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Original Article

Effects of Chemotherapy and Radiation Therapy on Visual Acuity and Color Vision in Cancer Patients

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ABSTRACT

Background: Anticancer therapies may be accompanied by ocular complications that can affect visual function. Objective: To assess visual acuity and color vision among cancer patients receiving chemotherapy, radiation therapy, or combined treatment and to describe visual findings according to treatment type and duration. Methods: This cross-sectional descriptive study included 150 cancer patients attending the Oncology Department of Combined Military Hospital, Rawalpindi, from March to April 2019. Participants were selected through purposive sampling. Visual acuity was assessed monocularly using a Snellen chart, and color vision was evaluated using Ishihara pseudo-isochromatic plates. Descriptive statistics and chi-square tests were used for analysis. Results: Of 150 participants, 92 (61.3%) were male. Chemotherapy alone was received by 82 (54.7%), combined therapy by 48 (32.0%), and radiation therapy alone by 20 (13.3%). Visual acuity below 6/9 increased across longer treatment-duration categories in the right eye from 26.3% at 1–6 months to 66.7% at 3–4 years and in the left eye from 26.3% to 75.0%. Treatment duration was associated with reduced visual acuity in the right ($p=0.001$) and left eyes ($p<0.001$), whereas treatment modality was not significantly associated with reduced acuity. Conclusion: Visual acuity impairment was common among treated cancer patients and was more frequent with longer treatment duration, while no significant difference was demonstrated according to treatment modality. Keywords: Chemotherapy; Radiation therapy; Visual acuity; Color vision; Cancer patients.

INTRODUCTION

Cancer encompasses a heterogeneous group of diseases characterized by abnormal and uncontrolled cellular proliferation, with the potential for local tissue invasion and distant metastasis. Improvements in cancer detection and treatment have increased the number of patients receiving systemic chemotherapy, radiation therapy, or combinations of these modalities. Although these treatments are essential for disease control and survival, their therapeutic effects may be accompanied by adverse effects involving multiple organ systems, including the eye. Antineoplastic agents have been associated with a range of ocular complications involving the ocular surface, lens,

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retina, optic nerve, and visual pathways, with the nature and severity of toxicity varying according to the therapeutic agent, dose, treatment duration, and individual susceptibility (1).

Radiation therapy may also affect ocular structures when the eye, orbit, optic pathways, or adjacent tissues are exposed to ionizing radiation. Radiation-related ocular injury may involve retinal vascular damage and other structural changes that can ultimately compromise visual function. Radiation retinopathy, for example, has been described as a delayed microvascular complication characterized by retinal vascular abnormalities that may lead to progressive visual impairment (2). When chemotherapy and radiation therapy are used together, patients may be exposed to multiple potential mechanisms of ocular injury; however, the extent of visual dysfunction in an individual patient may also be influenced by age, underlying ocular status, systemic disease, cancer characteristics, treatment duration, and the specific therapeutic regimen (3,4).

Visual acuity and color discrimination represent clinically relevant components of visual function that may be affected by retinal, optic nerve, or visual pathway abnormalities. Changes in visual acuity may interfere with activities of daily living, whereas disturbances in color vision may provide an additional indication of altered visual function. In patients undergoing cancer treatment, identifying such abnormalities is clinically important because visual changes may remain unrecognized until they become functionally significant. Assessment of visual acuity and color vision during cancer care may therefore help identify patients who require more detailed ophthalmological evaluation (5).

Despite the recognized potential for ocular toxicity associated with anticancer treatment, characterization of visual function among patients receiving chemotherapy, radiation therapy, or their combination remains important in routine oncology practice. In particular, evaluating visual acuity and color vision according to treatment modality and duration can provide descriptive information about the distribution of visual abnormalities in treated cancer patients and may help identify patterns requiring further investigation. Such assessment is particularly relevant in settings where ophthalmic monitoring is not routinely integrated into oncology follow-up.

Therefore, the present cross-sectional study aimed to assess visual acuity and color vision among cancer patients receiving chemotherapy, radiation therapy, or combined treatment at the Oncology Department of Combined Military Hospital, Rawalpindi, and to describe these visual findings according to treatment type and duration.

MATERIAL AND METHODS

A cross-sectional descriptive study was conducted in the Oncology Department of Combined Military Hospital (CMH), Rawalpindi, Pakistan, from March to April 2019. The study was designed to assess visual acuity and color vision among cancer patients receiving chemotherapy, radiation therapy, or a combination of both treatments and to describe the distribution of visual findings according to treatment modality and duration. The target population comprised patients with a confirmed diagnosis of cancer who were receiving anticancer treatment at the study setting during the data-collection period.

Patients of all ages and both sexes who had a diagnosed malignancy and were receiving chemotherapy, radiation therapy, or combined chemotherapy and radiation therapy were eligible for inclusion. Patients who had cognitive impairment or were unable to understand or cooperate with the visual examination procedures were excluded. Participants were selected using purposive sampling, and a total of 150 eligible cancer patients were included in the study. Relevant demographic and treatment-related information was obtained using a structured data-collection proforma after verballing informed consent had been obtained from each participant.

Visual acuity was assessed separately for each eye using a Snellen visual acuity chart positioned at a testing distance of 6 m. During monocular testing, the non-tested eye was occluded, and visual acuity was recorded according to the smallest line correctly identified by the participant. An occluder, trial frame, and trial box were available as part of the visual assessment procedure. For analysis and presentation, visual acuity was categorized into three Snellen ranges: 6/9–6/6, 6/24–6/12, and 6/60–6/36. Right- and left-eye findings were recorded and analyzed separately.

Color vision was assessed using Ishihara pseudo-isochromatic plates under standardized illumination conditions. Participants were evaluated for their ability to identify the figures or patterns presented on the plates, and color-vision findings were documented on the structured proforma. The principal visual outcomes of the study were

visual acuity and color-vision status. Treatment-related variables included the type of anticancer treatment received, categorized as radiation therapy alone, chemotherapy alone, or combined chemotherapy and radiation therapy, and treatment duration, categorized as 1–6 months, 7–12 months, 1–2 years, and 3–4 years. Demographic variables included age and sex.

Data were entered and analyzed using SPSS version 22. Descriptive statistics were used to summarize demographic characteristics, treatment-related variables, visual acuity, and color-vision findings. Categorical variables were presented as frequencies and percentages. Visual acuity findings were summarized separately for the right and left eyes according to treatment duration and treatment modality. As the reported analysis was descriptive, no inferential statistical tests, adjusted models, or causal estimates were applied.

Ethical approval for the study was obtained from the Research Ethics Committee of the Pakistan Institute of Rehabilitation Sciences (PIRS), ISRA University, Islamabad Campus. Administrative permission to conduct the study and collect data was obtained from Combined Military Hospital, Rawalpindi. Verbal informed consent was obtained from participants before data collection, and examinations were conducted as part of the approved study procedures.

RESULTS

A total of 150 cancer patients were included in the analysis. Of these, 92 (61.3%) were male and 58 (38.7%) were female. Chemotherapy alone was the most frequently reported treatment modality, received by 82 (54.7%) participants, followed by combined chemotherapy and radiation therapy in 48 (32.0%) and radiation therapy alone in 20 (13.3%). Regarding treatment duration, 57 (38.0%) participants had received treatment for 1–6 months, 45 (30.0%) for 7–12 months, 36 (24.0%) for 1–2 years, and 12 (8.0%) for 3–4 years (Table 1).

Table 1. Demographic and treatment characteristics of study participants (n=150)

Characteristic	n (%)
Sex	
Male	92 (61.3)
Female	58 (38.7)
Treatment modality	
Radiation therapy alone	20 (13.3)
Chemotherapy alone	82 (54.7)
Combined therapy	48 (32.0)
Treatment duration	
1–6 months	57 (38.0)
7–12 months	45 (30.0)
1–2 years	36 (24.0)
3–4 years	12 (8.0)

Visual acuity showed a progressive descriptive shift toward reduced acuity across longer treatment-duration categories (Table 2). In the right eye, the proportion with visual acuity of 6/9–6/6 decreased from 73.7% among participants treated for 1–6 months to 33.3% among those treated for 3–4 years. Correspondingly, the combined prevalence of visual acuity below 6/9 increased from 26.3% to 66.7%. A similar pattern was observed in the left eye, where 73.7% of participants in the 1–6-month group had visual acuity of 6/9–6/6 compared with 25.0% in the 3–4-year group; the corresponding proportions with acuity below 6/9 were 26.3% and 75.0%, respectively.

After combining the 6/60–6/36 and 6/24–6/12 categories as visual acuity below 6/9, treatment duration was associated with visual acuity category in both eyes. The association was observed in the right eye (χ^2=15.52, df=3, p=0.001; Cramér's V=0.322) and the left eye (χ^2=16.75, df=3, p<0.001; Cramér's V=0.334).

Table 2. Visual acuity according to treatment duration

Treatment duration	Right eye 6/60–6/36, n (%)	Right eye 6/24–6/12, n (%)	Right eye 6/9–6/6, n (%)	Left eye 6/60–6/36, n (%)	Left eye 6/24–6/12, n (%)	Left eye 6/9–6/6, n (%)
1–6 months (n=57)	3 (5.3)	12 (21.1)	42 (73.7)	4 (7.0)	11 (19.3)	42 (73.7)
7–12 months (n=45)	1 (2.2)	19 (42.2)	25 (55.6)	1 (2.2)	24 (53.3)	20 (44.4)
1–2 years (n=36)	1 (2.8)	22 (61.1)	13 (36.1)	1 (2.8)	20 (55.6)	15 (41.7)
3–4 years (n=12)	0 (0.0)	8 (66.7)	4 (33.3)	0 (0.0)	9 (75.0)	3 (25.0)
Total (n=150)	5 (3.3)	61 (40.7)	84 (56.0)	6 (4.0)	64 (42.7)	80 (53.3)

Chi-square analysis was performed after combining 6/60–6/36 and 6/24–6/12 as visual acuity below 6/9. Right eye: χ^2=15.52, df=3, p=0.001, Cramér's V=0.322. Left eye: χ^2=16.75, df=3, p<0.001, Cramér's V=0.334.

Visual acuity distributions according to treatment modality are presented in Table 3. In the right eye, visual acuity below 6/9 was present in 9 of 20 (45.0%) participants receiving radiation therapy alone, 35 of 82 (42.7%) receiving chemotherapy alone, and 22 of 48 (45.8%) receiving combined therapy. The overall distribution of reduced versus 6/9–6/6 visual acuity did not differ by treatment modality in the right eye (χ^2=0.13, df=2, p=0.936; Cramér's V=0.030).

In the left eye, visual acuity below 6/9 was observed in 8 of 20 (40.0%) participants receiving radiation therapy alone, 34 of 82 (41.5%) receiving chemotherapy alone, and 28 of 48 (58.3%) receiving combined therapy. Although the proportion was descriptively greater in the combined-treatment group, the overall association between treatment modality and reduced versus 6/9–6/6 visual acuity was not statistically significant (χ^2=3.87, df=2, p=0.144; Cramér's V=0.161).

Table 3. Visual acuity according to treatment modality

Treatment modality	Right eye 6/60–6/36, n (%)	Right eye 6/24–6/12, n (%)	Right eye 6/9–6/6, n (%)	Left eye 6/60–6/36, n (%)	Left eye 6/24–6/12, n (%)	Left eye 6/9–6/6, n (%)
Radiation therapy alone (n=20)	0 (0.0)	9 (45.0)	11 (55.0)	0 (0.0)	8 (40.0)	12 (60.0)
Chemotherapy alone (n=82)	4 (4.9)	31 (37.8)	47 (57.3)	6 (7.3)	28 (34.1)	48 (58.5)
Combined therapy (n=48)	1 (2.1)	21 (43.8)	26 (54.2)	0 (0.0)	28 (58.3)	20 (41.7)
Total (n=150)	5 (3.3)	61 (40.7)	84 (56.0)	6 (4.0)	64 (42.7)	80 (53.3)

Chi-square analysis was performed after combining 6/60–6/36 and 6/24–6/12 as visual acuity below 6/9. Right eye: χ^2=0.13, df=2, p=0.936, Cramér's V=0.030. Left eye: χ^2=3.87, df=2, p=0.144, Cramér's V=0.161.

Overall, 84 (56.0%) participants had right-eye visual acuity within the 6/9–6/6 category, while 61 (40.7%) had acuity of 6/24–6/12 and 5 (3.3%) had acuity of 6/60–6/36. For the left eye, the corresponding frequencies were 80 (53.3%), 64 (42.7%), and 6 (4.0%), respectively. The strongest statistical pattern was therefore observed across treatment-duration categories rather than across treatment modalities. Longer treatment duration was associated with a greater proportion of participants having visual acuity below 6/9 in both eyes, whereas treatment modality itself showed no statistically significant association with the dichotomized visual-acuity outcome.

DISCUSSION

The present study found that visual acuity impairment was relatively common among cancer patients receiving chemotherapy, radiation therapy, or combined treatment, and that the proportion of participants with visual acuity below 6/9 increased across longer treatment-duration categories. In contrast, treatment modality itself was not significantly associated with reduced visual acuity in either eye when the available categories were compared statistically. These findings suggest that visual abnormalities may accumulate or become more apparent with increasing duration of anticancer treatment, although the cross-sectional design does not permit determination of whether treatment duration itself caused the observed visual changes (5,6).

Ocular toxicity is a recognized complication of several antineoplastic agents, with potential involvement of the ocular surface, lens, retina, optic nerve, and visual pathways (7). Such effects may manifest as reduced visual acuity, visual-field abnormalities, optic neuropathy, retinal dysfunction, or disturbances in color perception. The relatively high frequency of reduced visual acuity observed in the present study is therefore clinically plausible, particularly among patients with longer exposure to cancer treatment. However, because information on specific chemotherapy agents, cumulative doses, and pretreatment visual status was not available in the reported analysis, the observed relationship cannot be attributed to any particular drug or treatment regimen (8,9).

Radiation-related ocular injury is also biologically plausible when radiosensitive ocular structures or the visual pathways are exposed. Radiation retinopathy has been described as a delayed microvascular complication characterized by endothelial injury, capillary closure, retinal ischemia, hemorrhage, and other vascular abnormalities that may ultimately impair visual function (10,11). The increasing proportion of reduced visual acuity across longer treatment-duration categories in this study may therefore reflect, at least in part, delayed treatment-related ocular effects. Nevertheless, radiation exposure to ocular tissues was not characterized by treatment site, dose, or fractionation, and the present findings should not be interpreted as evidence that radiotherapy directly produced the visual impairment observed (12,13).

The lack of a statistically significant association between treatment modality and reduced visual acuity is also clinically important. Although participants receiving combined therapy showed a higher descriptive proportion of

left-eye visual acuity below 6/9, particularly compared with the radiation-only and chemotherapy-only groups, this difference did not reach statistical significance. This suggests that treatment modality alone may not adequately explain the observed visual abnormalities. Differences in age, cancer type, disease stage, systemic comorbidities, pre-existing ocular conditions, treatment duration, and cumulative exposure may have contributed to the visual-acuity distribution. Because these potential confounding factors were not adjusted for in the available analysis, independent treatment effects cannot be established (14,15).

Color vision was also an intended outcome of the study, and the manuscript indicated that abnormalities were observed among treated patients, particularly in those receiving chemotherapy or combined therapy. This observation is clinically plausible because toxic injury involving the retina or optic nerve may alter color discrimination in addition to reducing central visual acuity (1). However, because detailed numerical Ishihara results were not available for quantitative analysis, the color-vision findings cannot be compared reliably across treatment groups or durations. They should therefore be interpreted as descriptive observations rather than evidence of a treatment-specific effect (16,17).

The findings have practical implications for the visual assessment of patients undergoing cancer therapy. Routine clinical attention to visual symptoms may be useful, particularly among patients receiving prolonged treatment, because visual impairment can affect reading, mobility, medication management, occupational functioning, and other activities of daily living. Detection of new or progressive visual abnormalities may justify more detailed ophthalmological evaluation, especially when treatment regimens are known to have potential ocular toxicity. Such monitoring should complement, rather than modify, oncologic management unless clinically indicated after specialist assessment (18,19).

A strength of the study is that visual acuity was assessed separately for each eye using a standardized clinical chart and that treatment duration and treatment modality were both examined in relation to visual status. The internally consistent treatment and visual-acuity counts also permitted additional analysis of associations between treatment duration and reduced visual acuity. Nevertheless, several limitations should be considered. The cross-sectional design precluded assessment of within-patient change from pretreatment visual status and therefore limits causal inference (20-22).Purposive sampling from a single oncology center may also reduce generalizability. In addition, the study did not account for potentially important confounders such as age, refractive error, cataract, glaucoma, diabetic or hypertensive retinal disease, pre-existing optic nerve disorders, or other ocular pathology. Information on chemotherapy regimens, cumulative drug exposure, radiation site and dose, and cancer type was not incorporated into the reported analysis. The relatively small radiation-only and longest-duration subgroups further limit precision. Finally, the absence of detailed numerical color-vision data prevented formal analysis of this outcome. These limitations indicate that the findings should be interpreted as descriptive evidence of visual abnormalities among treated cancer patients rather than proof of treatment-induced visual toxicity (23).

CONCLUSION

Among cancer patients receiving chemotherapy, radiation therapy, or combined treatment, reduced visual acuity was observed in a substantial proportion of participants and was more frequent across longer treatment-duration categories, whereas visual acuity did not differ significantly according to treatment modality. These findings indicate that visual abnormalities are present among patients undergoing anticancer therapy and support the clinical value of monitoring visual function during treatment, while recognizing that the cross-sectional design does not establish a causal relationship between therapy and visual impairment.

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