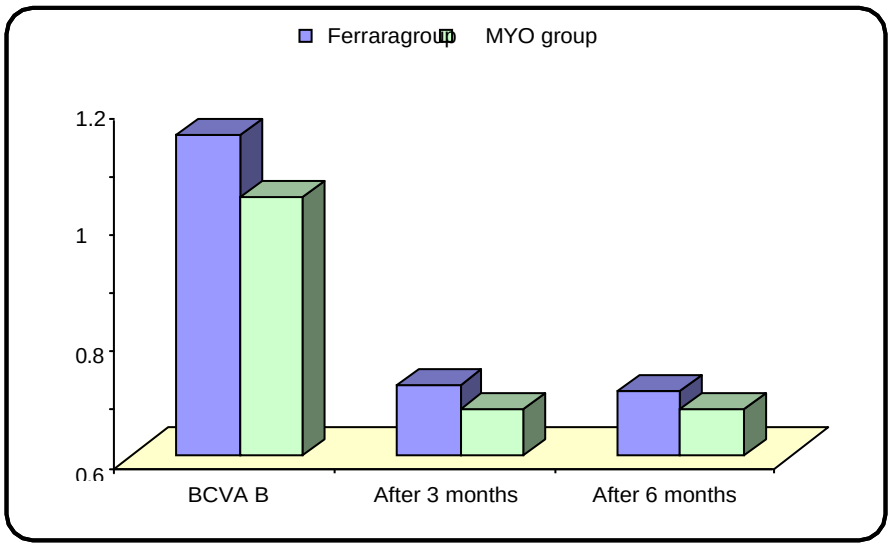

Figure (3): BCVA among studied group

A statistically significant improvement was detected in subjective refraction in MYO group in comparison to Ferrara group (p value < 0.05) in after 3 months data as in table (4).

Table (4): Comparison MYO group & Ferrara group as regards subjective refraction B

	MYO group		Ferrara group		Independent T test	
	Mean	SD	Mean	SD	t	p value
Subjective Refraction B	-2.82	9.49	-2.19	4.87	-0.302	0.764
After 3 months	-1.02	2.33	-2.63	2.78	2.167	0.035
After 6 months	-1.34	3.28	-1.97	3.34	0.643	0.523

A statistically significant decrease was reported in MYO group in relation to Ferrara group with KERATOMETRY B, 1 month post implantation and 6 months post implantation (p value<0.05).

Table (5): Discrimination between MYO group & Ferrara group as regards KERATOMETRY

	MYO group		Ferrara group		Independent T test	
	Mean	SD	Mean	SD	T	p value
KERATOMETRY B	49.14	4.03	46.08	9.42	1.397	0.169
After 1 month	43.80	2.07	46.01	2.80	-2.688	0.011
After 3 months	43.66	2.68	45.08	2.53	-1.796	0.080
After 6 months	**42.81**	**1.93**	**45.01**	**3.21**	**-2.650**	**0.011**

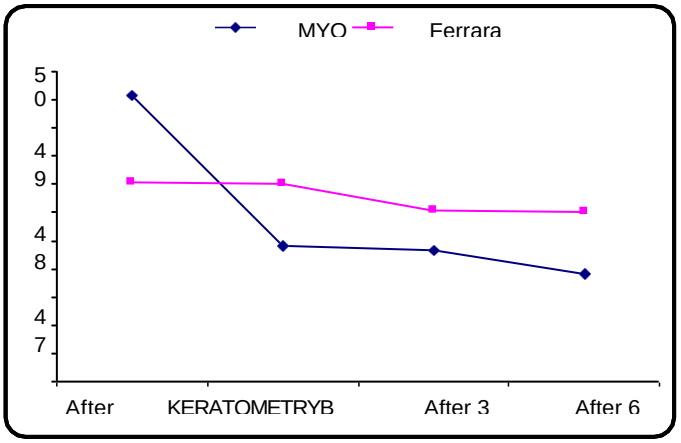

Figure (5): Keratometry among studied groups

A statistically significant increase was measured in MYO group with respect to Ferrara group with Anterior elevation B, first month post operation and third month post operation (p value<0.05).

Table (6): Comparison MYO group & Ferrara group as regards Anterior elevation

	MYO group		Ferrara group		Independent T test	
	Mean	SD	Mean	SD	T	p value
Ant. elevation B	31.61	14.90	36.14	13.90	-1.056	0.297
After 1 month	28.65	9.74	18.75	11.67	2.770	0.009
After 3 months	33.55	22.76	20.95	12.65	2.244	0.030

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After 6 months	22.19	8.89	20.60	11.28	0.475	0.637

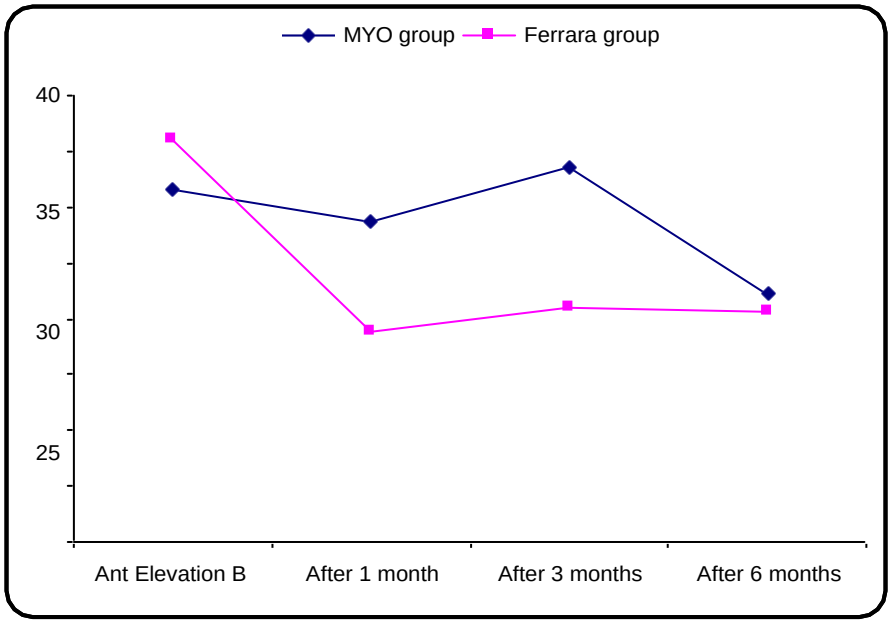

Figure (6): Anterior elevation among studied groups

A significant increase statistically was noted in MYO group in contrast to Ferrara group with posterior elevation after 1 month (p value = 0.043) as in table (7).

Table (7): Comparison MYO group & Ferrara group as regards post elevation

	MYO group		Ferrara group		Independent T test	
	Mean	SD	Mean	SD	t	p value
Post elevation B	46.56	12.62	73.62	37.14	-2.976	0.005
After 1 month	70.18	34.29	49.60	20.19	2.114	0.043
After 3 months	51.71	26.31	48.36	23.95	0.394	0.696
After 6 months	51.45	14.62	51.04	21.70	0.058	0.954

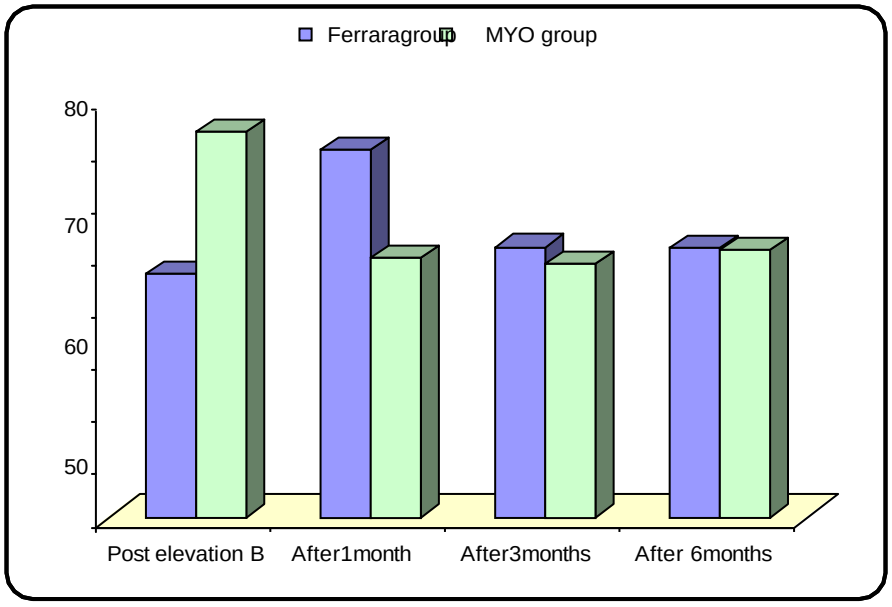

Figure (7): Post elevation among studied groups

Discussion

This study aims to discriminate intracorneal implantation in keratoconus using Femtosecond laser innovation between the Ferrara and Myo Ring. Since we assumed that several confounding factors could affect the visual acuity in the first few postoperative days, including eye surface problems and stromal edema. So, we assessed our patients before surgery (B), first month, third month, and sixth month after surgery, in both studied groups. In the current analysis, regarding MYO group the mean and standard deviation of central thickness preoperatively were 475.86±37.94; after 1 month were 475.76± 39.41; after 3months were

482.38±40.30 and after 6 months were 470.53±57.20; where Ferrara group were 454.96±50.78; 455.89±35.98; 461.53±38.75 and 462.54±43.12 μm respectively. A statistically significant difference was not measured in central thickness preoperatively, first month, third month, and sixth month after surgeryin comparison between MYO group and Ferrara group (P>0.05). In a recent study of El-Kasaby (13) conducted on 40 eyes of 25 patients with keratoconus grades 2–4; studied Moy ring and Ferrara ring segments implantation by help of Femtosecond laser for curing keratoconus and found that the mean±SD of the central corneal thickness preoperatively of MYO group was 440.25±44.49 increased postoperatively to 476.57±41.36 μm, (P>0.05). Regarding Ferrara group the central corneal thickness preoperatively was 441.35±43.02 and increased to 470.63± 41.96 μm postoperatively, (P>0.05). In the present study regarding MYO group the mean and standard deviation of unaided visual acuity (UAVA) preoperatively was 0.82± 0.49; after 1 month was 0.40±0.14; after 3 months was 0.38 ± 0.19 and after 6 months was 0.46 ± 0.22; while Ferrara group were 0.67 ± 0.78; 0.28 ± 0.22; 0.30 ±0.24 and 0.40 ± 0.73 Log MAR respectively. A statistically significant difference was not reported between the two groups regarding UAVA, (P>0.05), except significance increase in MYO group in comparison to Ferrara group with UAVA after 1 month (P<0.05). According Sammour et al. (14) in a prospective 40-eyes trial split into 2 classes; the mean MYO preoperative UAVA was 1.20±0.030 Log MAR (range 0.1-1.4 Log MAR). In Ferrara group, the mean preoperative UAVA was 1.04±0.33 Log MAR (range 0.2-1.4 Log MAR). A statistically significant difference not reported between two groups throughout the follow up postoperatively, (P>0.05). In the present study regarding MYO, group the mean and standard deviation of best-corrected visual acuity (BCVA) preoperatively was 1.10±3.88; after 3 months was 0.24± 0.17 and after 6 months was 0.38 ±0.19; while Ferrara group were 0.89±2.86; 0.16±0.11 and 0.16±0.12 Log MAR respectively. A statistically significant change not detected in the two classes related to BCVA, (P>0.05). Sammour et al. (14) stated that, the Mean Best Corrected Visual Acuity in the MYO group mean preoperative BCVA was 0.92 ± 0.29 Log MAR (range 0.40-1.3 Log MAR). In the Ferrara patients, the mean preoperative BCVA was 0.75±0.33 Log MAR (range 0.30-1.30 Log MAR). A significant difference statistically was calculated between two rings at the first month after implantation and twelfth month, (P>0.05). The MYO group in this research has mean and standard deviation of auto refraction preoperatively of - 6.28 ± 6.70; after 3months was -2.79 ± 5.13 and after 6 months post implantation was -2.74 ± 4.01; while Ferrara group were 4.82 ± -0.521; 3.63± -0.592 and 3.46 ± -0.172 respectively. a statistically significant change was not detected in auto refraction preoperatively, after 3 months and after 6 months in comparison between MYO group and Ferrara group (P>0.05). Corresponding to auto refraction El-Kasaby (13) reported that the mean±SD of MYO group preoperatively were -5.97±3.96 and postoperatively were 2.44±1.64. Ferrara group were - 4.87±3.06 preoperatively and 1.88±0.99, (P>0.05). In the current study, regarding MYO group the mean and standard deviation of subjective refraction preoperatively was -2.82 ± 9.49; after 3 months was -1.02 ± 2.33 and after 6 months was -1.34 ± 3.28; while Ferrara group were -2.19 ± - 4.87; -2.63 ± 2.78 and -1.97 ± 3.34 respectively. a significant difference statistically was not existed in subjective refraction preoperatively and after 6 months in comparison between MYO group and Ferrara group (P>0.05), a significant change was reported 3 months post operation, (P<0.05). Respecting subjective refraction El-Kasaby (13) reported that the mean±SD of MYO group preoperatively was -3.67±2.36 and postoperatively was -2.44±1.33. Ferrara group was -2.84±3.26 preoperatively and -1.11±0.35 post operation, (P>0.05). In the present study, MYO group has mean and standard deviation of keratometry preoperatively of 49.14 ± 4.03; after 1 month was 43.80 ± 2.07; after 3 months was43.66 ± 2.68 and after 6 months was 42.81± 1.93; while Ferrara group were 46.08 ± 9.42; 46.01±2.80; 45.08±2.53 and 45.01 3.21 respectively. A significant decrease was detected in MYO group in relation to Ferrara group with keratometry after 1 month and after 6 months, (P<0.05). Mean Keratometry Readings in thesis of Sammour et al. (14) was found to be in MYO group preoperatively as 52.56±4.44 SD (range 47.40_59.80 D), contrarily in Ferrara rings was 52.90±3.93 SD (range 46.4_59 D). In differentiation between Groups, a significant difference statistically was calculated between two groups throughout trial, (P>0.05). In the current study regarding MYO, group the mean and standard deviation of astigmatism preoperatively were -2.97 ± 3.75; after 1 month were -2.25 ± 2.03; after 3 months were -2.03 ± 1.59 and after 6 months were -2.22 ± 1.61 D; where Ferrara group were -3.52 ± 3.05; -1.99 ±1.72; -2.26 ± 1.77 and -1.53±1.96 D respectively. There was no statistically significant difference in astigmatism preoperatively, after 1 month, after 3 months and after 6 months in comparison between MYO group and Ferrara group, (P>0.05). El-Kasaby (13) found that the mean±SD of the astigmatism preoperatively of MYO group were -1.98 ± 4.72 and improved postoperatively to -1.81 ± 1.73 D, (P>0.05). Regarding Ferrara group the central corneal thickness preoperatively were -2.31 ± 3.69 and changed to -2.77 ± 1.23 D postoperatively, (P>0.05). In this trial, MYO group has mean and standard deviation of Root Mean Square

of total High Order Aberrations preoperatively were 4.09±1.51; after 1 month were 3.94±1.43; after 3 months were 3.84±1.21 and after 6 months were 4.46± 1.75; while Ferrara group were 2.62±1.47, 3.93±2.77, 3.98± 3.54 and 3.51±2.50 µm respectively. A statistically significant difference was not measured between studied groups regarding RMS, (P>0.05), except statistically significance in MYO group in comparison to Ferrara group with RMS preoperatively (P<0.05). Regarding MYO group Yousif and Said (15) who recently studied the contra lateral eye focusing on topographic, refractive, and aerometric influences after Femtosecond assisted Myo Ring involvement and DALK for repairing of keratoconus; found that there was a statistically significant lower mean RMS between preoperatively and postoperatively results, (P<0.05). Regarding Ferrara group Torquetti et al. (16) who recently evaluated front and back surfaces of the cornea using a Femtosecond laser in keratoconus patients involved with Intrastromal corneal ring segments; found that RMS reduced from 4.43±2.19 µm preoperatively to 3.88±1.83 µm postoperatively (P<0.05). In the current study regarding MYO group the mean and standard deviation of COMA preoperatively were 3.60±1.30; after 1 month were 2.64±0.89; after 3 months were 2.58±1.19 and after 6 months were 2.09±0.95, while Ferrara group were 2.34 ± 1.43, 2.35 ± 1.24, 2.16 ± 1.49 and 2.08 ± 1.25µm respectively. A significant difference statistically not calculated between studied groups respecting to COMA, (P>0.05), except statistically significance in MYO group in comparison to Ferrara group with COMA preoperatively (P<0.05). Corresponding to MYO group, Yousif and Said (15) stated a statistically significant lower mean COMA between preoperatively and postoperatively results, (P<0.05). Respecting to Ferrara group, Torquetti et al (16) stated that COMA reduced significantly from 1.96±1.33 µm preoperatively to 1.64±1.02 µm postoperatively (P<0.05). In the current study regarding MYO group, the mean and standard deviation of Anterior elevation preoperatively was 31.61±14.90; after 1 month was 28.65±9.74; after 3 months was 33.55±22.79 and after 6 months was 22.19± 8.89; while Ferrara group were 36.14 ±13.90, 18.75±11.67, and 20.95±12.65 and 20.60±11.28 µm respectively. There was no statistically significant change between studied groups regarding anterior elevation, (P>0.05), except statistically significance in MYO group in comparison to Ferrara group with anterior elevation at the first and third months of follow-up (P<0.05). Respecting to MYO group, Yousif and Said (15) reported a statistically significant high change in mean anterior elevation between preoperative and postoperative statistics, (P<0.05). In Ferrara group trial by Torquetti et al. (16) posterior elevation showed a significantly increased change from 21.1±27.8 µm preoperative to 27.7±22.5 µm postoperatively (P<0.05). In the current study regarding MYO group, the mean and standard deviation of posterior elevation preoperatively was 46.56±12.62; after first month was 70.18±34.29, after third month was 51.71±26.31 and after sixth month was 51.45±14.62; while Ferrara group were 73.62 ±37.14, 49.60±20.19, 48.36±23.95 and 51.04±21.70 µm respectively. A statistically significant change not recorded between studied rings in respect to posterior elevation, (P>0.05), except a statistically significance increase in MYO group in correspondence to Ferrara group with posterior elevation preoperatively and after 1 month of follow-up (P<0.05). Yousif and Said (15) stated that MYO implanted patients have a statistically significant higher mean posterior elevation between preoperatively and postoperatively results, (P<0.05). Regarding Ferrara group Torquetti et al. (16) noted that posterior elevation increased non significantly from 31.3±33.4 µm preoperatively to 35.4±27.6 µm postoperatively, (P>0.05). Some cases show non improvement in vision though improved topographic imaging; this is explained by tilting of rings in stroma approved by OCT anterior chamber.

Author's contributions

RSA collected data with organization and curation, provided materials and software. AMA conceived and put conceptualization with validation beside supervision and supporting efforts. EAA put methodology and visualization, wrote initial and final drafts. all authors have critically reviewed and approved the final draft and are responsible for the content and similarity index of the manuscript.

Conclusions

Intracorneal rings are superb for overcoming keratoconus. It is a harmless and a reversible therapy that can control the deviation of corneal surface inducing recovery of visual function. Using the Femtosecond laser technology has evolved an implantation technique to turn into an accurate, simple, low learning curve, and minimize to an immense extent the intraoperative complications.

Recommendations

For Myo Ring select central, symmetrical or partially asymmetrical cones with spherical equivalent > -5, also successfully in high k readings as 65 diopters provided that cornea is clear, it can flatten up to 10 diopters of K readings. Myo Ring can be repositioned easily with availability for complete evaluation by true postoperative optical axis.

Ferraring should be used in early par central cones, pellucid marginal degeneration and corneal ectasia after Excimer laser. Higher-order aberrations reflect the biomechanics of corneal tissue, should be considered in new nomogram

generations to improve results.

Ethical licence

The research linked to human use has obeyed all the national laws and institutional policies went with the principles of the Helsinki disclosure and approved by review board at National Laser Institute, Cairo University, Giza, Egypt, on 5 may 2018.

Informed consent

Informed consent has been signed from all individuals.

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