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ASSESSMENT OF MALONDIALDEHYDE, TOTAL ANTIOXIDANT CAPACITY, AND SERUM VITAMIN D LEVELS IN CATARACT PATIENTS

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ABSTRACT

Background: Cataract is one of the leading causes of visual impairment worldwide and is strongly associated with oxidative stress–induced damage to the lens. Oxidative stress results from an imbalance between the production of reactive oxygen species and the body's antioxidant defense mechanisms, contributing to lens opacification and cataract progression.

Objective: To investigate the role of malondialdehyde (MDA), total antioxidant capacity (TAC), and serum vitamin D levels in patients with mature and Immature cataract Patients.

Methods: Serum samples were collected from individuals diagnosed with cataract and appropriate controls. Oxidative stress was assessed by measuring serum MDA levels, while antioxidant defense was evaluated through TAC and serum vitamin D estimation. The obtained values were compared between study groups to determine their association with cataract development and progression.

Results: Patients with cataract exhibited significantly elevated serum MDA levels, indicating increased lipid peroxidation and oxidative stress. In contrast, TAC and serum vitamin D levels were significantly reduced compared to controls, suggesting compromised antioxidant defense mechanisms. The observed alterations were more pronounced with increasing severity of cataract.

Conclusion: Oxidative stress is associated with cataract progression, characterized by increased MDA and decreased TAC and vitamin D levels. These biomarkers may aid in assessing cataract severity and progression.

Keyword: Oxidative stress; malondialdehyde; Cataract; vitamin D; total antioxidant capacity

INTRODUCTION

Cataract is defined as a loss of lens transparency caused by changes in the lens's refractive properties and increased light scattering, leading to blurred vision or complete vision loss. Cataract can develop in one or both eyes and is a common age-related condition, particularly affecting older individuals. The lens of the eye focuses light onto the retina, which then sends signals to the brain, enabling clear vision. (1) The prevalence of cataract increases with age, from 3.9% in individuals aged 55–64 to 92.6% in those aged 80 and older. (2) With the global population ageing and life expectancies increasing, the 10.8 million cataract-blind individuals in 2010 are projected to rise to 40 million by 2025 (3). According to the WHO, cataract affects nearly 65.2 million people annually. In India, around 12 million individuals are blind, with 80% of these cases due to cataract. (4) The etiology of cataract is complex and multifactorial, with several contributing elements. While ageing is the primary risk factor, genetic predisposition also plays a role, with a family history of cataract increasing susceptibility. Cataract can be classified based on its maturity, indicating the degree of lens opacity or cloudiness, into two main categories: mature and immature cataract. Currently, there is no effective medical treatment for cataract other than surgical removal of the cataractous lens and replacement with a synthetic polymer lens. (5) Malondialdehyde (MDA) is a chemical compound that serves as a biomarker for oxidative stress and lipid peroxidation in biological systems. Cataract, characterised by the clouding of the eye's lens, is closely linked to oxidative stress, with MDA serving as a reliable marker of lipid peroxidation—an integral component of this stress cascade. Interventions aimed at reducing MDA levels may offer potential therapeutic avenues for preventing or slowing the progression of cataract, thereby preserving visual acuity and overall eye health. Regular monitoring of MDA levels in at-risk populations could contribute to early intervention and personalized approaches in managing cataract risk. (6) Antioxidants are molecules capable of preventing the oxidation of other molecules, a process that involves the transfer of electrons from a molecule to an oxidizing agent. Free radicals, produced by oxidation processes, are implicated in cataract formation. Total antioxidant capacity (TAC) is crucial in maintaining

lens transparency and proper function. Oxidative stress can lead to lipid peroxidation, protein modifications, and protein aggregation in the lens, contributing to lens opacification and impaired vision. Monitoring TAC levels and incorporating antioxidant-rich foods into one's diet may help promote eye health and reduce the burden of cataract. (7) Vitamin D, a steroid prohormone circulating in the blood in two forms, D3 and D2, is recognized for its role in reducing inflammation, a contributing factor to oxidative stress and cataract formation. By mitigating oxidative damage to lens cells and preventing protein aggregation that leads to lens opacification, vitamin D may help protect against cataracts. While emerging evidence suggests a potential link between vitamin D and cataract, more research is needed to establish a clear causal relationship and determine optimal vitamin D levels for ocular health.(8) Cataract are more prevalent in developing nations like India compared to wealthier countries. This work highlights the role of oxidative stress in cataract progression by estimating serum levels of the lipid peroxidation product malondialdehyde (MDA) and assessing the body's antioxidant defense system by measuring total antioxidant capacity (TAC) and serum vitamin D levels.

MATERIALS AND METHODS

The current hospital-based case control research was carried out in the Department of Biochemistry & Ophthalmology at SGT University, Chandu Budhera, Gurugram, Haryana. Sixty (60) patients aged 45-70 years suffering from senile cataract undergoing treatment in the outpatient department (OPD) of the Ophthalmology Department, SGT Hospital, Gurugram, were studied as cases. Including cataract patients (n=60). Thirty (30) age-matched non-cataract subjects were included as controls. The SGT University in Gurugram, Haryana, has an ethical committee that authorised the project. Before the sample was collected, written informed consent was obtained from each subject after explaining the study's goals and specifics to them. The duration of the study is 6 months. Cataract patients under 45 years, patients with congenital/complicated /traumatic/secondary cataract, pre-existing ocular disease (glaucoma, corneal opacity), patients who have taken any antioxidant drug, or steroids, or who have a history of substance abuse (alcohol and cigarettes), patients with chronic disease and metabolic disorders other than diabetes, as per clinical investigation, are excluded from the study.

Venous peripheral blood samples (5 ml) were obtained aseptically from both cases and controls via venipuncture after a 12-hour overnight fast. The blood was centrifuged at 3000 rpm for 10 minutes to separate the serum, which was then stored at -20° C for further analysis. With the help of commercially available kits, the Malondialdehyde (MDA) was done by Human Malondialdehyde, MDA GENLISA™ ELISA kit (KRISHGEN Biosystems catalog number HTAOC1123), Total antioxidant capacity was done by Human T-AOC ELISA kit (KRISHGEN Biosystems, catalog no: HTAOC1123), and Vitamin D (MAGLUMI-4000, 25-OH Vitamin D (CLIA)

Data and various parameters will be analyzed on SPSS software It will be calculated to see how the mean values of the parameters differ between the two groups. Using the student's "t" test for the unpaired data, the statistical significance will be ascertained. P-values will be used to evaluate the significance of the differences, and a p-value will be used to establish whether the differences are significant.

RESULTS

The present study was conducted to analyze the serum levels of MDA, TAC, and Vitamin D between the patients with Cataract and the healthy controls. The comparative study of MDA, TAC, and Vitamin D between the patients with cataract and the healthy controls was studied by an independent Student’s t-test. The demographic parameters of clinically diagnosed cases of cataract (n=60), in which 30 immature cataract patients and 30 mature cataract patients were taken for study, and the healthy controls (n=30) are depicted in Figure 1 below. There were 20 females (67%) and 10 males (33%) with cataract taken as cases. Similarly, the control group consisted of 28 males (56%) and 22 females (44%), respectively.

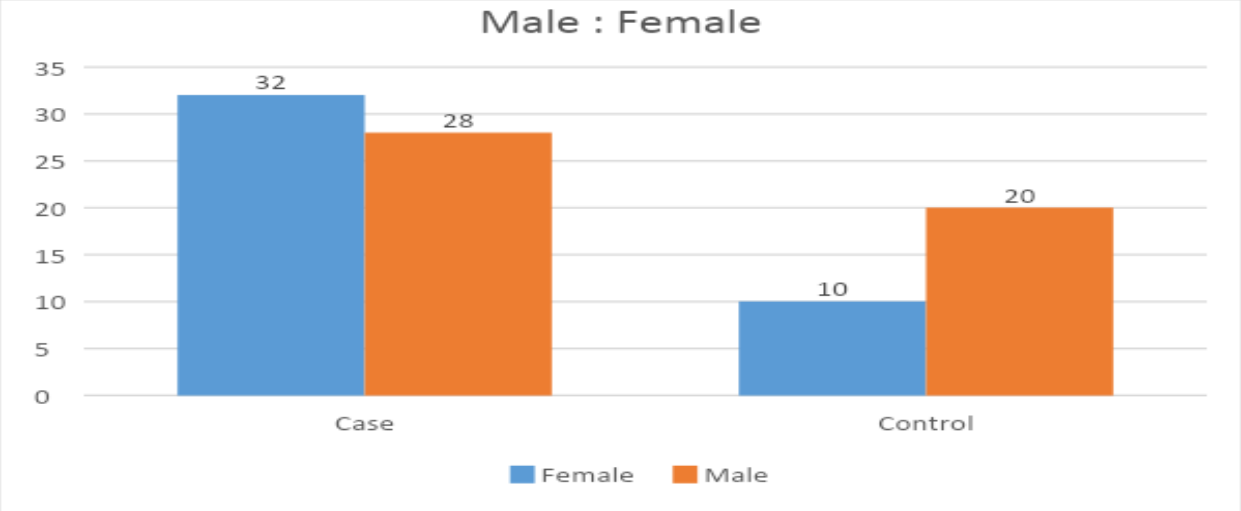

Figure 1: Male and Female ratio in the study population.

Table-1: MDA, TOAC, and Vitamin D levels in patients with mature and Immature cataract and controls

Biomarkers	Cases (N=60)	Controls	P value	
MDA (ng/ml)	5.02 ± 0.73	3.66 ± 0.24	0.0001**	9.91
TAOC (U/ml)	9.40 ± 8.24	13.59 ± 10.67	0.0427*	2.05
Vitamin D (ng/ml)	21.38 ± 9.67	24.35 ± 11.08	0.1944#	1.30

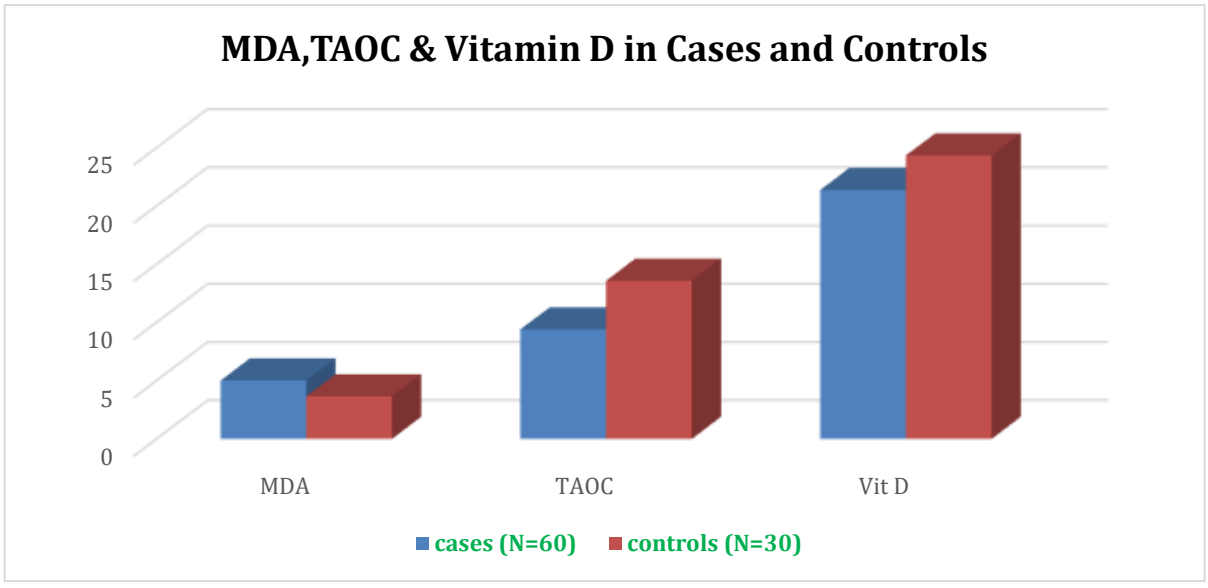

Figure 2: MDA, TOAC, and Vitamin D levels in a patient with mature and Immature cataract and controls

Our findings suggest that the level of MDA is significantly increased in mature cataract patients when compared to cataract patients, having p value <0.5, as shown in Figure 2. Our results show that the level of total antioxidant capacity slightly decreased in cataract cases when compared to controls. TAOC is non-significant in immature cataract patients compared to control having p value >0.5. The level of TAOC in mature cataract is significantly increased as compared

to controls, having p value <0.5. The level of TAOC is significantly increased in cataract patients when compared to mature cataract patients, having p value <0.1. **Vitamin D:** The level of vitamin D is decreased in cataract cases when compared to controls, having a p-value> 0.5, which is non-significant, whereas in cases of mature cataract, the level of vitamin D is significantly decreased when compared to controls, having p value <0.5.

DISCUSSION

Cataract is a prevalent eye condition characterized by the clouding of the eye's natural lens, resulting in blurred vision. This cloudiness often develops gradually and can be attributed to aging, although factors such as genetics, trauma, or certain medical conditions may also contribute. Common symptoms include decreased vision clarity, difficulty seeing in low light conditions, sensitivity to glare, and changes in color perception. (9) The primary treatment for cataracts is surgical intervention, where the cloudy lens is removed and replaced with an artificial intraocular lens. Cataract surgery is a well-established and highly successful procedure, generally restoring clear vision. Early detection through regular eye examinations is crucial for timely intervention and optimal management of the condition. Overall, cataracts are a manageable eye issue, and advancements in medical technology have made the surgical procedure safe and effective. (10) This cross-sectional observational study was carried out in the SGT Medical College, Hospital and Research Institute, Gurugram, Haryana, in the departments of biochemistry and Ophthalmology. Institutional ethics committee approval will be taken before collecting the samples. In the present study, we have included clinically diagnosed cases of cataract (n=60), including 30 cases of immature cataract and 30 cases of mature cataract, and age & gender matched 30 healthy volunteers. In our study, we conclude that the level of MDA is higher (4.38±0.25) in immature cataract cases when compared to controls (3.66±0.24), having p value <0.5 and t value -0.1. The level of MDA is also increased in mature cataract patients (5.7±0.4) when compared with controls (3.7±0.2) having significant p value (<0.5). When the level of MDA is compared between mature and immature cataract we find that mature cataract patients have significantly higher MDA levels having p value (<0.01). Similar studies by Angirekula S et al. (2018) study found serum malondialdehyde (MDA) levels in the various morphological forms and clinical phases of Senile Cataract. They enrolled 100 patients of senile cataract and separated it into two groups. In comparison to normal controls, the current study demonstrated a significantly higher concentration of serum MDA in senile cataract, particularly in the mature cataract stages in contrast to immature senile cataract stages. Furthermore, there was no statistically significant distinction in the morphological forms of age-related cataracts, i.e., cortical and nuclear.(11). Similar findings were shown by Jalees SS et al. that the level of MDA is also affected in cataract patients. (12)

In our study we conclude that the level of TAOC is lower (11.1±10.97) in immature cataract cases when compared to controls (13.59±10.49) having p value >0.5. We found that the level of TAOC is also decreased in mature cataract patients (6.7±1.7) when compared with controls (13.6±10.5) having significant p value (<0.5). TAOC is significantly higher in immature cataract patients when compared with mature cataract patients having p value <0.17. Similar study was conducted by Chang D et al. (2013) conducted their study in patients with age-related cataracts, they studied the activity of antioxidant enzymes and the byproducts of oxidative stress, and they compared the results with those in healthy control participants. (13)

According to our study, we conclude that the level of vitamin D is lower in immature cataract patients (24.07±10.37) when compared with healthy volunteers (24.35±10.85) and has a non-significant p value >0.1. The level of vitamin D is significantly lower in mature cataract patients (19.1±7.6) when compared with controls (24.4±10.9), having p value <0.5. The level of vitamin D is decreased in mature cataract patients when compared with immature cataract patients having p value <0.2. Similar studies conducted by Öktem Ç et al. (2021) (8) and Jee D et al. (2015) (14), have also shown that the level of vitamin D is decreased in cataract patients when compared with healthy controls and also shown the role of vitamin D in age-related cataract.

CONCLUSION

These results support the hypothesis that an imbalance between oxidant production and antioxidant defense is associated with cataract progression. Serum MDA, TAC, and vitamin D levels may serve as useful biochemical markers for assessing the severity and progression of cataracts. Further large-scale prospective studies are warranted to elucidate the underlying mechanisms and to evaluate the potential role of antioxidant and vitamin D supplementation in delaying cataract development and progression.

Limitation: Therefore, larger studies with longer follow-up periods are needed to validate and strengthen the present findings.

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