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Analysis and calculations of decentration amount and prism in eyeglass lenses

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Abstract

The error of refraction is a very common eye disorder. Untreated vision problems put a lot of burden on the global economy annually. One of the most important parameters in the correct treatment of visual defects is the correct assembly of the focal point of the glass. The study was carried out to reveal the decentration differences and the analysis of prism formation after glass assembly according to the prescriptions of 150 customers who came to an optical shop in Eskisehir on Saturdays, 2015-2016. A digital lensmeter was used for the measurement of glasses, and a digital and photographic pupilmeter was used to measure pupillary distances. Chi-square test was used in the frequency study, and differences in glass numbers were used the Marginal Homogeneity Test was used in the analysis of the accuracy of the data. Glass assemblies without decentration were achieved at a rate of 94.66% in distance glasses and 93.33 % in near glasses. When the errors made in applied physics are analyzed, the amount of decentration in the assembly of the glasses that are frequently used in daily life draws attention. In this case, it caused unwanted prism formation.

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1. Introduction

Globally, approximately 1.3 billion people are estimated to experience some form of visual impairment. 441.5 million People have visual impairment with regard to distance vision. Also, 826 million people suffer from near vision. 80% of visual impairment can be prevented [1, 2]. Top reasons of visual impairment are uncorrected refraction errors.

The error of refraction is a very common eye disorder. It occurs when the eye cannot clearly focus the images in the outside world. The result of refraction errors is blurred vision, sometimes severe enough to cause visual impairment [3]. According to W.H.O., untreated vision problems cost the global economy $ 200 billion annually [4].

Uncorrected refractive errors are one of the most important causes of preventable blindness in undeveloped or underdeveloped societies [5]. Therefore, when these refractive errors are not corrected or are wrongly corrected, they become an important health problem globally that causes serious health disorders [3, 6-8]. Uncorrected refractive defects lead to asthenopic symptoms such as pain, eyestrain and frontal headaches [9-11]. The number of people suffering from these complaints is very high.

If the corrective glasses are not installed correctly, a person experiencing difficulties with vision has trouble performing routine daily activities such as reading, writing, socializing, traveling and work life [12]. As a result, because the person's quality of life decreases, the person can become unhappy, stressed, and so on. which sometimes, it can cause various accidents at home, at work, at school[13].

When people go optic store to buy corrective glasses, they generally think various factors such as frame color, model and design [14-16]. But the main point to be considered here is personal measurement. As your personal measurement, the distance between the pupils (IPD) is defined as the distance between the centers of the pupils [14, 17].

Transferring the patient’s personal measurement data to the frame and overlapping and assembling the glasses provided on the prescription with this data will prevent possible unwanted prismatic effects. However, in the case of troubles such as dioptric changes, axial

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differences and mismatch of the pupil and optical axis, machine errors, the image of an object will be perceived at a different location from the actual location (prismatic effect) [18-20]

The other important point that can cause prismatic effect is that the measurement of the exact center of the pupil is very difficult because the proper parallelity cannot be provided between the floor and the ruler [14].

In this study, in order to correct the refractive errors properly, we have measured and statistically analyzed the reasons of the unwanted prismatic effects that occur when the optician is installing the glass to the frame. Taking data from a digital and photographic pupilometers, and the prismatic effects were calculated from the resulting differences. Unwanted prismatic effects are calculated with Prentice's rule [21, 22].

Our aim is to calculate the mistakes made by raising awareness about faulty eyeglass mounting that causes financial losses and health problems worldwide. A database has been created by performing prismatic effects, optical characterization and surface analysis of the glasses of glasses wearers who have been assembled glasses. Optical prism calculations made regarding the optic store in terms of being the first study in Turkey are expected to lead to other studies.

2. Materials and Methods

The study was carried out for decentration calculations and analysis as a result of the analysis of the glass values assembled according to the prescriptions of 150 customers who visited an optical store in Eskisehir on Saturday 2015-2016. The aim of the study is to check the conformity of the glasses mounted by the optician to the prescription and to calculate the prism values formed. 150 people participated in the study and there is no one among them whose data were not obtained. Out of a total of 361 glasses in the study, 214 were distant glasses and 147 were close to lenses.

In order for the results of the study to be interpreted by physics, opticianry, statistics departments, a form was created. In this form, it consists of the measurement values taken by the optician for the glass assembly and the glass values taken after the assembly.

The measurement of the glasses was taken with lensmeter (LM-1000P model, Nidek brand) [23].The values in the prescription and the lensmeter measurement values of the glasses made by the optician were noted on the form and all data were entered into the SPSS program. Marginal Homogeneity test [24] was used to statistically evaluate the accuracy of sph, cyl, ax values of the glasses written in the recipe and assembled. The difference between glass numbers causes prism and makes an important contribution to the decentration calculation [21].

Another major assembly error is that the distance between pupillary points is not measured accurately. The distance of difference between the focal point of the glass and the pupillary point is another parameter that contributes to decentralization. The distance between the pupils was measured with the Digital Pupilometer [25], Nidek brand PM-600 model and Photometric Focusing Measuring Device, Elegance Mirror Marked. Data entered into the SPSS.

Chi-square test was used in the frequency study [26], and the Marginal Homogeneity Test was used in the analysis of the accuracy of the data. $P < 0.001$ was used considered significant.

The surface images of the glasses presented to the glasses wearers in the optician store were taken with the Zeiss Ultra Plus model FESEM. To obtain FESEM images, the glasses were coated with 30 nm gold (Au) at 50 mA for 2 minutes.

For the optical characterization of the glasses, absorption-transmittance measurements were taken using 4802 UV / VIS Dual Beam Spectrophotometer, the data were marked as Pro 8 origin and graphics were created.

3. Results

61 (40.7 %) are male and 89 (59.3 %) are female of the participants. When the ages of the participants are examined, the smallest participant is 5 years old and the largest is 88 years old. According to Table 1, the average age of the participants is 45.47.

Table 1. Descriptive Statistics for Age

N	Average age	Standard Error
150	45.470	1.654

The distribution of age groups is as shown in Table 4. There are 10 persons in the age range of 5-14 years, 23 persons in the age range of 15-24 years, 14 persons in the age range of 25-34 years, 18 persons in the age range of 35-44 years, 37 persons in the range of 45-54 years, 16 persons in the range of 55-64 years, 21 persons in the age group of 65-74, and 11 persons in the age group of 75 and over.

Table 2. Distribution between distant glass and close glass groups

	Distant Glass		Close Glass	
Glass group	Number	%	Number	%
0-2	57	19.0	32	10.6
2-4	16	5.3	48	16.0
4-6	2	0.7	6	2.0
14-16	2	0.7	-	-
2/2	78	26.0	10	3.3
2/4	3	1.0	4	1.3
4/2	34	11.3	34	11.3
4/4	8	2.6	2	0.7
6/2	9	3.0	10	3.3
6/4	3	1.0	-	-
8/2	1	0.3	-	-
8/4	1	0.3	-	-
No Prescription	86	28.6	153	51.0
Total	300	100	300	100

When Table 2 is examined, it is found that the number of 2/2 sphero cylindrical glass group used by the optician is 78 and it is the most used glass, constituting 26.0% in the distant glasses. 0-2 spherical glass group constitutes 19.0% (57 pieces) of the distant glasses and it is the most used second glass group. Statistically, there was no significant difference between the groups of distant right and left glasses (p = 0.921). No Prescription statement in the last line means that the doctor did not write the distant prescription value in the prescription and wrote the close prescription value.

In the distribution of the close right-left glass group written in the prescriptions of the participants of the study (Table 2), while 48 (16.0%) constitutes spherical glass groups, the second 34 (11.33 %) constitutes sphero-cylindrical glass group. Statistically, p value between the right and left glass groups in the prescription was 0,785 and no difference was found.

When the glass group frequency distributions are examined (Table 2), when the close spectacle glass values have higher value, it will have more prismatic effect when faulty glass assembly is done. Therefore, it is necessary to assembly close glass more carefully than distant glass.

Table 3. Distribution between Distance Glass Group and Axis Value

	Distant Right Glass	Distant Left Glass	Total
Axis value	Number	Number	Number
0º-45º	13	16	29
46º-90º	19	22	41
91º-145º	14	7	21
146º-180º	24	22	46
Total	70	67	137

Table 3 gives the distribution of the distant glass axis. 46 of the astigmatic refraction defect have axis values between 146˚-180˚, 41 between 46˚-90˚, 29 between 0˚-45˚, and 21 between 91˚-145˚. Statistically, there is no difference between the distant right and left glass axes (Chi-square test, p = 0.410).

The glasses assembled by the optician did not show any change in the right and left glasses in reverse. This is a positive development because otherwise it would cause unwanted prism.

At firstly, glasses were measured with lensmeter after assembly. All data were entered into the SPSS. Prescription values and post-assembly values of the glasses were compared with Marginal Homogeneity Test. Statistical coherence analysis of the sph, cyl and axial values are shown in Table 4. Although the glass and axis values were not in full agreement, the statistical coherence analysis results showed that p> 0.05 ie values are in harmony and small number changes. It has been observed that small variations in glass numbers will produce a small amount of unwanted prism.

Table 4. Lens number differences resulting from measuring the glasses

Lens	p-Sph	p-Cyl	p-Axial
D-R	1.00	1.00	0.414
D-L	0.317	1.00	0.329
C-R	0.317	1.00	1.00
C-L	0.317	1.00	0.317

*D:distant C:Close R:Right L:Left *Marginal Homogeneity testi

Axis differences resulting from measuring the glasses with a lens meter after assembly were determined (Table 5). 0° axis change is in 67 people with distant right glass assembly, in 64 people with distant left glass assembly, in 31 people with close right glass assembly and in 29 people with close left glass assembly, in total 191 people. According to the Prentice rule, the angle change distribution contributes to the formation of undesirable prisms [21, 22].

Table 5. Axis differences resulting from measuring the glasses

	D-Right Glass	D- Left Glass	C- Right Glass	C- Left Glass	Total
Axis change	Number	Number	Number	Number	Number
0°	67	64	31	29	191
1°	2	0	0	0	2
2°	1	2	0	0	3
5°	0	1	0	1	2
Total	70	67	31	30	198

D-R: Distant Right D-L: Distant Left C-R: Close Right C-L: Close Left

Other axis changes cause a prismatic error and are calculated with the formula given below. α stands for required angle difference between the meridian and the axle value Dcyl for the cylindrical glass value of the glasses, Dsph for the spherical glass value of the glasses. DT, stands for the power of the glasses, prismatic effect Δ, the resultant of the distance of the pupil point to the desired point in cm, can be calculated after measuring (Equations 1,2).

$$D_T = D_{sph} + D_{cyl} \sin^2\alpha \qquad (1)$$

$$\Delta = D_T C \qquad (2)$$

After the glasses were mounted, the pupil measurement of the user was taken and compared with the measurement of the optician. The pupil measurements were measured with the pupilometer. The differences between the pupil values cause prismatic faults according to Equation 1.2 above. For this reason, the decentralization differences between the pupil values are given in Tables 6, 7.

When Table 6 is examined, the amounts and directions of decentralization are seen for the distant glasses. The glasses were assembled without any problems for 142 people with distant right glasses, 143 people with distant left glasses. There is no decentralization for the right and left eyes in the upward and outward directions. Decentralization in the downward direction was observed in 0.66% of the total glasses, that is for only 1 person. Decentralization in the inward direction was observed for 7 people in the right eyes and 6 people in the left eyes.

Table 6. Decentralization amount and directions of distant glasses

Decentralization amount (cm)		0		0.1 – 0.5		0.6 – 1.0	
Directions		Number	%	Number	%	Number	%
Centralize	D-R	142	94.66	0	0.0	0	0.0
	D-L	143	95.33	0	0.0	0	0.0
Upward	D-R	150	100.0	0	0.0	0	0.0
	D-L	150	100.0	0	0.0	0	0.0
Downward	D-R	149	99.33	1	0.66	0	0.0
	D-L	149	99.33	1	0.66	0	0.0
Inward	D-R	143	95.33	5	3.33	2	1.33
	D-L	144	0.96	6	4.0	0	0.0
Outward	D-R	150	100.0	0	0.0	0	0.0
	D-L	150	100.0	0	0.0	0	0.0

D-R: Distant Right D-L: Distant Left

Table 7 shows the amounts and directions of decentralization of close glasses. Of all close glasses, 149 are faultless. There is decentralization in the upward direction in the 2 glasses which constituted 1.32% of the close glasses. No decentralization is seen in downward, inward, and outward directions.

Table 7. Decentralization amount and directions of close right and left glasses

Decentralization amount (cm)		**0**		**0.1 – 0.5**		**0.6 – 1.0**	
Directions		Number	%	Number	%	Number	%
Centralize	C-R	149	99.33	0	0.0	0	0.0
	C-L	149	99.33	0	0.0	0	0.0
Upward	C-R	149	99.33	1	0.66	0	0.0
	C-L	149	99.33	1	0.66	0	0.0
Downward	C-R	150	100.0	0	0.0	0	0.0
	C-L	150	100.0	0	0.0	0	0.0
Inward	C-R	150	100.0	0	0.0	0	0.0
	C-L	150	100.0	0	0.0	0	0.0
Outward	C-R	150	100.0	0	0.0	0	0.0
	C-L	150	100.0	0	0.0	0	0.0

C-R: Close Right C-L: Close Left

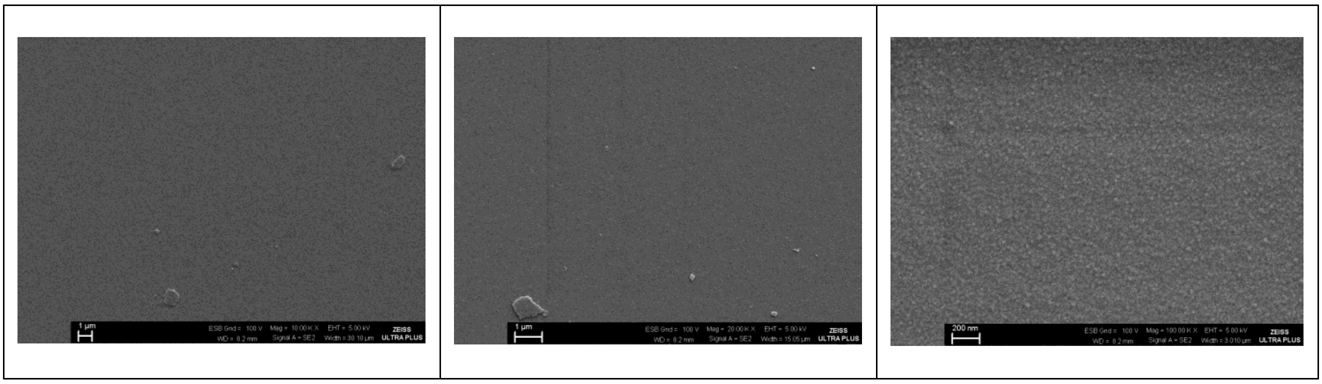

Figure 1. FESEM image of the lens at 10000, 20000, 100000 magnifications

Examining the spectacle lens analysis of eyeglass wearers (Figure 1), it is seen that the glass surfaces are quite smooth and homogeneous at 10000 and 20000 magnifications. When FESEM analyzes are examined at 100000 magnifications, ridges of about 20-25 nm in size appear. The eyeglass lenses are quite smooth and homogeneous compared to other glass works [29-31].

When the uncoated and coated glasses of eyeglass lenses were examined (Figure 2), it was observed that the light transmittance of coated glasses increased in the entire spectrum. While uncoated glasses have 85% light transmittance at 550 nm, light transmittance has increased to 97 % in anti-reflective glasses. When looking at similar studies [29,30], the spectra of the glass contributed positively tot he quality of vision and did not cause a prismatic effect. The fluctuations in the spectrum in similar studies are not seen in our study, and the smoothness of the spectrum increased the vision quality of the eyeglass wearer.

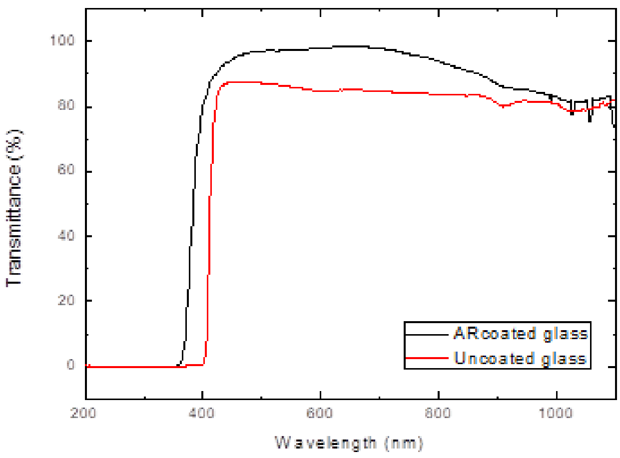

Figure 2. Transmittance graphs of lenses

When Figure 3 is examined, it is seen that two types of glass absorb in the UV region. It can be said that anti-reflective glasses absorb more in the UV region than normal glasses.

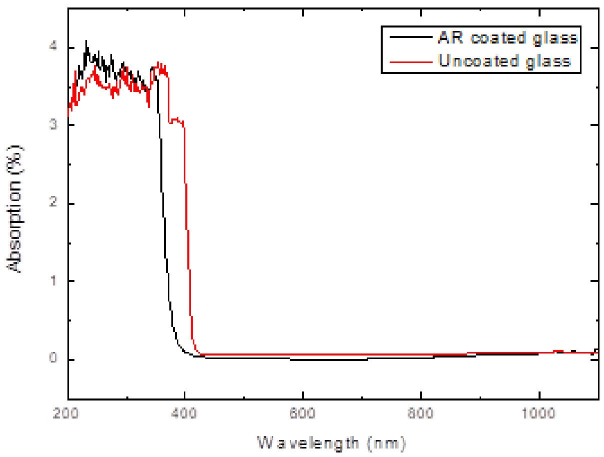

Figure 3. Absorption graphs of lenses

4. Conclusion and Recommendations

In this study, decentralization calculations and analyzes were performed as a result of glass analysis after assembly according to the prescriptions of 150 customers who visited an optical store between 2015 and 2016. The optician made mistakes while assembling the glass and measuring the pupillary distance. These errors arise from various difficulties [14, 17] and cause the unwanted prismatic effect [21, 22] to occur.

A study [27] similar to our study tested the accuracy of glasses on 100 people on a campus. There is a prismatic effect caused by faulty assembly in 100% of the glasses used by people. The difference of this study from our study is that it includes user errors as well as errors caused by the optician.

In another study [28] similar to our study, it is the calculation of the prismatic effects of glasses wearers who come to the hospital. In this study, a statistically significant difference was found due to the fact that pd values were not written on the prescription, the users went to different opticians and the opticians did not measure the pd distance ($p<0.001$).

When the data are examined, it is seen that the amount of decentration is very low. When glass numbers were also included, low prismatic effects occurred. According to other studied [18, 25, 27, 28] in the literature, one of the important points of observing low prismatic effects in our study is due to the careful use of the pupilometer during assembly and the more careful assembly because we are with the optician. Faults that occur despite careful assembly are caused by the suction pads getting wet and slipping during the cutting phase in the automatic glass cutting machine.

The use of non-parallel pupilometer to measure the distance between pupils causes pupil measurement errors. To avoid this, photographic and digital Pupilometer with the same length working with sensors had been used in the pd measurements. With this system, which is not used in most optical stores, we have prevented many of the errors.

Since the education status of each optician and the facilities available in his shop are not the same, different decentrations will occur during the welding of the eyeglass lenses, which will create an undesirable prismatic effect. Therefore, the results will differ when the study is done in different optical facilities.

When the surface analysis, transmittance and absorption spectra of the glasses worn by the eyeglass wearers were examined, it was seen that the wearer's vision quality increased and did not cause prismatic effects.

In the literature, there is no study in the optic shop related to the decentration calculation after prescription and eyeglass assemblying and the statistical analysis of distant-close lens groups. Prismatic effects, optical characterization and surface analysis of the users were made. In this case, it will shed light on the studies of optics in optician programs, which have been developing rapidly recently, where physicists work.

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Conflicts of interest

The authors state that did not have a conflict of interests.

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