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CORRELATION BETWEEN AUTOMATED ASSESSMENT OF SENILE CATARACT DENSITY AND THE APPLIED ULTRASOUND ENERGY DURING PHACOEMULSIFICATION

KORELACIJA IZMEĐU AUTOMATIZOVANE PROCENE GUSTINE SENILNE KATARAKTE I ULOŽENE ULTRAZVUČNE ENERGIJE TOKOM FAKOEMULZIFIKACIJE

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Summary

Introduction. Cataract density is highly important factor when choosing a surgical method and setting the parameters of a phacoemulsification device. Diagnostic devices enable automated assessment of lens opacification degree. **Material and Methods.** Study included 30 patients operated on for senile cataracts at the Clinic of Eye Diseases of the University Clinical Center of Vojvodina. After determining the preoperative best corrected visual acuity, cataract density was assessed using the Pentacam Nucleus Staging scale of the Scheimpflug imaging system, Pentacam AXL Wave (Oculus, Wetzlar, Germany). The evaluation of the applied ultrasound energy during phacoemulsification was quantified and expressed in the form of Cumulative Dissipated Energy index of the Centurion Vision System (Alcon, Irvine, USA) eye microsurgery device. The obtained results are expressed in the form of mean values, and their connection is presented in the form of correlation. **Results.** Statistically significant positive correlation was found between the cataract density expressed with use of the Pentacam Nucleus Staging scale and the applied ultrasound energy during surgery, expressed in the form of Cumulative Dissipated Energy index ($r=0.37$, $p=0.04$). No statistically significant correlation was found between preoperative best corrected visual acuity and cataract density expressed with the Pentacam Nucleus Staging scale ($p>0.05$) or between preoperative best corrected visual acuity and Cumulative Dissipated Energy index ($p>0.05$). **Conclusion.** The obtained data indicate a positive correlation ($r=0.37$, $p=0.04$) between the degree of lens opacification assessed by Pentacam Nucleus Staging scale and the required ultrasound energy applied during phacoemulsification expressed as Cumulative Dissipated Energy index.

Key words: Cataract; Phacoemulsification; Capsule Opacification; Ultrasonic Waves; Treatment Outcome

Sažetak

Uvod. Stepen gustine zamućenja sočiva veoma je važan faktor prilikom izbora hirurške metode i podešavanja parametara uređaja za fakoemulzifikaciju. Dijagnostički uređaji novije generacije omogućavaju automatizovanu procenu stepena gustine kataraktom zamućenog sočiva. **Materijal i metode.** U pitanju je prospektivna, nerandomizovana studija u kojoj je učestvovalo 30 konsekutivnih pacijenata operisanih zbog senilne katarakte na Klinci za očne bolesti Univerzitetskog kliničkog centra Vojvodine. Nakon određivanja preoperativne najbolje korigovane vidne oštine, procena gustine katarakte izvršena je pomoću Pentacam Nucleus Staging scale Scheimpflug imaging system, *Pentacam AXL Wave*, (Oculus, Wetzlar, Nemačka). Procena uložene ultrazvučne energije tokom hirurškog zahvata kvantifikovana je i izražena u vidu indeksa ukupne uložene energije, *Centurion Vision System (Alcon, irvine, SAD)* uređaja za mikrohirurgiju oka. Dobijeni rezultati su izraženi u vidu srednjih vrednosti, a njihova povezanost je predstavljena u vidu korelacije. **Rezultati.** Dobijena je statistički značajna pozitivna korelacija između gustine katarakte izražene pomoću Pentacam Nucleus Staging scale i uložene ultrazvučne energije tokom fakoemulzifikacije izražena u formi indeksa ukupno uložene energije ($r = 0,37$, $p = 0,04$). Nije utvrđena statistički značajna korelacija između preoperativno izmerene najbolje korigovane vidne oštine i gustine katarakte izražene pomoću *Pentacam Nucleus Staging scale* ($p > 0,05$), kao ni između preoperativno izmerene najbolje korigovane vidne oštine i indeksa ukupno uložene energije tokom operacije ($p > 0,05$). **Zaključak.** Dobijeni podaci ukazuju na pozitivnu korelaciju ($r = 0,37$, $p = 0,04$) između stepena gustine katarakte izražena pomoću Pentacam Nucleus Staging scale i uložene ultrazvučne energije tokom fakoemulzifikacije izražene u formi indeksa ukupno uložene energije, što može biti od značaja pri odabiru optimalne hirurške metode. **Ključne reči:** katarakta; fakoemulzifikacija; zamućenje kapsule sočiva; ultrazvučni talasi; ishod lečenja

Introduction

Cataract is one of the leading causes of blindness in the world, and is still considered a significant

health problem within the population [1]. Cataract is defined as any reduced transparency of the natural intraocular lens, regardless of whether it affects visual acuity. The human lens is a transparent bi-

Abbreviations

LOCS	– Lens Opacities Classification System
PNS	– Pentacam Nucleus Staging
CDE	– Cumulative Dissipated Energy
BCVA	– best corrected visual acuity
UCCV	– University Clinical Center of Vojvodina

convex structure made of many closely connected fibers inside the capsule. Lens fibers are formed by the migration of lens epithelial cells from the periphery to the center of the lens and their dedifferentiation into lens fibers.

Due to its germinal and metabolic potential, the lens epithelium, together with the lens fibers, is very susceptible to oxidative stress, which is one of the most important causes of senile cataracts. In relation to the localization of opacities, cataracts are divided into cortical, nuclear and subcapsular [2–4]. Cataracts could be classified according to the patient age at the time of their occurrence, where, roughly speaking, there are senile cataracts in patients older than 65 years of age (age related), presenile cataracts in patients under 65 years of age, and childhood cataracts, as well as cataracts caused by other ocular conditions and systemic diseases [5]. Finally, we come to the classification of cataracts in relation to its ‘maturity’ or density. This classification has the greatest clinical significance due to its predictive role in the context of treatment.

In practice, subjective and objective methods are used to quantify cataract density. Subjective assessment according to the Lens Opacities Classification System III (LOCS III scale) is the most widespread and frequently used method [6, 7]. It is based on the comparison of reference photographs of cataracts taken on a slit lamp in mydriasis. Although it is a cheap and fast method, its subjectivity is the biggest drawback. Therefore, objective methods for this type of assessment have been developed over time [8].

The use of the Scheimpflug system for the eye anterior segment visualization, incorporated into the Pentacam AXL Wave device (Pentacam HR, Oculus incorporation, Wetzlar, Germany), is the method of choice in many centers dealing with the diagnosis and treatment of eye diseases [9]. The principle of this method is based on the use of a non-contact rotator camera, most often in medicated mydriasis, which records up to 50 images of the anterior segment of the eye in different meridians [10, 11]. The obtained data are analyzed with special software, and the degree of lens opacification density is expressed in the form of the Pentacam Nucleus Staging (PNS) scale with a range of 0 to 5 density units [12].

One of the most important parameters during the surgical treatment of cataracts using the phacoemulsification method is the amount of ultrasound energy applied. The harmful effect of intraoperatively applied ultrasound energy on corneal endothelial cells, which can directly affect the postoperative outcome of treatment, is well known [13]. Modern phacoemulsification devices quantify this value based on the degree of applied ultrasound energy and the duration

of the operation, in the form of an index, such as the Cumulative Dissipated Energy (CDE) index within the Centurion Vision System (Alcon, Irvine, USA), which is used in our study [14].

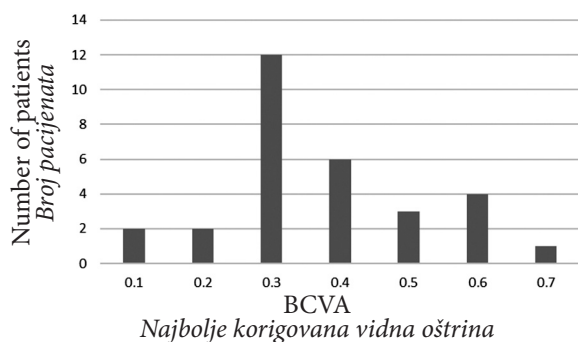
This study was created to determine the correlation between the preoperative best corrected visual acuity (BCVA), the automated lens-cataract density assessment scale, PNS and the total applied ultrasound energy index, CDE during the surgical treatment of cataract using the phacoemulsification method.

Material and Methods

The study we conducted was a non-randomized, prospective study. It included 30 consecutive patients that were operated for senile cataracts at the Clinic of Eye Diseases of the University Clinical Center of Vojvodina (UCCV) in the period from September to November 2021. Patients of both sexes, without associated eye diseases, with early senile cataract participated in the study. The exclusion factors for participation in the study included preoperative BCVA below 0.1, advanced corneal pathology, earlier eye surgeries and the occurrence of intra- and/or postoperative complications. Diabetes and chronic renal insufficiency were also exclusion factors for participation in the study as they are systemic diseases that can lead to the formation of cataracts. The best corrected visual acuity (BCVA) was determined with use of the Snellen optotype as part of the preoperative preparation for the patients. On the day of the operation, the patient’s pupils were dilated with Phenylephrine 10% and Tropicamide 1% drops instilled three times consecutively with an interval of 15 minutes. Images of the anterior segment of the eye were taken with a Pentacam AXL Wave device (Pentacam HR, Oculus incorporation, Wetzlar, Germany) one hour after instillation of the last dose of drops, when maximum medicated mydriasis was achieved. We used the automatic recording mode.

All patients were surgically treated by the same surgeon using the Centurion Vision System phacoemulsification device (Alcon, Irvine, USA). The operations were performed under topical anesthesia, making self-healing incisions (central limbal incision at 12 o’clock and two paracentesis, temporally and nasally) with the stop-and-chop technique, and with the use of Sterile Irrigating Solution (BSS) and dispersive viscoelastic. All patients received a suitable soft hydrophobic acrylate intraocular lens (HOYA 254, HOYA Surgical optics, Frankfurt am Main, Germany) that was implanted before the end of the operation. All operations were completed without any intraoperative complications, and the patients were discharged home the same day in good general condition. The index of total CDE from the phacoemulsification machine was read and recorded at the end of each operation.

Statistical analysis of parametric and non-parametric indicators was made using MedCalc software (v.20.104, MedCalc Software Ltd). Arithmetic mean and standard deviation were used to describe the monitored parameters given that they all showed the tendency of normal distribution. Relation between the



Graph 1. Mean values of preoperative BCVA
Grafikon 1. Srednje vrednosti preoperativno izmerene BCVA

two characteristics was carried out using correlation analysis, by calculating the Pearson correlation coefficient (r). An appropriate level of statistical significance was set for all tests. All values of $p < 0.05$ indicated that there was a statistically significant difference between the observed results, with a risk of 5%.

Results

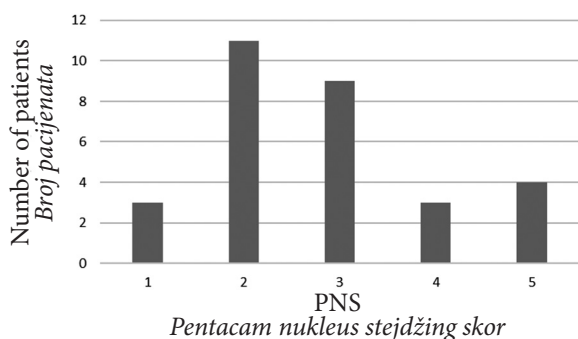
Our study included 30 consecutive patients operated on for senile cataract at the UCCV Clinic of Eye Diseases, aged 74 years in average (65-92 years), with a slight predominance of females (17/13).

The obtained mean values of preoperative BCVA were 0.37 (95% Ci; 0.31 - 0.42). The lowest recorded value was 0.10 and the highest 0.70 according to Snellen (**Graph 1**).

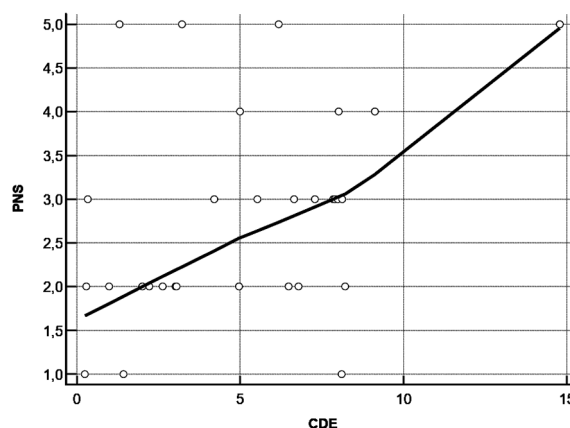
The Pentacam Nucleus Staging values averaged 2.80 or (95% CI; 2.35-3.24) and ranged from 1 to 5 (**Graph 2**).

The mean values obtained for CDE were 5.13 (95% Ci; 3.87 - 6.40). The lowest recorded value was 0.25, and the highest was 14.80.

No statistically significant correlation was found between CDE and BCVA, or between PNS and BCVA ($p > 0.05$). On the other hand, a statistically significant positive correlation of mild to moderate degree ($r = 0.37$, $p = 0.04$) was found between PNS and CDE (**Graph 3**).



Graph 2. PNS mean values ranging from 1 to 5
Grafikon 2. Srednje vrednosti Pentacam nukleus stejdžing skora u rasponu od 1 do 5



Graph 3. Correlation between CDE and PNS
Grafikon 3. Korelacija između uložene ultrazvučne energije i Pentacam nukleus stejdžing skora

Discussion

Cataract surgery is one of the most frequently performed surgical procedures in medicine with increasing postoperative expectations. Preoperative preparation and precise execution of the procedure is therefore gaining more and more importance, which has led to an increasing number of published studies like this one [15].

The Pentacam Nucleus Staging value in our study is 2.80, which is almost in the middle of the scale. It is important to note that an automatic program was used in this case to quantify the whole lens density and that the patient sample was relatively small. During their research on 238 patients, Xu Ke et al. used a software option to assess the degree of cloudiness of individual lens segments with different section depths. It was observed that PNS values vary significantly depending on the observed lens segment. In the lens segments at a depth greater than 3 mm in over 90% of the cases, the obtained PNS values were almost identical regardless of the degree of the cataract. The reason for this is the reflection-based principle of operation of the Scheimpflug camera and the resulting limitations, due to which deeper lens segments may remain inadequately quantified in cases with predominantly anteriorly located opacities [16]. This indicates that the measurement should be directed to the front segments of the lens or to an earlier clinically determined segment of the lens.

The correlation that showed no statistical significance in our research is the relationship between BCVA and PNS. On the other hand, the research conducted by Bělíková et al. on a slightly larger sample ($n = 55$) obtained a statistically significant positive correlation between these two parameters ($r = 0.451$) [17]. The result we obtained can be explained by the clinical phenomenon that patients with pronounced dominantly nuclear opacities of the lens often have preserved high visual acuity with appropriate myopic correction. On the other hand, centrally localized initial opacities of the pos-

terior cortex of the lens can lead to a drastic drop in BCVA. For this reason, we believe it is necessary to give preference to the evaluation of lens opacification in relation to the visual acuity level when deciding on the operation.

The correlation between PNS and CDE has statistical significance and a positive trend. Such results are not surprising. Sandhya Jeria et al. have found a similar result comparing these two parameters. Nixon finds that preoperative parameter setting on the phacoemulsification device, based on the PNS score, has multiple significance. The operating time is shortened, and the ultrasound energy delivered to the eye is reduced to the required minimum [18].

Lim et al. compared the LOCS III system and the PNS scale for cataract assessment, and they have obtained a result that strongly supports the PNS scale as a better predictor of surgical outcome [19].

Conclusion

Comprehensive preoperative evaluation of cataract patients is one of the most important conditions for choosing and performing an optimal surgical procedure, as well as for achieving maximum postoperative goals. Our results that show statistically significant positive correlation ($r=0.37$, $p=0.04$) between the degree of lens opacification assessed by Pentacam Nucleus Staging scale and the amount of ultrasound energy invested during surgery expressed as Cumulative Dissipated Energy index, may have an improving effect on the surgical outcome. We believe that further research aimed at calculation of the Pentacam Nucleus Staging score, as well as increasing the availability of the device for its measurement will help in achieving the above mentioned goal. One of the main disadvantages and limiting factors is the price of the device, which reduces its overall availability and prevents wider usage.

References

1. Resnikoff S, Pascolini D, Etya'ale D, Kocur I, Pararajasegaram R, Pokharel GP, et al. Global data on visual impairment in the year 2002. *Bull World Health Organ.* 2004;82(11):844-51.
2. Murthy G, Gupta SK, John N, Vashist P. Current status of cataract blindness and Vision 2020: the right to sight initiative in India. *Indian J Ophthalmol.* 2008;56(6):489-94.
3. Gupta VB, Rajagopala M, Ravishankar B. Etiopathogenesis of cataract: an appraisal. *Indian J Ophthalmol.* 2014;62(2):103-10.
4. Chylack LT Jr. Mechanisms of senile cataract formation. *Ophthalmology.* 1984;91(6):596-602.
5. Alshamrani AZ. Cataracts pathophysiology and managements. *Egyptian Journal of Hospital Medicine.* 2018;70(1):151-4.
6. Chylack LT. Surgical anatomy, biochemistry, pathogenesis, and classification of cataracts. In: Steinert RF, editor. *Cataract surgery.* Philadelphia: Saunders; 2010. p. 11-9.
7. Chylack LT Jr, Wolfe JK, Singer DM, Leske MC, Bullimore MA, Bailey IL, et al. The Lens Opacities Classification System III; the longitudinal study of Cataract Study Group. *Arch Ophthalmol.* 1993;111(6):831-6.
8. Grewal DS, Brar GS, Grewal SP. Correlation of nuclear cataract lens density using Scheimpflug images with Lens Opacities Classification System III and visual function. *Ophthalmology.* 2009;116(8):1436-43.
9. Faria-Correia F, Lopes BT, Ramos IC, Monteiro T, Franqueira N, Ambrósio R Jr. Application of different Scheimpflug-based lens densitometry methods in phacodynamics prediction. *Clin Ophthalmol.* 2016;10:609-15.
10. De Bernardo M, Borrelli M, Imperato R, Cione F, Rosa N. Anterior chamber depth measurement before and after photorefractive keratectomy. Comparison between IOLMaster and Pentacam. *Photodiagnosis Photodyn Ther.* 2020;32:101976.
11. Salouti R, Kamalipour A, Masihpour N, Zamani M, Ghoreyshi M, Salouti K, et al. Effect of photorefractive keratectomy on agreement of anterior segment variables obtained by a swept-source biometer vs a Scheimpflug-based tomographer. *J Cataract Refract Surg.* 2020;46(9):1229-35.
12. Magalhães FP, Costa EF, Cariello AJ, Rodrigues EB, Hoffling-Lima AL. Comparative analysis of the nuclear lens opalescence by the Lens Opacities Classification System III with nuclear density values provided by Oculus Pentacam: a cross-section study using Pentacam Nucleus Staging software. *Arq Bras Oftalmol.* 2011;74(2):110-3.
13. Chen X, Xiao W, Ye S, Chen W, Liu Y. Efficacy and safety of femtosecond laser-assisted cataract surgery versus conventional phacoemulsification for cataract: a meta-analysis of randomized controlled trials. *Sci Rep.* 2015;5:13123.
14. Chen M, Sweeney HW, Luke B, Chen M, Brown M. A retrospective randomized study to compare the energy delivered using CDE with different techniques and OZil settings by different surgeons in phacoemulsification. *Clin Ophthalmol.* 2009;3:401-3.
15. Brunet S, Canadanovic V, Babic N, Miljkovic A, Jovanovic S, Barisic S. Dry eye syndrome and cataract surgery. *Med Pregl.* 2019;72(3-4):105-9.
16. Xu K, Hao Y. Determination of the density of human nuclear cataract lenses. *Mol Med Rep.* 2013;8(5):1300-4.
17. Belikova J, Synek S. Correlation of age-related cataract density graded by the Scheimpflug Imaging System with visual function and phacoemulsification energy. *Coll Antropol.* 2013;37 Suppl 1:25-30.
18. Jeria S, Aggarwal A, Singh K, Jeria S, Pradhan A, Khedia D. Assessment of age-related cataract using Scheimpflug Imaging System and its correlation with phacoemulsification parameters. *J Clin Diagn Res.* 2020;14(6):1-4.
19. Lim SA, Shin JY, Chung SH. Useful prediction of phacodynamics by Scheimpflug lens densitometry in patients over age 70. *Semin Ophthalmol.* 2017;32(4):482-7.

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