WORLD JOURNAL OF PHARMACEUTICAL RESEARCH
SJIF Impact Factor 8.084
Volume 10, Issue 13, 448-461. Review Article ISSN 2277– 7105

THE IMPACT OF RADIATION ON THE EYE AND ITS *AYURVEDIC* MANAGEMENT

Dr. Rajendra Kumar Soni*[1], Dr. Ashok Kumar[2] and Prof. Shamsa Fiaz[3]

[1]Assistant Professor, Department of Shalakya Tantra, National Institute of Ayurveda, Deemed University, Jaipur, Rajasthan, India.

[2]Associate Professor, Department of Shalya Tantra, National Institute of Ayurveda, Deemed University, Jaipur, Rajasthan, India.

[3]Professor & H.O.D, Department of Shalakya Tantra, National Institute of Ayurveda, Deemed University, Jaipur, Rajasthan, India.

Article Received on
14 Sept. 2021,

Revised on 04 October 2021,
Accepted on 24 October 2021

DOI: 10.20959/wjpr202113-22024

***Corresponding Author**
Dr. Rajendra Kumar Soni
Assistant Professor, Department of Shalakya Tantra, National Institute of Ayurveda, Deemed University, Jaipur, Rajasthan, India.

ABSTRACT

Rationale- These days, due to ozone layer breakdown and global environmental condition, human exposure to electromagnetic radiation, especially UVR and IR rays are increasing day by day. Ultraviolet rays and infrared rays have large public health complications and because of this U.V. and IR rays- related ocular diseases are to be expected. In Ayurveda Classical text, the loss of vision (*Darshannasha*) due to seeing god, sage, *Gandharva*, very large snakes, and the sun, has also been described by Acharya Sushruta and termed it as '*Animittaja Lingnasha*'. In context to *Nayanabhighata,* Acharya Videha has described *Atapa* (sunlight) and *Surya* as a causative factor in causing ocular injuries and symptoms like redness, burning sensation, pricking type pain, inflammation, suppuration etc. So as per Ayurveda, the impact of radiation especially UV and Infrared rays on the eyes can be a resemblance to these states of Acharya Sushruta & Acharya Videha. In allopathy, there are no treatment options for the prevention and care of this pathology except the use of spectacles, contact lenses, goggles, eye shields, intraocular lenses, and gas permeable hard lenses, helmets consisting of absorptive or reflective filters to manage the unwelcomed radiation. But in Ayurveda there are many procedures like *Parisheka, Nasya, Tarpana, Putapaka,* and *Anjana* etc. which are used for the prevention of this pathology and maintaining the eyes in a healthy state. These procedures restore the normal osmolarity of tears which help in nourishment and rejuvenation

of the ocular surface and make the eyes tolerant of wind and sunlight. **Background-** The course of energy with the speed of light when travels through an empty space or a medium forms a electric and magnetic fields that forms electromagnetic radiation such as radio waves, visible light, and gamma rays. The objects present within the field of vision reflects the light into the eyes. Even though having a broad spectrum, only a small range of light is visible to the human eye. The visible spectrum range extends from 400 - 700 nm. Beyond the long end, there are infrared (heat), radar, and radio waves. Beyond the short end, there are ultraviolet (UV), X-ray, and cosmic waves. **Outcome**- To assess the relationship between radiation and its hazardous effects on various ocular media and explore the contribution of Ayurveda to prevent and minimize the effect of radiation on the eye.

KEYWORDS: Radiation, Ultraviolet light, Infrared, Ocular diseases, *Animittaja Linganasha*, Ayurveda.

INTRODUCTION

Electromagnetic radiation is the flow of energy at the universal speed of light through free space or through a material medium in the form of electric and magnetic fields that make up electromagnetic waves such as radio waves, visible light, and gamma rays. The electromagnetic spectrum is formed by visible light, microwaves, infrared, radio waves, ultra-violet, gamma rays, X - rays. Light is reflected into the eyes by the objects within the field of vision. The spectrum of light is broad but only a small part is visible to the human eye. The visible spectrum range extends from 400-700 nm and infrared, radar, radio waves are located beyond the long end of visible spectrum and ultraviolet, X- ray and cosmic waves are located beyond the short end of visible spectrum.

Ultraviolet rays and infrared rays have large public health complications and because of this U.V. and IR rays- related ocular diseases are to be expected. It has been suggested that long-term exposure to these rays may damage the eyes and manifest many ocular diseases.

The human eye is disclosed every-day to UV radiation. The solar source is the principle source of UVR. A range of ocular sicknesses is supposed to have an interrelation with acute and progressing UVR subjection. These days person's vulnerability to UVR is growing due to the ozone layer break down and change in the climate globally which is influencing the level of surface radiation.[1] The majority of the people experience the heating impact of

infrared from the solar, but, maximum of the time, the temperature furnaces in the glass and steel industries are dangerous for the human eye.

In Ayurveda classical text, the loss of vision (*Darshannasha*) due to seeing god, sage, *Gandharva*, very large snakes and the sun, was also described by Acharya Sushruta and termed it as '*Animittaja Lingnasha*'.[2] And, in context to *Nayanabhighata,* Acharya Videha has described *Atapa* (sunlight) and *Surya* as a causative factor in causing ocular injuries and symptoms like redness, burning sensation, pricking type pain, inflammation, and suppuration etc.[3] So as per Ayurveda, the impact of radiation especially UV and Infrared rays on the eyes can be a resemblance to these states of Acharya Sushruta & Acharya Videha.

In allopathic science, no treatment options for the prevention and care of this condition is available, except the use of spectacles, contact lenses, goggles, eye shields, intraocular lenses, gas permeable hard lenses, helmets consisting of absorptive or reflective filters to manage the unwelcomed radiation. In this condition, Acharya Videha has described the same treatment which Acharya Shusruta has described in the treatment of *Nayanabhighata* like *Nasya, Asyalepa (Mukhalepa), Perishechan, Tarpana* etc.; using the same therapy as in *Raktaja* and *Pittaja Abhishyanda* and doing *Drishti Prasadjanana Karma* with the help of *Snigdha, Hima,* and *Madhura Dravyas.*[4]

ULTRAVIOLET LIGHT AND OCULAR DISEASES

UVR is an electromagnetic radiation that contains wavelength of 100-400 nm. It has more potential to cause damage because it contains more energy than visible or infrared rays. These UV rays range can be sub-divided into three bands: UV-A (ranging from 315-400 nm), UV-B (ranging from 280-315 nm), and UV-C (ranging from 100-280 nm).[5] All UV-C rays and nearly 90% of UV-B rays are absorbed by the ozone, layer, water vapor, oxygen and carbon-dioxide[5] and only 10% of UV-B rays and all of the UV-A rays reaches the earth's surface with a ten-fold concentration.[5] When UV rays reaches the eye, its proportion which are absorbed by different structures of the eye depends on its wavelength.[6] The cornea usually absorbs most of the biologically active shorter wavelengths. The longer wavelength, that is passed by the cornea are absorbed by the lens and retina. Overall, the light lesser than 300 nm is absorbed by the cornea while the light below 400 nm is absorbed by the crystalline lens. Though the absorption properties of the cornea remain unchanged but the lens alters throughout the life. The light between 400 and 1400 nm is absorbed by the uvea and retina.[7]

Effect of Ultraviolet radiation on the Eyelids

In malignant tumors of the eyelid, two most common malignancies, the Basal cell carcinoma (BCC) and Squamous cell carcinoma (SCC) are discovered because of impact of ultraviolet rays. Basal cell carcinoma records approximately 90% of all eyelid malignancies[8] and Squamous cell carcinoma records nearly 9 % of all periocular cutaneous tumors.[8]

There is evidence connecting exposure of UV-B with eyelid malignancies.[9] The evidence, concerning carcinogenic impact of UV-B rays are found stronger for squamous cell carcinoma.[10] It is well established that long term sunlight exposure play vital role in causing the development of SCC. Now it is accepted that the intensity of the UV exposure in young age is more responsible to cause formation of BCC than the cumulative dose for a time.

It is thought that UVR cause cellular harm and changes in immunologic activity and from this pathology it produces destructive effect on the pores and skin. In photo aging of the skin and skin cancer, UVR play an important role by producing DNA damage, immunosuppression, gene mutations, inflammatory response, and oxidative stress.[11] In addition to this pathology, UVR are able to create mutations in the p^{53} tumor suppressor genes which contributes in DNA repair or cell apoptosis having plenty of DNA impairment. Hence, if p^{53} genes gets mutated, DNA repair process will get hindered and as a consequence, there is deregulation of apoptosis, expansion of mutated keratinocytes, and this leads to initiation of skin cancer.[12]

Effects of ultraviolet rays on the Conjunctiva and Cornea

Pterygium and Pinguecula

A pterygium is a degenerative and hyperplastic condition of the conjunctiva, progressively encroaching the cornea. It is believed that, Pterygium occurs as a response to long term effect of environmental factors such as exposure to sunlight (ultraviolet rays), high wind, dry heat and plenty of dust. It is broadly accepted that the formation of pterygium is strongly connected with UVR exposure.[13]

Pinguecula is a fibro-fatty degenerative condition of the bulbar conjunctiva within the palpebral aperture. It has been occurring more common in persons who are exposed to strong sunlight, dirt and wind. There is a belief that formation of the pinguecula is also linked to UVR exposure.[14]

Photokeratitis

A painful superficial punctate keratopathy known as photokeratitis is produced via acute exposure of UV-B and UV-C rays. It develops after 6 hours of exposure and resolves voluntarily within 8-12 hours.[15] The physiological loss of corneal epithelial cells can boost up by UV light using two process, shedding and apoptosis.

'Snow blindness' is a term used for photokeratitis which occurring from naturally UV-B radiation. During mountain climbing, skiing, or swimming or sitting at the beach, the UVR reflectivity of the environment is extraordinary high and those situation propose to be increase snow blindness. In the course arc welding the welder's flash is an artificial source of UVR which can cause photokeratitis by even transient subjection to UV-B and UV-C radiation.[16]

Climatic droplet keratopathy

The spheroidal degeneration of the superficial part of corneal stroma is referred to CDK. It is generally limited to geographical areas such as the arctic and tropical areas which contain exposure of high levels of UV rays.[16] Exposure of chronic UV-A and UV-B radiation is associated with development of CDK.

Ocular surface squamous neoplasia

The precancerous and cancerous epithelial lesions of the conjunctiva and cornea are known as OSSN.[17] In the development of OSSN subjection to UVR coming from sun has been recognized in various research as a primary etiological aspect. Although, human papilloma virus (HPV) and human immunodeficiency virus (HIV) additionally play a position within the development of OSSN.[17]

Effect of ultraviolet radiation on the Lens

The term cataract refers to development of any opacity in the lens or its capsule. Clinically, the term cataract refers to an opacification of sufficient severity to impair the vision (Dorland's Illustrated Medical Dictionary, WB. Saunders, Philadelphia). It has been suggested by modern experimental studies that UV-B rays induces anterior and posterior (later) cortical opacities.[18] After exposure to the UVR, it has been found that the energy-dependent sodium-potassium ATP-se that is responsible for the maintenance of the sodium-potassium balance over lens cell membranes has to become impaired. It has been discovered that low dose exposure of UVR induce changes in lens proteins.[18]

Effects of ultraviolet rays on the retina and choroid

Age-related macular degeneration

In ARMD, the retinal pigment epithelial defect can be caused due to the exposure to higher degree of UVR or sunlight.[19]

Uveal melanoma

Primarily on the basis of findings with cutaneous melanoma, it is accepted that exposure of the UV light cause to undergo malignant transformation of the melanocyte.[20] Thus it is thought that melanocytes present the eye may react likewise to UV light exposure.[21] In children, the the UV light is transmitted through the lens to the posterior uvea, while the adult lens & cornea filter UV-B and most UV-A. So, the carcinogenic impact of UV light might be more critical in children than adults.[21]

INFRARED RADIATION AND OCULAR DISEASES

The wavelength of IR rays ranges from 700-1400nm. Because of increase of solar exposure, working in hot surroundings there are high chances of developing IR induced ocular injuries. Electric radiant heaters, arc lamps, or type of lasers such as carbon dioxide laser or YAG, are used in industrial activities which also emit infrared radiation. Because of the properties of high-level wavelength and a long way away from the visible spectrum IR-C is the most dangerous for the human eye.[22]

The effects of the Infrared rays on ocular structures

Eyelids

Mild redness to severe burns of the eyelids skin is the most usual effect which occurs due to infrared exposure and in severe cases damage and detach of the skin can occur due to exposure of very high intensity of infrared for a very short time or to low intensity of infrared over a long time.[22]

Cornea

The level of harm which occur because of infrared rays is quite high because the cornea transfer 96% of the falling infrared in the range 700-1400 nm, especially in the range of 750-990 nm. This type of radiation involves the damaging effects through the protein coagulation of the cornea's anterior and middle layers (the epithelium and stroma).[22] Corneal damage due to higher dose of IR produces sudden pain and vascularization. In due course, the burn

can be reason of ulcer formation, which results in corneal transparency loss and develops opacification.[22]

Iris

53-98% of incident infrared rays (750-990 nm) are absorbed by the iris, depending on the level of pigmentation of the iris. The most common medical conditions which are develop due to longtime exposure of IR includes swelling, cell death, hyperemia, and pupillary miosis.[22] Inflammations and burns can be develop because of the higher wavelengths.[22]

Lens

The lens transfers light of higher wavelength i.e., >1400 nm that are selected the cornea and aqueous humor. In some specific occupations which involve long term contact with IR, the most common affection is cataract.[22]

Retina

The Pigment epithelium of the retina absorbs the energy radiation that is reaching the retina.[22] A upward push within the temperature and some sort of damage due to IR energy depends on the factors like the optical quality of the retinal image, pupil size, duration of exposure, health of the retina, retinal image size, etc.[22] Burns and de-pigmentations are the most common damage.

MANAGEMENT THROUGH *AYURVEDIC* SCIENCE

- In modern, No treatment options are available for the prevention and care of this pathology except the use of spectacles, contact lenses, gas permeable hard lenses, intraocular lenses, goggles, shields, or helmets that use absorptive or reflective filters to control the undesirable radiation.
- This limitation in allopathy, opens the opportunity for other medicinal systems to contribute, propose, and conduct research to alleviate or to check the deterioration.
- This challenge of the time was accepted by the *Ayurvedic* scholars, as they believed that nature provides both diseases and drugs together. Eyes were greatly valued by ancient Indians and much importance has been accorded to their perception.
- In this condition, Acharya Videha has described the same treatment which Acharya Sushruta has described in the treatment of *Nayanabhighata* like *Nasya, Asyalepa (Mukhalepa), Perishechana, Tarpana* etc., using the same therapy as in *Raktaja* and

Pittaja Abhishyanda and doing *Drishti Prasadjanana Karma* with the help of *Snigdha, Hima,* and *Madhura Dravyas.*[4]

- *Chakshushya,* the term indicating regeneration of the eyesight was in practice in India for centuries. The classics of ancient Indian wisdom have invented and practiced many drugs like *Triphala, Saptamrita lauha* etc., diets, procedures (i.e. *Tarpana, Nasya, Putapaka, Parisheka* etc.), and regimen for the benefit of the weak eyes.

***Parisheka*- Irrigation of the eyeball**

Acharya Sushruta has described the *Parisheka* procedure in *Kriyakalpa* Chapter and told that if it is used accordingly to various *Doshas,* it has capacity to destroy strong and progressive diseases.[23] *Parisheka* means instillation of medicated solution into the partially opened eye, continuously for a stipulated time period.[24] Various types of *Parisheka Yogas* are mentioned in *Samhitas* for treatment of Dry eye like *Saindhava* mixed with milk restores normal osmolarity of tears which help in nourishment and rejuvenation of ocular surface.[25] In case of loss of vision by looking at solar eclipse, bright fire, thunder-bold etc; Acharya Chakrapani has described the use of *Triphala (Parisheka)* in the evening.[26]

Nasya

Administration of the medicine through the nasal route is known as *Nasya.*[27] Good numbers of *Nasya Yogas* are also described for the treatment of eye diseases because the nose is a gateway of drug administration in the case of *Urdhwajatrugata Rogas*[28] & *Nasya* is the only procedure that directly influences to all the *Indriyas.*[29] Acharya Sushruta has described *Snehana Nasya* for *Drishtiprasadjannartha* (increases the eyesight).[30] As the word *Sneha* suggests, *Snehana Nasya* gives strength to all *Dhatus* and is used as *Dhatuposhaka.*

Anjana- Application of Collyrium

Acharya Sushruta has described *Anjana* in detail in *kriyakalpa Adhyaya.*[31] A wide number of *Anjana Yogas* are mentioned specifically for the treatment of *Timira* in *Samhitas*. Acharya Sushruta has described *Prasadana Anjana* for the purification of vision defect.[32] Acharya Sushrutra has also described its benefit in *Chikitsa Sthana* that it makes the eyes tolerant to wind and sunlight.[33]

Probably, *Anjana Karma* acts as a subconjunctival injection, permeability is also possible through the sclera and enters into the systemic circulation and may act on posterior segmental

disorders of the eye. Disposal of the drug is very minimal so the tissue contact time is more; absorption is maximum thus bio-availability is naturally more.[24]

Tarpana

Acharya Sushruta has described the *Tarpana* procedure in detail in *Kriyakalpa Adhyaya*.[34] *Tarpana* means anything which satisfies or regenerates or rejuvenates.[35] In *Ashtang Hridaya,* Acharya Vagbhatta has described that if *Tarpana* procedure is done well then it gives the ability to tolerate the light in the eyes.[36] Keeping or retaining medicated *Ghee* or oil over the eye for a stipulated period. The absorption of the drug in the *Tarpana* procedure is more because the drugs used are lipid suspension. Penetration is high irrespective of molecular size. The tissue contact time of the drug is also more so the bio-availability and therapeutic concentration can be achieved.[24]

Putapaka

Acharya Sushruta has described the *Putapaka* procedure in detail in *Kriyakalpa Adhyaya*.[37] Acharya Sushruta has described that if the *Putapaka* procedure is done well then it gives the ability to bear the wind and heat in the eyes.[38] Topical application of extracts prepared out of the plant, animal flesh, and mineral by heating their mixture (paste) in a closed chamber. This extract is retained over the eyes as in *Tarpana*. Compliance, disposal, and tissue contact time are also same as in *Tarpana*. As far as the absorption is concerned; the drug being a suspension of fat and water-soluble contents; should have more absorption than *Tarpana*.[24]

Numerous *Yogas* of *Putapaka* are mentioned in the severe xerotic condition of the eye. By application of *Putapaka* as *Tarpana* procedure enhances more effects in terms of epithelial-trophic growth of ocular surface and nourishment of choroid and retina employing concentric properties of medication used in *Putapaka.*

DISCUSSION

It's quite clear that electromagnetic radiation, especially U.V rays and infrared rays has broad public health complications. Today, due to increased ozone depletion and global climate changes, human exposure to UVR and IR rays are increasing day by day. Normally these rays are absorbed according to their wavelength by different ocular structures but long time exposure to these rays may damage ocular tissue & surface and manifest many ocular disorders like tumors of eyelids, pterygium, pinguecula, photokeratitis, cataract etc.

In Ayurveda, the concept of light energy can be described in the term of radiation. *Prakash* is a Sanskrit term which indicates the light.[39] It is the function of *Agni Mahabhoota*.[40] Therefore, the light can be explained on the basis of *Gunas* (properties) of *Agni Mahabhoota.* It is *Teekshna* (penetrating), *Sookshma* (minute), & *Ushna* (hot)).[41] Due to having *Sookshma Guna* it can easily pass through different structures in the eyes and reaching the retina and having *Ushna* and *Teekshna Gunas* it can damage the ocular tissue in long time exposure and causing many ocular diseases.

In modern, there are no treatment options for the care and prevention of this pathology except the use of spectacles, contact lenses, goggles, eye shields, intraocular lenses, and gas-permeable hard lenses, helmets consisting of absorptive or reflective filters to manage the unwelcomed radiation. But in Ayurveda, there are many procedures like *Parisheka*, *Nasya*, *Tarpana*, *Putapaka*, and *Anjana* etc. which are used for the prevention of this pathology and maintaining the eyes in a healthy state. These procedures restore the normal osmolarity of tears which help in nourishment and rejuvenation of the ocular surface and make the eyes tolerant of wind and sunlight.

CONCLUSION

There are many ocular disorders that are associated with exposure to radiation especially UVR and IR. Malignancies of the eyelids considering BCC and SCC are greatly related with UVR exposure and mild reddening to third-degree burns of eyelid tissue are strongly associated with IR exposure. Exposure of acute UVR is caused to develop photokeratitis, while exposure of chronic UVR is caused to develop CDK. It is suggesting that the exposure of UVR are strongly connected in the development of pterygium and cortical cataract while their (UVR) role remain limited in the development of nuclear cataract, posterior subcapsular cataract, pinguecula, ocular melanoma & OSSN. Because of insufficient evidence it is difficult to determine whether AMD is associated or not with UVR exposure. Now it is suggested that visible radiation especially blue light is probably related with development of AMD rather than UV exposure.

No remedial actions for the prevention of this pathology except the use of spectacles, contact lenses, gas permeable hard lenses, intraocular lenses, goggles, shields, or helmets that use absorptive or reflective filters to control the undesirable radiation.

Although Ayurveda is the holistic science takes care of human being with help of nature. Medicaments and procedure of application described compensating the vitiated *Doshas* and *Dhatus*. So, it is irrelevant to exactly explain the pharmacology of *Ayurvedic* medicines based on Modern science. But for the globalization of Ayurveda and the increasing numbers of lifestyle disorders in the world population, it is mandatory to find a better solution for the prevention and management of diseases occurring due to the impact of radiation on the eye. Management mentioned by the author is adaptive to restore normalcy and strengths of ocular structure.

REFERENCES

1. McKenzie RL, Bjorn LO, Bais A, Ilyasad M (2003) Changes in biologically active ultraviolet radiation reaching the Earth's surface. Photochem Photobiol Sci., 2(1): 5–15.
2. Sushruta. Sushruta Samhita. Reprint Edition. Ambika Dutta Shastri, Commentator. Varanasi: Chaukhambha Sanskrit Sansthan; 2016. Uttara Tantra, Adhyaya 7, Verse 43-44. pg. 47.
3. Sushruta. Sushruta Samhita. Reprint Edition. Dr Keval Krishna Thakral, Hindi Commentator. Varanasi: Chaukhambha Orientalia; 2017. Uttara Tantra, Adhyaya 19, Verse 3. pg. 132-133.
4. Sushruta. Sushruta Samhita. Reprint Edition. Dr Keval Krishna Thakral, Hindi Commentator. Varanasi: Chaukhambha Orientalia; 2017. Uttara Tantra, Adhyaya 19, Verse 3-4. pg. 132-133.
5. World Health Organization (2002) Global solar UV index: a practical guide. World Health Organization, Geneva.
6. McCarty CA, Taylor HR (2002) A review of the epidemiologic evidence linking ultraviolet radiation and cataracts. Dev Ophthalmol, 35: 21–31.
7. Young S, Sands J (1998) Sun and the eye: prevention and detection of light-induced disease. Clin Dermatol, 16(4): 477–485.
8. Tse TG, Gilberg SM (1997) malignant eyelid tumours. In: Krachmer JH, Mannis MJ, Holland EJ (eds) Cornea, vol II. Mosby, St. Louis, 601–605.
9. Rigel DS (2008) cutaneous ultraviolet exposure and its relationship to the development of skin cancer. J Am Acad Dermatol, 58(5 Suppl 2): S129–S132.
10. Gallagher RP, Hill GB, Bajdik CD, Coldman AJ, Fincham S, McLean DI et al (1995) Sunlight exposure, pigmentation factors, and risk of nonmelanocytic skin cancer. II. Squamous cell carcinoma. Arch Dermatol, 131(2): 164–169.

11. Meeran SM, Punathil T, Katiyar SK (2008) IL-12 deficiency exacerbates inflflammatory responses in UV-irradiated skin and skin tumors. J Invest Dermatol, 128(11): 2716–2727.
12. Benjamin CL, Ananthaswamy HN (2007) p53 and the pathogenesis of skin cancer. Toxicol Appl Pharmacol, 224(3): 241–248.
13. Cameron M (1965) Pterygium throughout the world. Charles C. Thomas, Springfifield
14. Norn MS (1982) Spheroid degeneration, pinguecula, and pterygium among Arabs in the Red Sea territory, Jordan. Acta Ophthalmol (Copenh), 60(6): 949–954.
15. Cullen AP (2002) Photokeratitis and other phototoxic effects on the cornea and conjunctiva. Int J Toxicol, 21(6): 455–464.
16. Oliva MS, Taylor H (2005) Ultraviolet radiation and the eye. Int Ophthalmol Clin, 45(1): 1–17.
17. Pe'er J (2005) Ocular surface squamous neoplasia. Ophthalmol Clin North Am, 18(1): 1–13, vii.
18. Bergmanson JP, Soderberg PG (1995) the significance of ultraviolet radiation for eye diseases. A review with comments on the efficacy of UV-blocking contact lenses. Ophthalmic Physiol Opt., 15(2): 83–91.
19. Cruickshanks KJ, Klein R, Klein BE (1993) Sunlight and age-related macular degeneration. The Beaver Dam Eye Study. Arch Ophthalmol, 111(4): 514–518.
20. Jhappan C, Noonan FP, Merlino G (2003) Ultraviolet radiation and cutaneous malignant melanoma. Oncogene, 22(20): 3099–3112.
21. Shah CP, Weis E, Lajous M, Shields JA, Shields CL (2005) Intermittent and chronic ultraviolet light exposure and uveal melanoma: a meta-analysis. Ophthalmology, 112(9): 1599–1607.
22. Dr Janet Voke. Radiation effects on the eye. Part 1- Infrared radiation effects on ocular tissue. The College of Optometrists. May 21. 1999.
23. Sushruta. Sushruta Samhita. Reprint Edition. Ambika Dutta Shastri, Commentator. Varanasi: Chaukhambha Sanskrit Sansthan; 2016. Uttara Tantra, Adhyaya 18, Verse 44. pg.97.
24. Prof. K.S. Dhiman. Shalakya Tantra- Kriyakalp Vijnana (Ophthalmic, ENT & Oro-dental Therapeutics in Ayurveda). First Edition. Varanasi: Chaukhambha Vishwa Bharti; 2013. pg. 142.
25. Sushruta. Sushruta Samhita. Reprint Edition. Ambika Dutta Shastri, Commentator. Varanasi: Chaukhambha Sanskrit Sansthan; 2016. Uttara Tantra, Adhyaya 9, Verse 22. pg.53.

26. Chakrapani. Chakradatta. Reprint Edition. Acharya Priya Vrat Sharma, Editor. Varanasi: Chaukhambha Publishers; 2007. Netra- Roga, Adhyaya 59, Verse 56. pg. 490.
27. Vagbhata. Ashtanga Samgraha. Reprint Edition. Kaviraj Atrideva Gupta, Hindi Commentator. Varanasi: Chowkhamba Krishnadas Academy; 2019 (vol.1). Sutra Sthana, Adhyaya 29, Verse 3.pg. 216.
28. Vagbhata. Ashtanga Hrdayam. Reprint Edition. Dr Brahmanand Tripathi, Hindi Commentator. Varanasi: Chaukhamba Sanskrita Pratishthan; 2019. Sutra Sthana, Adhyaya 20, Verse 1. pg. 244.
29. Sushruta. Sushruta Samhita. Reprint Edition. Ambika Dutta Shastri, Commentator. Varanasi: Chaukhambha Sanskrit Sansthan; 2016. Chikitsa Sthana, Adhyaya 40, Verse 33. pg.226.
30. Sushruta. Sushruta Samhita. Reprint Edition. Ambika Dutta Shastri, Commentator. Varanasi: Chaukhambha Sanskrit Sansthan; 2016. Chikitsa Sthana, Adhyaya 40, Verse 22. pg.225.
31. Sushruta. Sushruta Samhita. Reprint Edition. Ambika Dutta Shastri, Commentator. Varanasi: Chaukhambha Sanskrit Sansthan; 2016. Uttara Tantra,Adhyaya 18, Verse 52. pg.98.
32. Sushruta. Sushruta Samhita. Reprint Edition. Ambika Dutta Shastri, Commentator. Varanasi: Chaukhambha Sanskrit Sansthan; 2016. Uttara Tantra, Adhyaya 18, Verse 56. pg.99.
33. Sushruta. Sushruta Samhita. Reprint Edition. Ambika Dutta Shastri, Commentator. Varanasi: Chaukhambha Sanskrit Sansthan; 2016. Chikitsa Sthana, Adhyaya 24, Verse 19. pg.132.
34. Sushruta. Sushruta Samhita. Reprint Edition. Ambika Dutta Shastri, Commentator. Varanasi: Chaukhambha Sanskrit Sansthan; 2016. Uttara Tantra, Adhyaya 18, Verse 5. pg.93.
35. Sharangadhara. Sharangadhara- Samhita. Edition. Dr Brahmanand Tripathi, Hindi Commentator. Varanasi: Chaukhamba Surbharti Prakashan; 2016. Uttara Khanda, Adhyaya 13, Verse 38.pg. 281.
36. Vagbhata. Ashtanga Hrdayam. Reprint Edition. Dr Brahmanand Tripathi, Hindi Commentator. Varanasi: Chaukhamba Sanskrita Pratishthan; 2019. Sutra Sthana, Adhyaya 24, Verse 11. pg. 270.

37. Sushruta. Sushruta Samhita. Reprint Edition. Ambika Dutta Shastri, Commentator. Varanasi: Chaukhambha Sanskrit Sansthan; 2016. Uttara Tantra, Adhyaya 18, Verse 19-20. pg.95.
38. Sushruta. Sushruta Samhita. Reprint Edition. Ambika Dutta Shastri, Commentator. Varanasi: Chaukhambha Sanskrit Sansthan; 2016. Uttara Tantra, Adhyaya 18, Verse 31. pg.96.
39. Monier Williams M. a Sanskrit English Dictionary. Prakasha. 1st ed. Reprint. New Delhi: Motilal Banarasidass Publishers; 2007. p. 653.
40. Trikamji J, Ram N, editors. Sushruta Samhita of Sushruta, Sutra Sthana; Dravya Vishesha Vijnaaneeyam. 1st ed; Ch. 41. Verse 3. Varanasi: Chaukhambha Sanskrit Sansthan; 2010. p. 181.
41. Sadashiva HS, editor. Astanga Hrudaya of Vagbhata, Sutra Sthana; Dravya Vishesha Vijnaaneeyam. 1st ed., Ch. 9. Verse 7. Varanasi: Chaukhambha Sanskrit Sansthan; 2011. p. 166.