ORİJİNAL ARAŞTIRMA ORIGINAL RESEARCH

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Prevalence of Corneal Astigmatism in Cataract Surgery Candidates from Turkey

Türkiye'deki Katarakt Cerrahisi Adaylarında Korneal Astigmatizm Prevalansı

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ABSTRACT Objective: Corneal astigmatism is the most important cause of poor vision after cataract surgery without any complications. We aimed to analyze the prevalence and presentation of corneal astigmatism profile and estimated toric intraocular lens (IOL) candidates in cataract patients from Turkey. **Material and Methods:** The axial length (AL), keratometry (steep ,flat) and astigmatic measurements were performed using autokeratorefractometer and partial coherence interferometry (IOLMaster) and calculated retrospectively. All parameters correlated by age groups. The correlation between AL and kerotemetric values, astigmatic values and age were evaluated. **Results:** This study comprised 797 eyes of 401 cataract surgery candidates with a mean age of 68.13±11.1 (SD) years. The mean astigmatism and AL were 1.03±0,9 D and 23.40±1.27 mm respectively. The corneal astigmatism of 1.00D or higher was found in 293 eyes (36.76%). There was no correlation between AL and corneal astigmatism. **Conclusion:** This study demonstrated that, one third (36.76%) of the cataract patients have significant corneal astigmatism (>1D) in Turkey. To correct their astigmatism, different methods from routine cataract surgery should be considered. According to recent reports, toric IOL implantation seems encouraging for moderate and high degree astigmatism. This results can help to improve toric IOL surgery on the basis of clinical and manufacturing.

Keywords: Cataract extraction; astigmatism; phacoemulsification

ÖZET Amaç: Korneal astigmatizm , komplikasyonsuz katarakt cerrahisi sonrası en önemli görme azlığı nedenlerindendir. Çalışmamızda Türkiye'deki katarakt hastalarının korneal astigmatizm profilini ve tahmini torik intraoküler lens (İOL) adayı sıklığını ortaya koymayı amaçladık. **Gereç ve Yöntemler:** Aksiyel uzunluk (AU), keratometri (düz, dik) ve astigmat ölçümleri parsiyel koherens interferometri (İOL MASTER) kullanılarak retrospektif olarak hesaplanmıştır. Tüm parametreler yaş gruplarıyla korele edildi. AU ve keratometrik değerler ve astigmatik değerler ve yaş arasındaki korelasyon değerlendirildi. **Bulgular:** Çalışmamızda yaş ortalaması 68,13±11,1 (SD) yıl olan 401 katarakt cerrahisi adayının 797 gözü kullanıldı. Ortalama astigmatizm ve AU değerleri sırasıyla 1,03±0,9 D ve 23,40±1,27 mm olarak bulundu. 293 gözde (%36,76) 1.00 dioptriden fazla astigmatizm saptandı. AU ve korneal astigmatizm arasında korelasyon bulunmadı. **Sonuç:** Bu çalışma Türkiye'dek katarakt hastalarının yaklaşık üçte birinin (%36,76) önemli derecede korneal astigmatizm (>1D) olduğunu göstermiştir. Astigmatı düzeltmek amacıyla rutin katarakt cerrahisi dışında değişik metodlar değerlendirilebilir. Güncel yayınlara göre, orta ve ileri derece astigmatizm düzeltmesinde torik İOL uygulaması ümit vermektedir. Bu sonuçlar klinik ve üretim anlamında torik İOL cerrahisini geliştirmede yardımcı olabilir.

Anahtar Kelimeler: Katarakt ekstraksiyonu; astigmatizm; fakoemülsifikasyon

Cataract is the cause of the half of blindness worldwide and cataract extraction is one of the most commonly performed surgeries.[1] Cataract surgery has made great progress since that first performed. Results of the surgeries became more satisfactory with advances in surgery techniques, intraocular lens (IOL) calculation formulas, IOL technologies and biometry techniques. But the patients always demand near-perfect vision in one step surgery without any postop spectacles. After correction of the spherical refractive error, residual corneal astigmatism became main factor affecting postoperative vision.

There are several methods to reduce or eliminate astigmatism during surgery. But these methods have limitations and the outcomes can be unexpected.[2] Another option for astigmatism correction is toric IOL which described by Shimizu et al. firstly.[3] According to the reports that toric IOLs are effective method, the researchers pointed out to astigmatism prevalence of the cataract surgery candidates is important.

This study designed to evaluate the prevalence of corneal astigmatism in cataract surgery candidates from Turkey.

MATERIAL AND METHODS

In this retrospective study, the patients', who underwent cataract surgery, data were analyzed. Exclusion criteria were irregular astigmatism, previous ocular surgery, ocular trauma and inflammatuar conditions. Before surgery, all the patients underwent slit lamp biomicroscopy examination, biometry, intraocular pressure measurement and fundus examination through dilated pupil. The corneal astigmatism measurement was performed using autokeratorefractometer (TOPCON KR-8900, Tokyo; Japan) The measurement were performed three times per eye. The axial length (AL) evaluated with optic biometer (IOL Master 500, Carl Zeiss Meditec AG, Jena ; Germany)

The patients were divided into 6 age groups: 40 years and younger, 41 to 50 years, 51 to 60 years, 61 yo 70 years, 71 to 80 years, 80 years and older.

This study adhered to the tenets of the Declaration of Helsinki to review the patient data.

Data were analyzed using the SPSS version 21.0 system. The Kolmogorov-Smirnov test was used to evaluate the normality of distribution for all variables. The Kruskal-Wallis test was applied for the comparison of variance for nonnormally distributed data among age groups. Correlations between variables were analyzed with the Pearson or Spearman coefficient depending on their distributions. P value <0.05 was accepted as statistically significant.

RESULTS

This study was composed of 797 eyes from 401 patients. Table 1 shows patients' demographic data and Table 2 shows the data compared to previously

TABLE 1: Demographic characteristics of patients.

Characteristic	Value
Eyes / Patients	797 / 401
Mean Age (y) ± SD	68.13±11.1
Range of Age (y)	26-93
Gender (male/female)	181/220
Mean Corneal Astigmatism (D) ± SD	1.03±0,9
Range of Corneal Astigmatism (D)	0.11-11.48
Mean Keratometry (D)	
Flat ± SD	43.42±1.7
Steep ± SD	44.44±1.87
Range of Keratometry (D)	34.65-61.48
Mean Axial Length (mm) ± SD	23.40±1.27
Range of Axial Length (mm)	19.41-32.55

TABLE 2: Comparison of patient demographics between present and other studies.

Parameters	Current Study	Ferrer-Blasco et al	Khan and Muhtaseb	Bernardo et al	Chen et al	Cui et al	Ünlü et al	Yuan et al
Eyes / Patients	797 / 401	4540/2415	1230/746	757 /380	4831/2849	6750/4561	219/219	12449/6908
Mean Age (y) ± SD	68.13 ± 11.1	60.59±9.87	75.54±10.71	71.89±10.19	70.56±9.55	70.4±10.5	67.08 ± 12.6	69.80±11.15
Range of Age (y)	26 – 93	32 – 87	30-104	33-96	40-95	40-101	18 – 87	30-97
Gender (male/female)	181/220	768/1647	343/403	176/204	1090/1759	2026/2535	107/112	3199/3709
Mean Corneal Astigmatism (D)±SD	1.03±0,9	0.9 ± 0.93	1.03 ±0.72	1.02±069	1.01±0.69	0,9	1.00±0.96	1.15±0.84
Range of Corneal Astigmatism (D)	0.11 –11.48	0.25 – 6.75	0 – 6.2	0.06-4.57	0.05-6.59	-	0 – 6.00	0-6.63
Mean Keratometry (D)								
Flat ± SD	43.42 ± 1.7	43.48±1.61	43.43±1.49	43.54±1.43	43.76±1.53	43.57±1.69	43.43±1.81	43.93±1.67
Steep ± SD	44.44±1.87	44.08±1.59	44.46±1.56	44.56±1.52	44.76±1.56	44.69±1.69	44.43±1.87	45.08±1.73

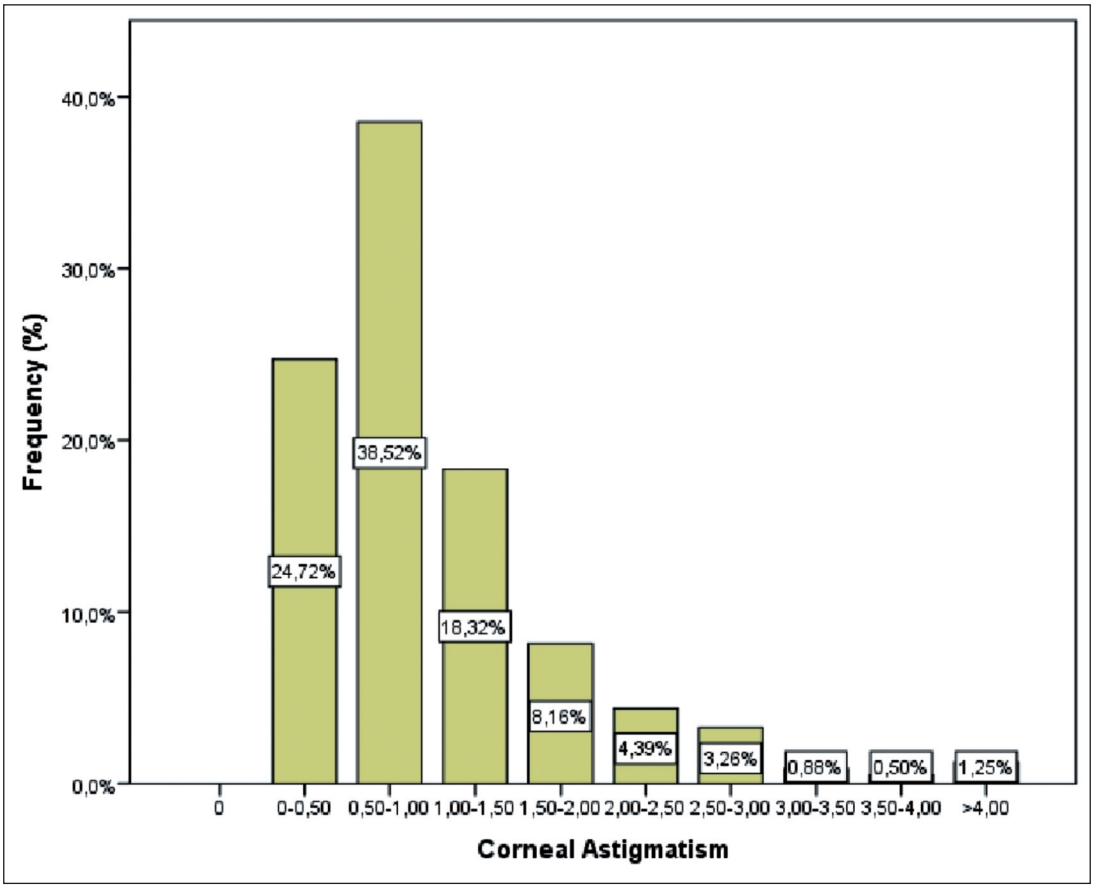

FIGURE 1: Histogram of corneal astigmatism distiribution all 797 eyes.

published studies. The distribution of corneal astigmatism was 0.5 D or less in 197 eyes (24.72%), 0.51-1.00 in 307 eyes (38.52%), 1.01-1.50 in 146 eyes (18.32%), 1.51-2.00 in 65 eyes (8.2%), 2.00-2.50 in 35 eyes (4.4%), 2.50-3.00 in 26 eyes (3.3%) and 3.00 or higher 21 (2.63%). A histogram with frequency distribution of astigmatism values are shown in Figure 1.

The number of eyes in the 6 age groups was as follows: under 40 years, 15 eyes; 41 to 50 years, 36 eyes; 51 to 60 years, 107 eyes; 61 to 70 years, 242 eyes; 71 to 80 years, 285 eyes; and 81 and older 112 eyes. Figure 2 shows the box-plot of corneal astigmatism value and Figure 3 distribution of corneal astigmatism in each age group. AL, steep K, flat K and astigmatic values are significantly difference in 6 age groups which shown in Table 3.

There was a statistically significant negative correlation between AL and steep K, flat K values and age (Steep K: r=-0.427, p<0.001; Flat K: r=-0.48, p<0.001; Age: r=-0.198, p<0.001). But there was no correlation between AL and corneal astigmatism (p=0.534).

There was no statistically significant difference in corneal astigmatism between sexes unlike other values. Keratometric values are greater in women than in men (Table 4).

DISCUSSION

Residual astigmatism after cataract surgery is responsible from proportional visual acuity loss in patients.[4] Therefore, correction of astigmatism during cataract surgery became more important to achieve best visual outcome. This condition can be managed by several methods; corneal incision on the steep axis, corneal or limbal relaxing incisions and toric IOL implantation. With corneal incision on the steep axis can be sufficient for patients with less than 1.0 D of astigmatism.[5] Limbal and corneal relaxing incisions can be used to treat for moderate

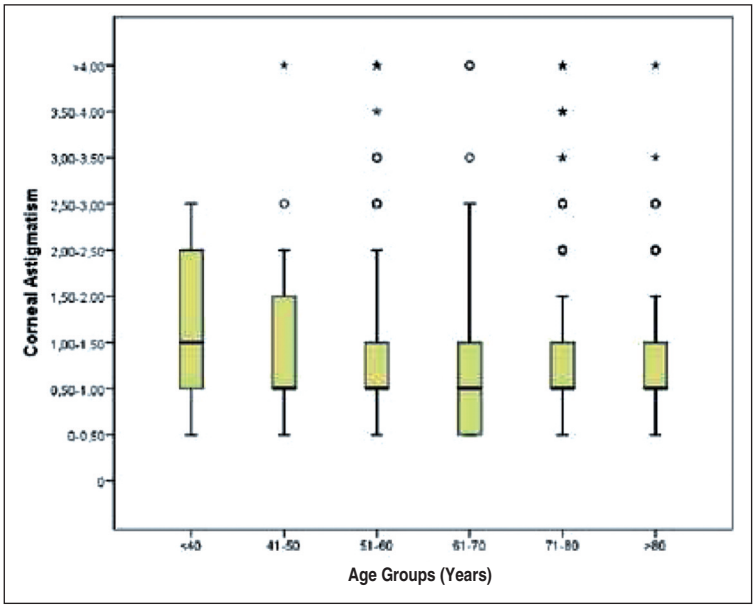

FIGURE 2: Corneal cylinder in all 6 age groups. Bold lines in the boxes represent the median (50% percentile), the upper and lower limits of the box represent the first quartile (25% percentile) and third quartile (75% percentile), and the bars represent the minimum and maximum values.

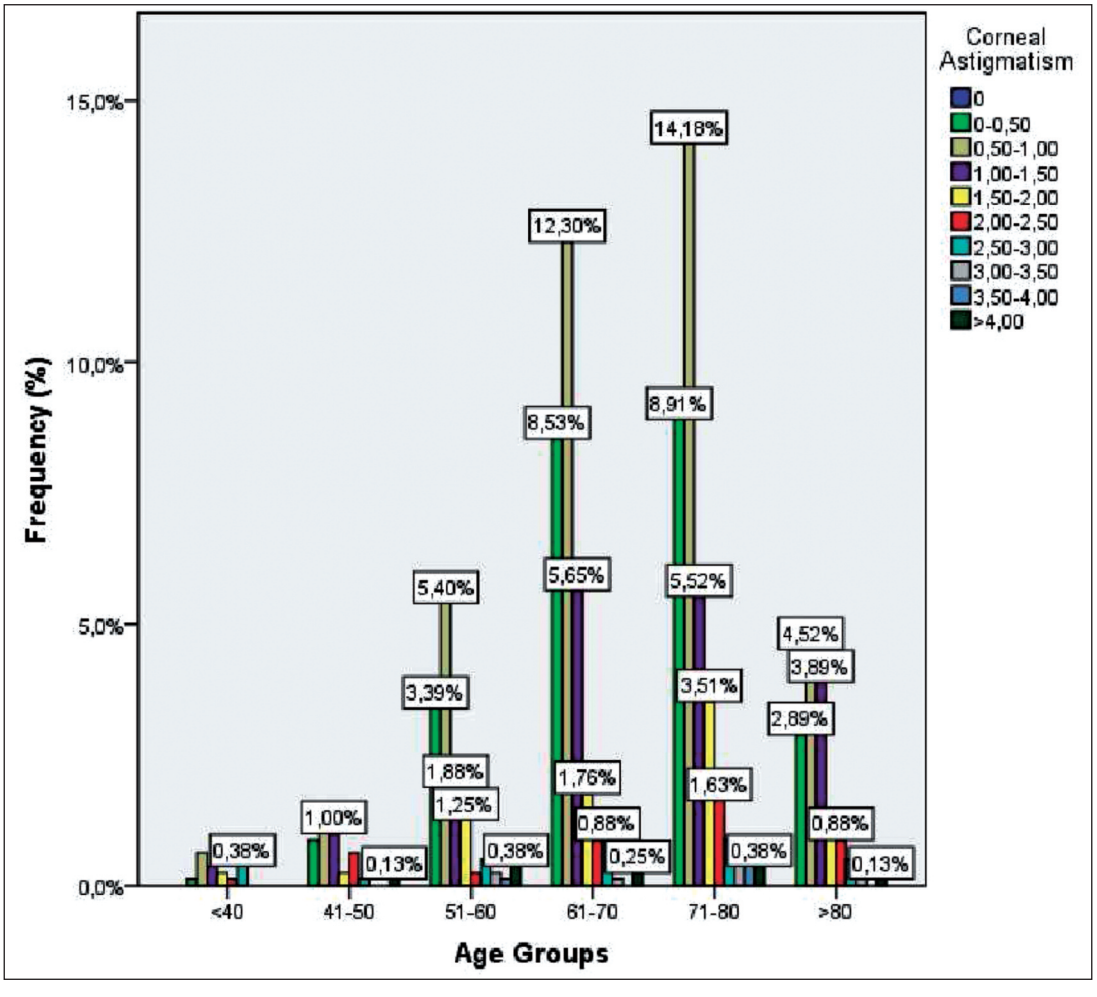

FIGURE 3: Frequency distiribution of corneal astigmatism in 6 age groups.

TABLE 3: Distribution and comparison of parameters between age groups.

Age group	Cylinder	Flat K	Steep K	Axial Length	Eyes (n)
< 40	1.42	42.44	43.90	23.52	15
41 – 50	1.38	42.63	44.02	24.09	36
51 – 60	1.08	42.66	43.74	24.01	107
61 – 70	0.9	43.64	44.53	23.30	242
71 – 80	1.03	43.42	44.44	23.44	285
>80	1.08	44.02	45.11	23.06	112
Total	1.03	43.42	44.44	23.45	797
Significance *	0.027	0.00	0.00	0.00	

*Kruskall – Wallis test.

TABLE 4: Sex distiribution of parameters.

Sex (eyes)	Mean Astigmatism	Mean Flat K	Mean Steep K	Mean AL
Male (359)	1.009 ±0.8	43.10±1.73	44.10±1.80	23.58±1.53
Female (438)	1.05±0.9	43.68±1.63	44.72±1.89	23.34±1.70
Total (797)	1.03±0,9	43.42 ± 1.7	44.44 ±1.87	23.40 ± 1.27
P value	0.528	<0.05	<0.05	<0.05

K: Keratometry; AL: Axial length.

astigmatism but results are not always predictable and can cause complications.[6-8]

Despite this techniques, toric IOL implantation seems very successful and predictable to correct moderate and especially high degree astigmatism.[9,10]

With the widespread use of toric IOLs, the researchers needed to evaluate prevalence of astigmatism in their countries. Table 2 shows, comparison of the values between other studies and the current study. Mean corneal astigmatism in our study (1.03±0.9) is similar to previous studies.[10-14] In our sample 63.24% of the eyes have less than 1 D astigmatism. This eyes may have benefit from techniques described above. For the remained eyes (36,76%), more predictable methods, like toric IOL implantation can be more effective. Compared with the other studies our results are slightly lower except Ferrer-Blasco et al's study (34.8%).[11,12-15] In addition to these, the study from our country with a limited sample reports ratio of the astigmatism equal or higher than 1 D was 29.7%.[16] The reason for the differences of our study can be racial factors (other country based studies) and regional or sample size origin (our country based study).

The mean flat (43.42±1.7) and steep (44.44±1.87) keratometry were similar with other studies. [10-14] Conversely range of keratometry was little higher (34.65-61.48). As well as, hyperopic shift in older groups was seen our study too.[17] As shown in Table 3, the flat and steep K values tended to increase with increasing age.

In our study, the sex distribution has been shifted to female patients (181/220). This finding were observed similar with the other studies. The AL, steep and flat K values were greater than men in women unlike corneal astigmatism (p=0.514). Due to AL is the important parameter for the IOL calculation, we have evaluated and compared with keratometric and astigmatic values. The mean AL and the range was 23.40 mm (±1.27) and 19.41 – 32.55 mm respectively. Although it was similar to report from our country, slightly shorter than the others.[13-16,18] There was a statistically significant negative correlation between AL and steep K, flat K values and age (Steep K: r=-0.427, p<0.001; Flat K: r=-0.48, p<0.001; Age:r=-0.198, p<0.001). But there was no correlation between AL and corneal astigmatism (p=0.534).

With the rising implantation of toric IOLs, IOL model and range which came into use is also increasing at the same rate. Thus, candidate of the toric IOL implantation may increase. As we know, the first study which planned with this mind is Ferrer-Blasco et al's study. This researchers showed that five toric IOL brand exists with various dioptry range at that time. But now in this study we have seen that five more IOL brand added to that list. Table 5 shows specifications of toric IOL brands which available on the market and the percentage of eyes this study that are susceptible to correction. In previous studies, researchers took the cut-off value of toric IOL implantation 1 or 1.5 D. So the candidate range changes from 29.7% to 47.27%.[12-16,19]

TABLE 5: Range of cylindrical powers and corneal astigmatism capable of correcting the toric IOLs.

Company	Toric IOL Model	Available Cylinder Power	Range of Corneal Astigmatism to Correct	Percentage of Eyes*
Alcon	AcrySof IQ Toric SN60T3-T9	1.5 to 6.0	1.0 to 4.2	17.3
Zeiss	Acricomfort 643TLC-646TLC	1.0 to 12.0	0.7 to 8.4	36.8
Rayner	T-flex 573T/623T	1.0 to 6.0	0.7 to 4.2	35,6
		1.0 to 11.0	0.7 to 7.7	36.8
Oculentis	Lentis T Plus	0.5 to 12.0	0.35 to 8.4	75.28
Staar Surgical Company	AA4203TF	2.0 and 3.5	1.4 and 2.4	5.89
	AA4203TL	2.0 and 3.5	1.4 and 2.4	
Humanoptics	Torica-S	2.0 to 12.0	1.4 to 8.4	10.28
AMO	Tecnis ZCT150,225,300,400	1.5 to 4.00	1.03 to 2.74	17.19
Hoya	AF-1 toric	1.5 to 3.0	1.03 to 2.1	15.81
Calhoun Vision	Light-adjustable lens	0.75 to 2.0	0.5 to 1.4	36.48
Morcher GmbH	Morcher 89A	0.5 to 8.0	0.35 to 5.6	70.26
VSY	Acriva^{UD} BB T UDM 611	1.0 to 10.0	0.7 to 8.1	36.2

* Considering only corneal astigmatism in the eyes in the present study (n=797).

In the current study, if we consider 1D or higher astigmatism, rate of the toric IOL candidate was 36.76%. But some new IOL brands (Oculentis and Morcher GmbH) suggested that their IOL range begins from 0.5D. With this cut-off value, the patient rate jump to 75.28% suddenly in our study.[20] However the effectiveness of that lower D IOLs has not been evaluated yet. Furthermore, routine cataract surgery with the steep axis corneal incision may be enough to correct astigmatism for these patients as we discussed above. According to current evidence, it appears that a minimal amount of corneal astigmatism of approximately 1.25 D should be present before toric IOL implantation is considered. Another dimension of the patient selection; maybe the most important, is the cost effectiveness of the application. Because the unnecessary implantations, can create burden financially to patients or healthcare systems of countries, besides the absence of benefit to the patients. In our study, we haven't done any toric IOL implantation to the patients. Astigmatic corrections have been done with spectacles or contact lens.

In conclusion, we purposed to reveal the prevalence of the corneal astigmatism from our country. As the results show, a significant amount of patients can be toric IOL candidate, depending on the cut-off value of corneal astigmatism. The prevalence of the corneal astigmatism and also the wide range of toric IOL models are important to overcome the residual astigmatism. We thought that this data will be helpful for ophthalmology clinics and IOL manufacturers.

Conflict of Interest

Authors declared no conflict of interest or financial support.

Authorship Contributions

Idea/Concept: *Sinan Emre, Lale Dinçer;* ***Design:*** *Sinan Emre, Mahmut Oğuz Ulusoy;* ***Control/Supervision:*** *Sinan Emre;* ***Data Collection and/or Processing:*** *Sinan Emre, Mahmut Oğuz Ulusoy;* ***Analysis and/or Interpretation:*** *Sinan Emre, Mahmut Oğuz Ulusoy;* ***Literature Review:*** *Sinan Emre, Lale Dinçer;* ***Writing the Article:*** *Sinan Emre, Mahmut Oğuz Ulusoy;* ***Critical Review:*** *Sinan Emre;* ***References and Fundings:*** *Sinan Emre;* ***Materials:*** *Sinan Emre.*

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