Review Article

BIOMEDICAL Journal of Scientific & Technical Research

ISSN: 2574 -1241

DOI: 10.26717/BJSTR.2019.17.002973

Changes in the Refraction and Visual Acuity of Patients during a Period of the First Month after Phacoemulsification Surgery

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ARTICLE INFO

Received: April 10, 2019

Published: April 22, 2019

ABSTRACT

Citation: Pateras E, Alonistiotis D, Hyska B and Tsiantakou G. Changes in the Refraction and Visual Acuity of Patients during a Period of the First Month after Phacoemulsification Surgery. Biomed J Sci & Tech Res 17(2)-2019. BJSTR. MS.ID.002973.

Introduction

The crystalline lens of the eye is a transparent and biconvex structure, which is placed at the posterior chamber of the eye, between the iris and the vitreous humor [1-3]. The lens is suspended in place by the radially arranged zonules fibers. Also, is anatomically composed by a surrounding capsule, the epithelial cells, which are placed at the posterior surface of the capsule and the lens fibers, which is the main substance of the crystalline lens (cortex and nucleus). The main function of the lens is to contribute to the refraction of light and its focus on the retina. When beholding a far distance object, the image of the target on the retina is well focused and we decide to focus at a near distance object, increasing the refractive power of the eye is necessary, so as to have the image of the target on the retina always well focused (accommodation). What we know today about the mechanism of accommodation are based on the theory of Helmholtz (1856) Therefore, when looking in far distance, the ciliary body is relaxed and its diameter increases, keeping the zonules fibers tense. As a result, the curvature of the crystalline lens decreases (the lens becomes flatter).

During accommodation, the ciliary muscle decreases in diameter, while the fibers get loose. Then the elastic capsule of the crystalline lens, regains its physiological curved form. Over time, the lens loses its elasticity and become harder, inflexible and more opaque in color. As a result, the lens loses the ability of accommodation. The gradual loss of the crystalline lens clarity is the pathological eye condition of cataract and is treated surgically (Figure 1).

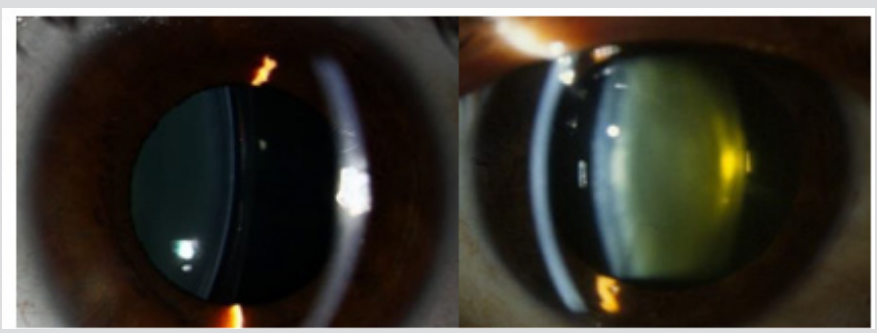

Figure 1: Natural crystalline lens (left) – Crystalline lens with cataract (right).

Phacoemulsification Technique

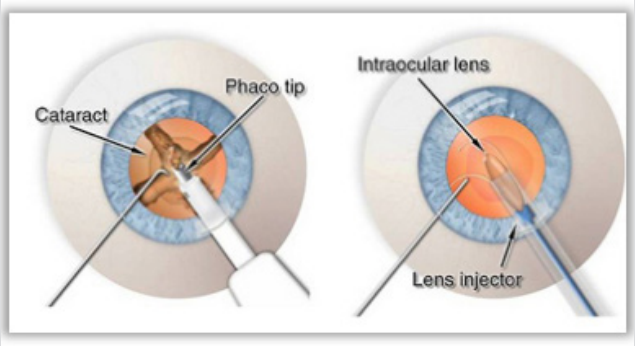

Figure 2: Presentation of crushing the nucleus and emulsification.

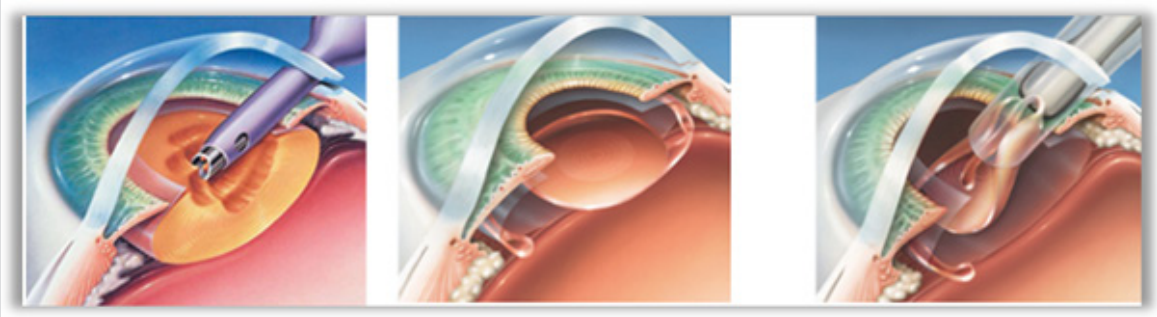

Figure 3: Crushing the nucleus of the crystalline lens during phacoemulsification surgery and insertion of the IOL.

In our days, phacoemulsification [1-3] is the most widespread method of surgical treatment of cataract. The main advantages of this technique are the successful removal of the crystalline lens through a small incision, the reducing of the hospitalization period, the avoidance of intraoperative and postoperative complications and the accelerating of postoperative visual rehabilitation of the patient. During this technique, the nucleus of the crystalline lens gets emulsified by a ultrasonic handpiece and the crushed parts are get removed from the anterior chamber of the eye by an irrigation-aspiration probe. Finally, a new intraocular lens (IOL), that replaces the crystalline lens, is placed inside the empty capsule. From the April to June of 2017, at "ATTIKON" Athens University General Clinic, a clinical study took place. The purpose of the study was to examine the evolution of the refraction of eighteen patients, during the first month after phacoemulsification surgery. Also, the study aims to investigate, if the cases that were examined developed the technique's main advantages [4, 5-9]. Of the total of eighteen patients, eleven were women and seven were men. Their ages fluctuated between the ages of 49 and 88. They were operated by the same surgeon, who followed the same surgical process in all cases (Figures 2 & 3).

Fifteen and thirty days after every patient's surgical treatment, a check of the operated eye's refraction was held. Special attention was paid to the evolution of visual acuity. Of all patients, two people showed findings of dry type of age-related macular degeneration, preoperatively. In the first case (No 6), this condition affected the visual acuity of the patient and remained in low levels, postoperatively. In the second case (No 11), the visual acuity of the patient improved and didn't get affected by this pathological condition. In two people, also, appeared aspects on the Descemet's membrane fifteen days after phacoemulsification. As a result, the first patient (No 8) ended with low visual acuity and the second patient (No 18) ended with secondary myopia, because of corneal edema.

Presentation of Astigmatism Changes

Fifteen days after phacoemulsification, four patients developed an unimportant amount of stigmatism, between 0 - 0.25 D and six patients developed between 0.50 - 0.75 D. From the eighteen patients, six developed astigmatism between 1.00 – 1.25 D and two of them an amount of 1.75 D. In total, all cases concluded with a postoperative astigmatism. The highest rate was at 1.75 D, which is not considered important as it's going to decrease in the next few days. At the refractive check, thirty days after the surgery, there was a little improvement in the astigmatic error. Six patients developed an unimportant rate of astigmatism between 0 – 0.25 D, five developed an astigmatic rate between 0.50 – 0.75 D and six developed astigmatism between 1.00 – 1.75 D. Finally, only one case developed a high rate of astigmatic error, at 2.00 D. In conclusion, out of the eighteen clinical cases, six people developed astigmatism "with the rule", from 0.50 to 1.50 D, four patients ended with zero astigmatism and seven patients developed "against the rule" astigmatism from 0.25 to 1.00 D. A special clinical case, was one patient (No 18), who had a final increase in astigmatism, at 2.00 D, because of a pterygium, which entering the cornea caused a refractive error (Table 1).

Table 1: Presentation of astigmatism changes ,15 and 30 days after phacoemulsification surgery.

Number of Patients	POST-OP CYL (15 DAYS)		POST-OP CYL (30 DAYS)	
	Cyl	**AXIS**	**Cyl**	**AXIS**
1	-0,5	15	-0,25	80
2	-1,75	70	-1,25	75
3	-1,25	90	-1,5	106
4	-0,25	5	-0,5	160
5	0,5	170	0,5	170
6	1	75	0,75	70
7	-0,75	20	0,75	90
8	1,75	20	-1,75	100
9	0	0	0	0
10	-1	90	-1	90
11	-0,5	80	-0,25	11
12	-0,25	115	0	0
13	0	0	0,5	106
14	1,25	40	1	130
15	-1	114	-1	90
16	-0,5	45	0	0
17	-0,5	165	0	0
18	-1	96	-2	90

Presentation of the Spherical Component of Refraction Changes

Fifteen days after the phacoemulsification, four patients developed a low myopic error, ranging from 0.25 to 0.50 D. Eight clinical cases, also, developed a zero sphere and the other six developed a low hyperopic error, from 0.25 to 0.50 D. Thirty days after the surgical treatment, the noticed changes were very small, as we were already talking about a negligible sphere. As a result, the sphere remained stable in nine of the eighteen clinical cases, decreased by 0.25 D in three cases and small increase of 0.25 – 0.50 D, was noticed in six patients.

Presentation of Visual Acuity before and after Surgery

The preoperative sphere and astigmatism weren't included as clinical data in the study, because special attention was paid to preoperative visual acuity. That's how the success of the phacoemulsification surgery gets more understandable in terms of restoring the visual capacity of the patients. Therefore, preoperatively, the visual acuity of the patients ranged from light perception (LP) to 5/10. Thirty days after the phacoemulsification surgery, twelve clinical cases developed very good to excellent visual acuity (9 – 10/10), as final postoperative visual acuity. In addition, six patients developed good visual acuity (7 – 8/10). There was complete visual acuity recovery even in patients who did not exceed 1/10 or LP, preoperatively, as the cataract was the only pathological problem of the eye. In six patients, visual acuity remained stable at 15 and 30 days and in twelve patients the vision improved. Also, thirty days after the surgery, in six out of the eighteen cases, there was a final improvement in visual acuity above two lines, when compared to visual acuity by applying the optimal refractive correction. Therefore, the use of corrective ophthalmic lenses has been proposed to them (Table 2).

Table 2: Presentation of visual acuity.

Patients	PRE-OP VA	POST-OP VA (15 days)	POST-OP VA without glasses (30 days)	POST-OP VA with glasses (30 days)
1	0,4	0,5	0,9	1
2	0,4	0,4	0,7	0,8
3	0,4	0,6	1	1
4	0,05	0,4	0,3	1
5	0,3	0,5	0,5	0,7
6	0,15	0,7	0,7	0,7
7	0,3	0,7	0,8	0,9
8	0,05	0,4	0,6	0,9
9	0,3	0,8	0,8	1

10	0,3	0,7	0,7	0,8
11	0,2	0,7	0,9	0,9
12	0,2	0,6	0,7	0,8
13	0,4	0,6	0,7	0,9
14	0,2	0,7	1	1
15	0,5	0,9	0,9	1
16	0,05	0,8	1	1
17	0,3	0,8	0,9	0,9
18	0,3	0,4	0,6	0,8

Statistical Study

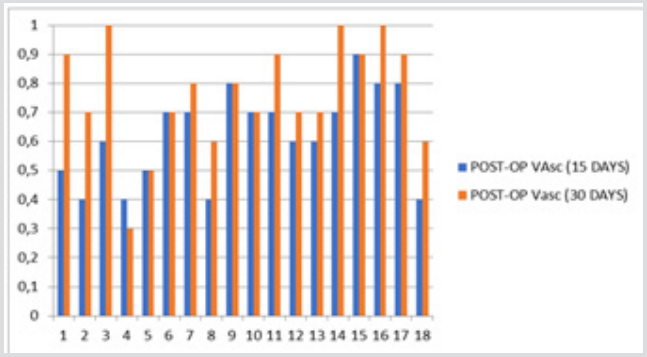

Figure 4: Changes of visual acuity post-operative 15 days & 30 days.

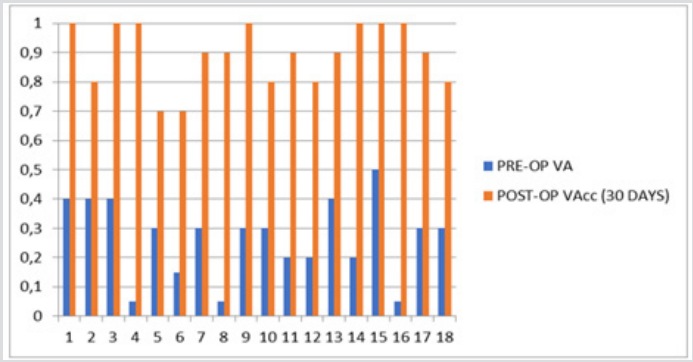

Figure 5: Changes of visual acuity pre-operative and 30 days after with glasses.

Table 3: Post-operative visual acuity.

Number of eyes	V.A. without glasses	Number of eyes	V.A. with glasses
9	5/10→ 7/10	6	7/10→ 8/10
9	8/10→ 10/10	12	9/10→ 10/10

Table 4: Paired T-tests before phacoemulsification and 15 days after.

Sample 1	V.A._PRO_OPER	
Sample 2	V.A._15_DAYS_AFTER_OPER	
	Sample 1	Sample 2
Sample Size	18	18
Arithmetic mean	0,2667	0,6222
95% CI for the mean	0,2006 to 0,3327	0,5430 to 0,7014
Variance	0,01745	0,02536
Standard deviation	0,1328	0,1592
Standard error of the mean	0,03131	0,03753

Paired samples t-test	
Mean difference	0,3556
Standard deviation of differences	0,1901
Standard error of mean difference	0,04481
95% CI	0,2610 to 0,4501
Test statistic t	7,935
Degrees of Freedom (DF)	17
Two-tailed probability	P<0,0001
Differences	
Chi-squared test for Normal distribution of differences	Accept Normality (P=0,6080) (Chi-squared=0,995 DF=2)

Table 5: Paired T-tests 15 days and 30 days after phacoemulsification.

Sample 1	**V.A._15_DAYS_AFTER_OPER**	
Sample 2	**V.A._30_DAYS_AFTER_OPER**	
	Sample 1	**Sample 2**
Sample Size	18	18
Arithmetic mean	0,6222	0,7611
95% CI for the mean	0,5430 to 0,7014	0,6675 to 0,8548
Variance	0,02536	0,03546
Standard deviation	0,1592	0,1883
Standard error of the mean	0,03753	0,04438
Paired samples t-test		
Mean difference	0,1389	
Standard deviation of differences	0,1461	
Standard error of mean difference	0,03443	
95% CI	0,6624to 0,2115	
Test statistic t	4,034	
Degrees of Freedom (DF)	17	
Two-tailed probability	P=0,0009	
Differences		
Chi-squared test for Normal distribution of differences	Accept Normality (P=0,3231) (Chi-squared=0,976 DF=1)	

Table 6: Paired T-tests before phacoemulsification and 30 days after.

Sample 1	**V.A._PRO_OPER**	
Sample 2	**V.A._30_DAYS_AFTER_OPER**	
	Sample 1	**Sample 2**
Sample Size	18	18
Arithmetic mean	0,2667	0,7611
95% CI for the mean	0,2006 to 0,3327	0,6675 to 0,8548
Variance	0,01765	0,03546
Standard deviation	0,1328	0,1883
Standard error of the mean	0,03131	0,04438
Paired samples t-test		
Mean difference	0,4944	
Standard deviation of differences	0,1955	
Standard error of mean difference	0,04607	
95% CI	0,3972 to 0,5916	
Test statistic t	10,733	

Degrees of Freedom (DF)	17
Two-tailed probability	P < 0,0001
Differences	
Chi-squared test for Normal distribution of differences	Accept Normality (P=0,9311) (Chi-squared=0,14 DF=2)

Table 7: Paired T-tests 30 days after phacoemulsification with and without applying the optimal refractive correction.

Sample 1	**V.A._30_DAYS_AFTER_OPER**	
Sample 2	**V.A._15_DAYS_AFTER_OPER_WITH_GLASSES**	
	Sample 1	**Sample 2**
Sample Size	18	18
Arithmetic mean	0,7611	0,8944
95% CI for the mean	0,6675 to 0,8548	0,8419 to 0,9469
Variance	0,03546	0,01114
Standard deviation	0,1883	0,1056
Standard error of the mean	0,04438	0,02488
Paired samples t-test		
Mean difference	0,1333	
Standard deviation of differences	0,1680	
Standard error of mean difference	0,03961	
95% CI	0,04977 to 0,2169	
Test statistic t	3,367	
Degrees of Freedom (DF)	17	
Two-tailed probability	P=0,0037	
Differences		
Chi-squared test for Normal distribution of differences	Accept Normality (P=0,0011) (Chi-squared=10,629 DF=1)	

Table 8: Paired T-tests preoperatively and 30 days after phacoemulsification with applying the optimal refractive correction.

Sample 1	**V.A._PRO_OPER**	
Sample 2	**V.A._15_DAYS_AFTER_OPER_WITH_GLASSES**	
	Sample 1	**Sample 2**
Sample Size	18	18
Arithmetic mean	0,2667	0,8944
95% CI for the mean	0,2006 to 0,3327	0,8419 to 0,9469
Variance	0,01765	0,0114
Standard deviation	0,1328	0,1056
Standard error of the mean	0,03131	0,02448
Paired samples t-test		
Mean difference	0,6278	
Standard deviation of differences	0,1674	
Standard error of mean difference	0,03945	
95% CI	0,5446 to 0,7110	
Test statistic t	15,915	
Degrees of Freedom (DF)	17	
Two-tailed probability	P<0,0001	
Differences		
Chi-squared test for Normal distribution of differences	Accept Normality (P=0,8386) (Chi-squared=0,352 DF=2)	

The above registration data of visual acuity, preoperatively and postoperatively, were used to perform a statistical study (Figures 4 & 5). Tables, statistics and paired T–tests for each case are listed below (Tables 3-8).

Conclusion

The clinical research concluded that the visual recovery of all patients was at a high level achieved without significant complications, within the first month after phacoemulsification. As a result, the phacoemulsification technique succeeded in keeping up with its promises, as better surgical treatment of ocular cataracts. This period of time was also sufficient for the eye to incorporate the IOL, heal the incisions, restore its physiology and stabilize its refraction. For this reason, the optometrist, who will be called to check the refraction of a patient who has undergone a phacoemulsification operation, must be conscious and avoid prescribing corrective ophthalmic lenses by the end of the first month.

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ISSN: 2574-1241

DOI: 10.26717/BJSTR.2019.17.002973

Pateras E. Biomed J Sci & Tech Res

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