Macro Mineral Levels as Markers For Senile Cataract- A Case Control Study

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ABSTRACT

INTRODUCTION

Cataract surgery stands as one of the most prevalent surgical interventions globally, addressing the opacification of the crystalline lens, a condition known as cataract. Responsible for over half of blindness cases. Multitude factors leading to opacity of lens. Calcium, magnesium, and phosphorus collectively play pivotal roles in lens permeability, equilibrium regulation, and homeostasis. Calcium contributes to normal permeability and dynamic equilibrium regulation between the lens and its surrounding fluid. Magnesium-dependent ATPases maintain lens homeostasis, crucial for cellular functions. Additionally, phosphorus likely influences these processes, though its specific mechanisms warrant further exploration. Understanding the interplay of these minerals is essential for unraveling the complexities of lens physiology and pathology.

OBJECTIVE

The primary goal of this study is to comprehend the variations in serum calcium, phosphorus, magnesium levelsand the ratio of calcium to magnesium in senile cataract patients in comparison to individuals without cataracts.

MATERIALS AND METHODS

This prospective study involved a total of 168 participants, comprising 84 individuals with cataracts as cases and 84 without cataracts as controls.Both groups consisted of patients aged 50 years and above.Serum levels of calcium, magnesium, and phosphorus were measured and compared between the two groups.

RESULTS

The data collected in this study underwent statistical analysis.An independent t-test was employed to establish associations between the parameters.Thefindings indicate significantly elevated levels of serum calcium, phosphorusand the calcium: magnesium ratio in cataract patients ($p<0.05$) compared to the control group.

CONCLUSION

Monitoring these parameters at regular intervals can prove beneficial in extending the period before obvious cataract development necessitating medical intervention.

KEYWORDS: Cataract, Calcium: Magnesium Ratio,Phosphorous

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INTRODUCTION

Senile cataract presents a significant public health challenge, impacting a substantial portion of the aging population. The eye, a complex organ with intricate components, plays a crucial role in maintaining normal vision. The collaboration of these components is vital for clear vision. Senile cataract emerges as a primary contributor to visual impairment and disability, ultimately progressing to blindness, particularly prevalent in countries like India where the magnitude of this issue is staggering. This physiological eye disorder primarily affects elderly patients, involving various factors that lead to lens opacity, subsequent swelling, and eventual shrinkage, culminating in complete loss of vision.[1]

The clouding or opacity observed in the eye lens is defined as cataract.[2] The development of cataract occurs when the attachment or folding of a protein shifts and clumps together.[3] These clumps induce clouding in the lens, preventing the entry of light. Towards the onset of cataract, the lens becomes more susceptible to oxidative damage from reactive oxygen species (ROS).[4]

Cataract and the associated surgery have a substantial economic impact, prompting researchers to explore the molecular and biochemical processes in cataractogenesis. Calcium and phosphorus play crucial roles in causing membrane damage, protein-lipid alteration, aggregation, inflammation, and lenticular apoptosis.[1,5] Elevated serum calcium levels increase permeability, leading to heightened intralenticular calcium concentration—a significant risk factor for cataractogenesis.[6]

Magnesium deficiency states and ATPase dysfunctions result in intracellular buildup of Ca(2+), activating the enzyme calpain II. This activation initiates the denaturation of crystalline, a soluble lens protein crucial for preserving lens transparency.[7,8] Continued magnesium deficiency further depletes antioxidant defenses, escalating free radical production. These processes collectively modify the refractive properties of the lens, resulting in opacity and cataract formation.

This study aims to investigate the correlation between serum levels of magnesium and phosphorus, including calcium, and the calcium:magnesium ratio as potential contributors to the etiology of senile cataract.

MATERIALS AND METHODS

This comprehensive case-control study enrolled a total of 168 subjects, all aged above 50 years, with senile cataract identified as 84 cases. 84 Controls were defined as individuals aged above 50 years without cataracts, with matching criteria based on age and gender. Ethical approval for the study was secured from the Institutional Ethics Committee. Participants were selected from the pool of patients attending the Ophthalmology Outpatient Department of R.L. Jalappa Hospital and Research in Kolar over a period of 1 year, spanning from December 2022 to December 2023.

Patients with a history of comorbidities such as diabetes, hypertension, and rheumatoid arthritis. Individuals with a history of oral steroid intake were also excluded from the study. Moreover, individuals with ocular diseases affecting anterior structures (e.g., lens subluxation, ocular trauma, corneal scar, and uveitis) and those with a history of retinal vascular disorders like central retinal vein occlusion (CRVO) and branch retinal vein occlusion (BRVO) were not included in the study. Additionally, cases with poor pupil mydriasis (less than 6 mm) were excluded from the analysis to ensure a more homogeneous study population.

The evaluation of each participant involved a detailed history, covering aspects like sociodemographic profile, occupation, habits, dietary patterns, systemic disorders, long-term drug therapy, ocular trauma, and surgical history. The ophthalmic assessment included visual acuity using Snellen's chart for distant vision, near vision using Jaeger's chart, slit lamp biomicroscopy for grading cataract, and fundus examination. Additional procedures, such as intraocular pressure (IOP) measurement, gonioscopy, and optical

coherence tomography (OCT), were conducted as needed.

After participant selection, each individual contributed a 2ml venous blood sample, collected under aseptic conditions, for the estimation of serum calcium, magnesium, and phosphorous levels using the VITROS slide method. The blood samples were allowed to clot and subsequently underwent centrifugation to separate the serum from other blood components. The isolated serum was then stored at -20°C until analysis. Analysis of serum calcium, magnesium, and phosphorus was carried out utilizing specific VITROS slides, designed for compatibility with the VITROS system—an automated clinical chemistry analyzer. The determination of element concentrations (calcium, magnesium, and phosphorus) in the serum was accomplished through Atomic Absorption Spectroscopy, a technique measuring light absorption by atoms at a specific wavelength. The quantitative determination of calcium, magnesium, and phosphorus concentrations in the serum samples was achieved by comparing the light absorption of the samples with that of known standards.

Before the study commenced, written informed consent was obtained from all participating subjects, ensuring their voluntary participation and understanding of the research.

STATISTICAL ANALYSIS

In the data analysis phase, the collected data was input into a Microsoft Excel spreadsheet and analyzed using SPSS version 22 software. Categorical data is presented in the form of frequencies and proportions. For qualitative data, the significance was assessed using either the Chi-square test or Fischer's exact test (limited to 2x2 tables).Continuous data were expressed as mean and standard deviation. The Independent t test was employed to assess the significance of the mean difference between two quantitative variables.Graphical representation of the data was achieved using Microsoft Excel and Microsoft Word, generating various types of graphs for a more comprehensive visualization of the results.

To determine statistical significance, a p-value (representing the probability that the result is true) of less than 0.05 was considered.

RESULTS

In cataract patients, the levels of serum calcium (8.684524±0.5719327) mg/dl were significantly elevated compared to controls (8.338095±0.3786166) with a p-value <0.001. Similarly, serum phosphorus levels in cataract patients (4.097619±0.5594697) mg/dl were significantly higher than controls (3.32023±0.6403651) with a p-value <0.001. Conversely, the levels of serum magnesium in cataract patients (1.986905±0.2075559) mg/dl were found to be lower than controls (2.061905±0.4708118) with a p-value of 0.183, indicating no statistical significance. Interestingly, the ratio of serum calcium to magnesium in cataract patients (4.423782±0.5900768) mg/dl was significantly higher than controls (4.330759±0.3481087) with a p-value <0.001, as detailed in Table 1 and Table 2.

Parameters	Control (Mean ± SD)	Cases (Mean ± SD)	P-value
Calcium	8.338095±0.3786166	8.684524± 0.5719327	<0.001
Magnesium	2.061905±0.4708118	1.986905 ± 0.2075559	0.183
Phosphorus	3.32023 ±0.6403651	4.097619±0.5594697	<0.001
Ca:Mg	4.330759±0.3481087	4.423782±0.5900768	<0.001

Table 1:The mean differences between case and control group.

Independent t-test was used to calculate P-value

P-value considered significant when it less than 0.05

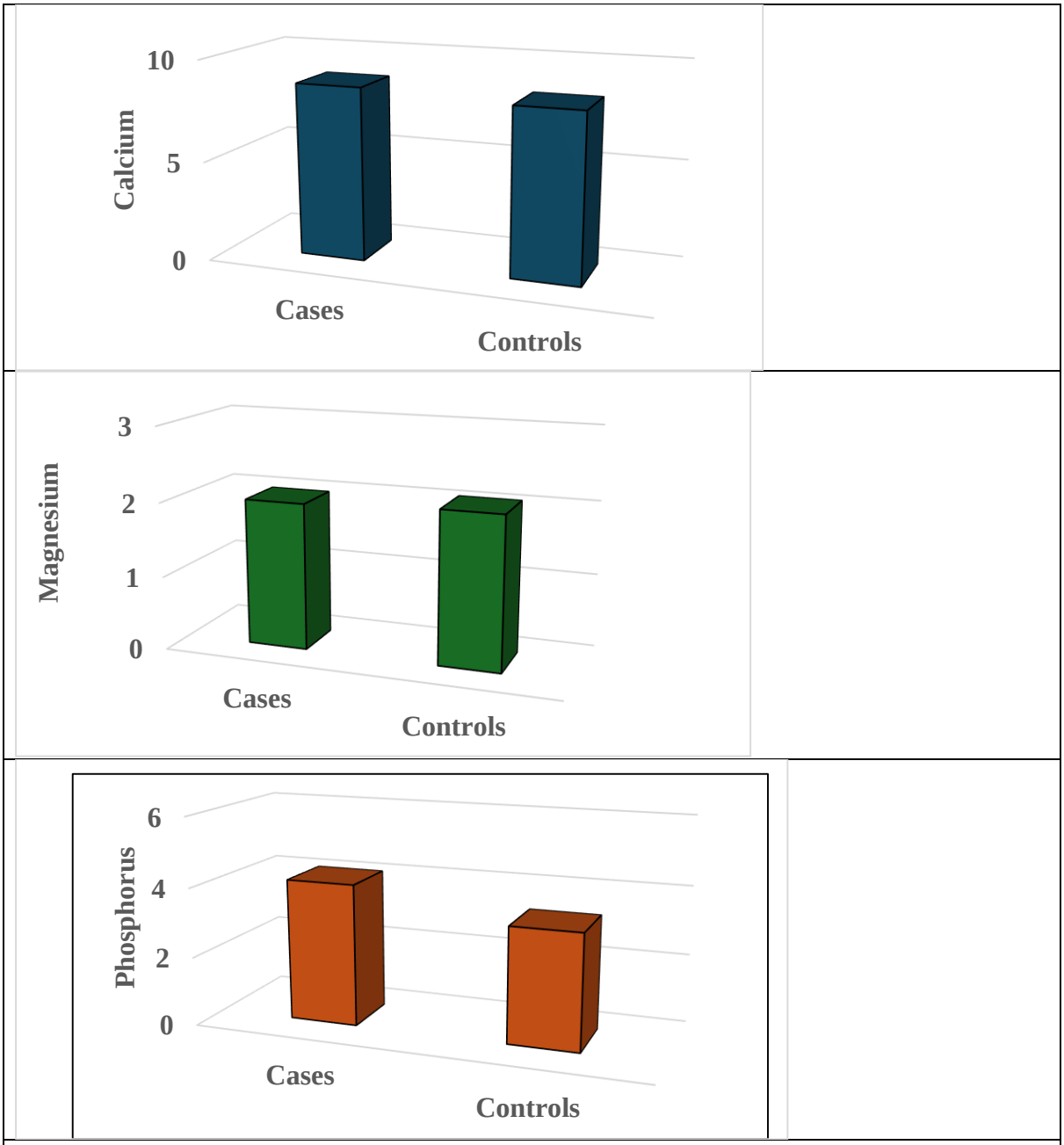

Table 2: Graphical representation of Calcium(a), Magnesium (b) and Phosphorus (c).

(a)

DISCUSSION

In our comprehensive study investigating the biochemical profiles of senile cataract patients, we observed notable deviations in serum calcium, phosphorus, and magnesium levels when compared to a control group. Specifically, our findings revealed elevated levels of serum calcium and phosphorus in cataract patients, demonstrating a significant departure from the corresponding levels in the control group. Moreover, the calculated calcium-to-magnesium (Ca: Mg) ratio was found to be substantially higher in cataract patients, reinforcing the potential association of these minerals with senile cataract development.

Conversely, serum magnesium levels exhibited a distinctive pattern, showing a

reduction in senile cataract patients compared to normal healthy volunteers without cataracts. This observation adds a nuanced layer to our understanding of the mineral dynamics in the context of age-related cataracts. The intricate interplay between these macro minerals suggests a multifaceted involvement in the pathogenesis or progression of senile cataracts, prompting a call for further research to unravel the underlying mechanisms.

Significantly, our study contributes novel insights to the existing body of research, as all three macro minerals—calcium, phosphorus, and magnesium—were comprehensively investigated. This distinctive approach sets our study apart and underscores the need for a holistic understanding of mineral imbalances in cataract development. The positive associations identified in our research align cohesively with the findings of previous studies conducted by Nitturkar et al. (2021)[5], Rehab OM Altouhami, Abdalla E Ali (2018)[8]and, Hemalathaa et al. (2022)[9] collectively reinforcing the relevance of these macro minerals in the intricate landscape of cataract pathology.

The observed derangement in the parameters of serum calcium, phosphorus, and magnesium not only signifies their individual importance but also points towards their collective significance in the pathogenesis of age-related cataracts. This underscores the potential clinical relevance of monitoring and understanding these mineral imbalances for early detection, prevention, or therapeutic interventions. The consistent positive associations across studies further solidify the importance of investigating these macro minerals in the context of cataract development. Thus, our study opens up promising avenues for further exploration, offering a deeper understanding of the intricate biochemical nuances involved in senile cataracts and their potential implications for clinical management.

CONCLUSION

The study findings unveil a compelling association between elevated concentrations of calcium and low serum magnesium levels, signifying a heightened risk of cataract formation in aged patients. Notably, the serum calcium-to-magnesium ratio emerges as a potential marker with the capacity to identify and facilitate early treatment of age-related cataracts. This insight holds significant clinical implications, suggesting that monitoring the serum calcium and magnesium levels, along with their ratio, could serve as an effective strategy for early detection and intervention in the context of age-related cataracts.

Moreover, our investigation identifies a noteworthy increase in both serum calcium and phosphorus levels among patients with cataracts compared to those without, further emphasizing the biochemical alterations associated with cataract development. This insight underscores the importance of routinely tracking these serum parameters at regular intervals. Such monitoring could prove beneficial by offering an early indication of cataract formation, potentially extending the period during which medical intervention may be initiated.

In conclusion, the study underscores the clinical significance of serum calcium, magnesium, and phosphorus levels, along with their ratios, in identifying and managing age-related cataracts. The proposed use of the serum calcium-to-magnesium ratio as a potential marker for early detection is particularly noteworthy and warrants further exploration. Implementing routine monitoring of these biochemical parameters may offer a valuable approach to enhance our ability to detect and address cataract development in its early stages.

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