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ORIGINAL RESEARCH

Role of Oxidative enzymes in Cataract formation in Flouride Endemic areas

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ABSTRACT

Background: Fluoride contamination in drinking water is a global public health concern, with its effects being particularly severe in fluoride-endemic regions such as Rajasthan, India. Prolonged exposure to high fluoride levels leads to oxidative stress, which contributes to cellular damage, particularly in the human crystalline lens. This study investigates the oxidative damage caused by fluoride toxicity and evaluates the impact of surgical intervention and biochemical markers in mitigating its effects. **Materials & Methods:** A prospective interventional study was conducted on individuals from fluoride-endemic areas, focusing on oxidative stress markers in the crystalline lens. Comprehensive ophthalmic assessments, including slit lamp examination and fundoscopy, were performed to evaluate cataract formation. Blood and urine samples were analyzed for fluoride levels and oxidative stress markers, including lipid peroxidation (LPO) and superoxide dismutase (SOD). Biochemical analyses were performed preoperatively and postoperatively to assess oxidative stress variations. **Results:** A significant reduction in lipid peroxidation (LPO) was observed postoperatively, with levels decreasing from 12.7658 ± 1.52084 to 7.5414 ± 1.50898 (p = 0.00), indicating reduced oxidative damage. Conversely, blood superoxide dismutase (SOD) levels showed a substantial postoperative increase, from 74.4330 ± 14.51036 to 149.1251 ± 27.28967 (p = 0.00), suggesting an improved antioxidant defense. These findings highlight the correlation between high fluoride intake and oxidative stress while demonstrating the effectiveness of surgical intervention in mitigating oxidative damage. **Conclusion:** This study establishes a direct association between fluoride toxicity and oxidative damage in the human crystalline lens, contributing to cataractogenesis. The findings emphasize the need for early detection, fluoride exposure mitigation, and surgical intervention to reduce oxidative stress and improve visual outcomes. Public health measures, including safe drinking water initiatives and antioxidant supplementation, are essential in fluoride-endemic regions.

Keywords: Fluoride toxicity, Oxidative stress, Lipid peroxidation, Superoxide dismutase, Cataract, Crystalline lens, Public health.

INTRODUCTION

Fluoride pollution in potable water is a widespread issue that substantially contributes to endemic fluorosis in a variety of regions. This contamination poses considerable risks to both animal and human health.[1] Excessive fluoride intake leads to its accumulation in bones and teeth of both humans and animals. Fluorosis, which occurs due to prolonged exposure to elevated doses of fluoride, presents as oral discoloration and skeletal problems including joint discomfort, rigidity, severe deformities, increased bone density, and weakened bones.[2]

Rajasthan is significantly impacted by elevated fluoride in drinking water, sometimes reaching levels as high as 24 ppm, putting approximately 11 million people at risk.[3] Nearly all districts in Rajasthan have fluoride levels exceeding the permissible limit. Fluoride’s high electronegativity allows it to ionize readily in solution, converting to hydrogen fluoride in the stomach. As hydrogen fluoride, the stomach absorbs 40% of fluoride, whereas the intestine absorbs 45%. The remaining amount is absorbed by processes

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that include carriers.[4]

Over fluoride may cross the blood-brain barrier and accumulate in sensitive tissues including the brain. Free radicals and lipid peroxide levels generated by fluoride toxicity can damage dendrites and synaptic connections, leading to neuron destruction.[5] Due to its high lipid and protein content, the brain is exceedingly susceptible to oxidative stress, exacerbated by low antioxidant levels and the presence of ions and metals.[6]Fluoride exposure produces reactive oxygen species (ROS), which may cause lipid peroxidation, protein oxidation, and antioxidant alterations.[7]The present study was conducted to assessoxidative damage to human crystalline lens due to high intake of fluoride.

MATERIALS & METHODS

The study was carried out on 386 subjects of both genders. All gave their written consent to participate in the study.

Data such as name, age, gender etc. was recorded. A history of the use of glasses, frequent changes in prescription, and family history of eye diseases and surgeries was recorded.Cataracts were assessed using slit lamp examination.Examination with an auto-refractometer and keratometer, as well as subjective vision testing, was performed.The selected population underwent blood tests, and post-operative lenses (POL) were collected for the assessment of oxidative stress markers, namely lipid peroxide levels (LPO), and superoxide dismutase (SOD). Results thus obtained were subjected to statistical analysis. P value < 0.05 was considered significant.

RESULTS

Table I Demographic data

CATEGORY	n (%)
Total Subjects	386 (100)
Age, Mean ± SD	44.87 ± 21.28
GENDER	
Female	192 (49.7%)
Male	194 (50.3%)
AREA OF POPULATION	
Rural	201 (52.1%)
Urban	185 (47.9%)
MARITAL STATUS	
Married	199 (51.6%)
Single	187 (48.4%)
OCCUPATION	
Farmer	114 (29.5%)
Labourer	40 (10.4%)
Office Worker	52 (13.5%)
Teacher	38 (9.8%)
Unemployed	111 (28.8%)
Worker	31 (8.0%)
DIETARY HABITS	
Non-Vegetarian	195 (50.5%)
Vegetarian	191 (49.5%)
WATER SOURCE	
Bottled	48 (12.4%)
River	60 (15.5%)
Tap	135 (35.0%)
Well	143 (37.0%)

Table I shows that in 386 subjects, the mean± SD age was 44.87 ± 21.28 years. There was female 192 (49.7%) and male 194 (50.3%). Rural were 201 (52.1%) and urban185 (47.9%). Married were 199 (51.6%) and single 187 (48.4%), farmer 114 (29.5%), labourer40 (10.4%), office worker52 (13.5%), teacher38 (9.8%), unemployed111 (28.8%) and worker31 (8.0%). Non- vegetarian195 (50.5%), vegetarian191 (49.5%). Water source was bottled in 48 (12.4%), river in 60 (15.5%), tap in 135 (35.0%) and well in 143 (37.0%).

Table II Variance of Visual Activity pre and post operatively

Variable	Pre- operative	Post- operative	P value
Visual Activity	0.5254 ± 0.19532	0.8285 ± 0.12167	0.00

Table II shows that pre- operative visual activity was 0.5254 ± 0.19532 and post- operative was 0.8285 ± 0.12167. The difference was significant (P< 0.05).

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Table III Variance of Blood LPO pre and post operatively

Variable	Pre- operative	Post- operative	P value
Blood LPO	12.7658 ± 1.52084	7.5414 ± 1.50898	0.00

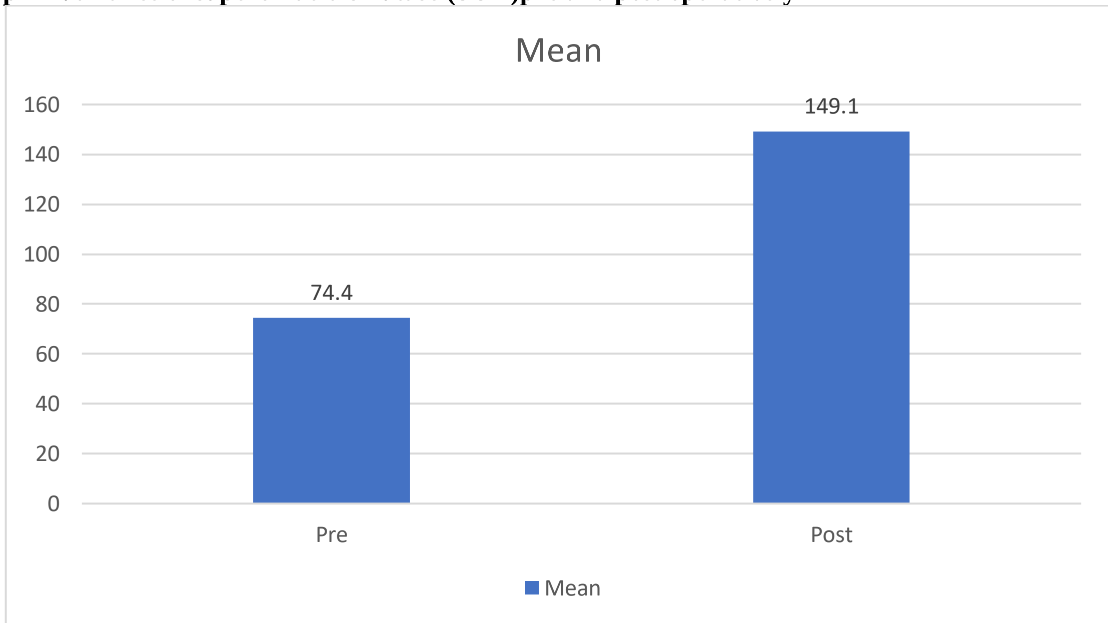
Table III shows that in the preoperative period, the mean blood LPO level was 12.7658 ± 1.52084, while in the postoperative period, it was 7.5414 ± 1.50898. This reduction was highly statistically significant, with a p-value of 0.00 ($p < 0.05$).

Table IV Variance of superoxide dismutase (SOD)pre and post operatively

Variable	Pre- operative	Post- operative	P value
SOD	74.4330 ± 14.51036	149.1251 ± 27.28967	0.00

Table IV, graph I shows that the mean preoperative blood SOD level was 74.4330 ± 14.51036, and the mean postoperative blood SOD level was 149.1251 ± 27.28967. This increase was highly statistically significant, with a p-value of 0.00 ($p < 0.05$).

Graph I Variance of superoxide dismutase (SOD)pre and post operatively



DISCUSSION

Fluoride is a naturally occurring element that serves two distinct functions in the realm of public health.[8,9] Although moderate fluoride levels in potable water can prevent dental caries, excessive fluoride ingestion can result in negative health consequences, such as oxidative injury to the human crystalline lens and dental and skeletal fluorosis.[10,11]The present study was conducted to assessoxidative damage to human crystalline lens due to high intake of fluoride.

We found that in 386 subjects, the mean± SD age was 44.87 ± 21.28 years. There was female192 (49.7%) and male194 (50.3%). Rural were 201 (52.1%) and urban185 (47.9%). Married were 199 (51.6%) and single187 (48.4%), farmer 114 (29.5%), labourer40 (10.4%), office worker52 (13.5%), teacher38 (9.8%), unemployed111 (28.8%) and worker31 (8.0%). Non-vegetarian195 (50.5%), vegetarian191 (49.5%). Water source was bottled in 48 (12.4%), river in 60 (15.5%), tap in 135 (35.0%) and well in 143 (37.0%). Waugh[12] summarized the data that excessive fluoride levels might induce chromosomal abnormalities and DNA damage. Fluoride disrupts DNA repair pathways and causes genetic mutations, according to experimental and epidemiological research. At low doses, fluoride prevents dental cavities, but its genotoxic effects at larger levels offer serious health hazards. The study suggested further research to understand fluoride-induced genotoxicity and set safer exposure limits. Waugh also proposed reassessing public health regulations on fluoride usage in water fluoridation and other uses to lessen genetic hazards.

We found that pre- operative visual activity was 0.5254 ± 0.19532 and post- operative was 0.8285 ± 0.12167. In the preoperative period, the mean blood LPO level was 12.7658 ± 1.52084, while in the postoperative period, it was 7.5414 ± 1.50898. Arlappa et al[13]examined fluoride exposure in India, focusing on dental and skeletal fluorosis' high incidence. The study showed that millions of Indians suffer from fluorosis, especially in areas with high drinking water fluoride levels. National health surveys and field investigations were used to assess fluorosis prevalence and severity in different states. They found that chronic discomfort, deformities, and dental and skeletal anomalies in newborns and people in these locations lower quality of life. They stressed the need of public health initiatives such safe drinking water

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sources, defluoridation, and fluoride awareness. The report advised health officials and lawmakers to collaborate to tackle this public health concern.

We observed that the mean preoperative blood SOD level was 74.4330 ± 14.51036, and the mean postoperative blood SOD level was 149.1251 ± 27.28967.Susheela et al[14]examined water samples from rural and urban areas and found fluoride contamination. Researchers found that fluoride levels in several states surpassed the WHO acceptable limit, which had serious health consequences for the impacted people. Rural regions had more newborns and adults with dental and skeletal fluorosis, according to the research. Susheela et al. stressed the need of public health initiatives such safe drinking water, defluoridation, and fluoride awareness programs. The findings show that India must regulate fluoride levels to protect public health.

The shortcoming of the study is small sample size.

CONCLUSION

This study establishes a direct association between fluoride toxicity and oxidative damage in the human crystalline lens, contributing to cataractogenesis. The findings emphasize the need for early detection, fluoride exposure mitigation, and surgical intervention to reduce oxidative stress and improve visual outcomes. Public health measures, including safe drinking water initiatives and antioxidant supplementation, are essential in fluoride-endemic regions.

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