



Understanding Hair Loss due to Air Pollution and the Approach to Management

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Abstract

Young patients recently shifted to metro cities are presenting with prickling in the scalp, itching, dandruff, oily scalp and pain in the hair roots. Various studies have identified this as 'Sensitive Scalp Syndrome' resulting from exposure to increasing levels of air pollution including particulate matter, dust, smoke, nickel, lead and arsenic, sulfur dioxide nitrogen dioxide, ammonia and polycyclic aromatic hydrocarbons (PAH) which settle on the scalp and hair. Indoor air conditioned environments because volatile organic compounds (VOC) released from various sources to settle on the scalp. The pollutants migrate into the dermis, transepidermally and through the hair follicle conduit, leading to oxidative stress and hair loss. We have used antioxidants, regular hair wash, Ethylene di-amine tetra acetic acid (EDTA) shampoo, and application of coconut oil to provide protection the hair and counter the effects of pollution. In this review, we have evaluated the causes, clinical presentation, mechanism of hair loss due to pollution and discussed the management of hair loss due to air pollution (HDP). Hair loss due to pollution can coexist with or mimic androgenic alopecia. It requires careful history and trichoscopic evaluation to identify and advice a planned hair care program. Patients uniformly show an encouraging response within 6-8 weeks of following the hair care regimen.

Keywords: Hair loss; Pollution; Polycyclic aromatic hydrocarbons; Volatile organic compounds; Ethylene diamine tetra-acetic acid shampoo; Cell phone radiation; Coconut oil

Introduction

There is worldwide awareness on respiratory diseases, sinus problems and allergies caused by air pollution. Now we have evidence that this can also occur in indoor environments [1-3]. The skin and hair form the first barrier exposed to pollution. Large suspended particle, small airborne particles, smoke and gaseous pollution settle on the scalp and hair, causing irritation and damage. The fact was noticed when Industrial Toxicology Research Center, Lucknow, published a study with reference to effects on human hair in 1994 [4]. Hair loss due to pollution (HDP) can coexist or mimic androgenic alopecia just like diffuse un-patterned hair loss, diffuse alopecia areata, early cicatricial alopecia or chronic telogen effluvium can mimic androgenic alopecia. We need to keep an eye for suspicion and correct the damage to deliver a successful clinical outcome.

Aims and Objectives

The aim of this review is to understand the mechanism of hair loss due to pollution, identify the clinical presentation and evaluate effective modes of treatment for preventing hair damage caused by air pollution.

Material and Methods

Patients who presented with un-patterned hair loss and reveal exposure to pollution were evaluated clinically and treated for protection from effects of pollution. All patients had detail recording of history, nature of work and daily commuting conditions. All patients had clinical scalp examination, trichoscopy counts for hair density per square centimeter (Figure 1a and 1b), hair caliber in microns (Figure 2a and 2b) and global photographic records. The evaluation, trichoscopy and photographs were repeated every 2 months to compare the progress. Patient's personal response to improvement of dandruff (Figure 2a), dryness of scalp, redness and itching (Figure 3), burning of the scalp, pain in the hair roots was also recorded every two months. Patients were asked to report hair fall on running fingers in the head, combing, shampooing and hair strands seen on the pillow every morning.

Criteria for hair loss due to pollution based on patient history, clinical scalp evaluation and trichoscopy

We have used clinical criteria from two studies to identify hair loss due to pollution. First study by Misery et al. in 2008 [5-7] which defined the 'Sensitive Scalp Syndrome' caused by the effects of pollution. The second study by Fabio Rinaldi in 2011 [8]. The suggestive history and clinical evaluation criteria from these two studies that describe hair loss due to pollution are summarized below.

Criteria on patient history

History: Acute hair loss after change of residence, moving to another city, change of work place, added traveling distance, exposure to wind, dust, strong sunlight, excess heat or cold, smoke, smog or chemical fumes, construction area, mining areas, oil rigs, petroleum products, petroleum transport, fertilizer and cement factories or sites.

Criteria on clinical examination and trichoscopy

- Diffuse hair loss affecting all over the scalp
- Excessive sweating and sebum secretion
- Severe dandruff, scalp irritation, itching,
- Redness in the scalp, burning, trichodynia,
- Dandruff or scaling along the temporal and parietal rim where sweat is trapped and creates prolonged contact with the irritating agent
- Dry frizzy hair
- Minimal anisotrichosis

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Figure 1a: Trichoscopic hair counts before treatment.



Figure 1b: Trichoscopic hair counts showing 24% improvement after 4 months of care program.

- Few occasional vellous hair in the 1 sq. cm. trichoscopy field
- Areas of excoriation on the scalp due to itching
- Peri follicular swelling
- Sebum around the hair roots
- Dry scales along with dandruff

Method of Treatment

Aim of the treatment plan was offering protection from effects of pollution and promotion of hair growth. Antioxidants were used to neutralize free radicals created from exposure to pollution. EDTA shampoo (less than 2% concentration) was used for chelating and removing the pollution deposits from the hair and scalp [9] twice week (Monday and Friday) and regular non-medicated shampoo twice a week (Wednesday and Sunday). For both the shampoos patients were instructed to wet the hair, massage the shampoo into the hair roots and leave it for 3-5 minutes before washing it off which allows for good cleansing.

Coconut oil was advised to be applied over the shaft of the hair to protect and prevent entry of pollutants into the hair [10-12]. Men used 5-10 drops of the oil applied over the outer surface of the hair, not on the scalp (minoxidil is to be applied on the scalp). Women used 2-3 ml coconut oil depending on length of the hair. Since effects of pollution will slow down the hair growth cycles, we need to stimulate the hair follicles to regrow. Stimulation of hair growth cycles was achieved with the application of low dose 2% Minoxidil 1 ml twice a day. Finasteride was not used in any of these patients. The care program was easily accepted by all patients and showed results within 2-4 months.

Observations and Results

Patients reported reduction in hair fall when running fingers through the hair, combing, shampooing and occasional to no hair strands seen on the pillow, within 6-8 weeks of commencing the care program. They had reduced itching, dandruff, correction of dryness of scalp, burning and pain in the hair roots by the end of 4 months of following the hair care program. Trichoscopy showed 9-12% improvement in density and 5-7% improvement in hair caliber at 2 months which further improved as the hair care continued (Figures 1a, 1b, 2a and 2b). It was noted that all patients showed some degree of improvement and none reported lack of benefit or failure of response to the hair care program. The improvement continued every two months as the hair care continued further.

Result in a patient working on Petroleum transport ship after 4 months of the care program can be seen in Figure 4a and 4b. An architect girl, working in dust and cement for the supervision of building construction sites presented with thinning of hair all over the scalp including temporal areas as seen in Figure 5a. Improvement achieved with 4 months of the hair care program is seen in Figure 5b.

During the study we noted that the clinical presentation of hair loss from chlorinated swimming pool water and benefit from hair care are similar to hair loss due to air pollution. Hair loss from chlorinated water, in a regular swimmer seen in Figure 5a, which improved after 4 months of the care program.

Unusual case of hair loss from effects of electromagnetic radiation from a cell phone:



Figure 2a: Trichoscopic evaluation of dandruff and hair caliber before treatment.

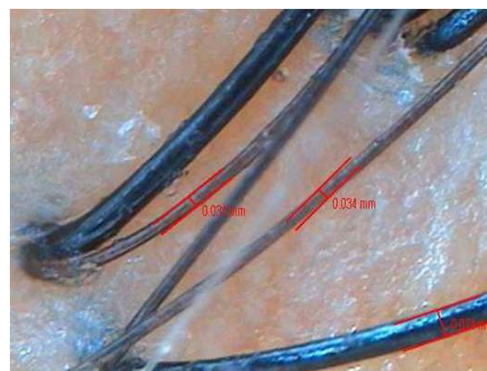


Figure 2b: Trichoscopic improvement in scalp condition and hair caliber after 2 months of hair care program.

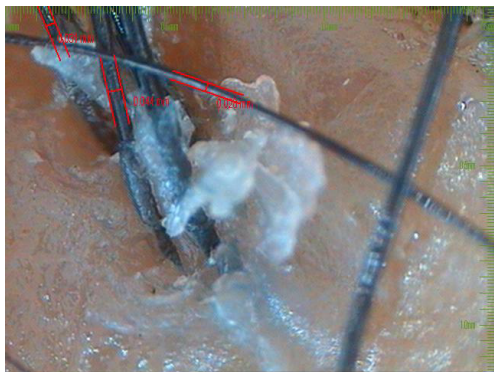


Figure 3: Redness from scalp irritation and itching caused by pollution.

We encountered a patient with unusual hair thinning on the left temporal and parietal area, around the left ear. The patient had developed a hair less patch which did not show exclamation mark hair or signs of alopecia areata on trichoscopy. Patient had history of prolonged cell phone talk with continuous long conversations holding the phone by pressing it between the left shoulder and the ear. Patient could recall at least 18-20 business conversations of more than 20 minutes duration every day for past 9-10 months. This was 6-7 hours of cell phone usage per day. On review of literature we found an interesting study showing single-strand DNA breakage in human hair root cells exposed to mobile phone radiation [13]. According to the study these changes are temporary and normal healthy cells are capable of complete recovery from such effects [13]. The patient was advised to reduce cell phone conversation time, use hands free option instead of holding the phone to the ear and follow the hair care program for protection of hair and stimulation of hair growth. Patient reported good benefit beginning to show improvement within 2 months. The regrowth of hair with improved density and hair caliber can be appreciated. The additional response all over the scalp is due to application of minoxidil all over and generalized benefit of antioxidants on hair roots all over the scalp.

Discussion

Misery [5-7], noted that exposure to pollution causes redness, irritation (Figure 1), faster exfoliation of outer layers of the scalp, exposing sensitive inner layers, causing more sensitivity, leading to further scaling and even psoriasis on prolonged exposure [8]. Patients complain of dandruff (Figure 2a) not responding to standard treatments. Irritation due to pollution which on continued exposure, perpetuates excessive seborrhea and oily scalp (Figure 2a). With continued exposure to pollutants, hair follicles suffer unabated low grade inflammation leading to fibrosis and permanent hair loss. Microscopic changes of signs of inflammation and accumulation of phagocytes are reported to be seen on scalp biopsy from effects of pollution [8].

Fabio Rinaldi, held public campaign in the city of Milan, to study and document the effects of pollution on human hair, entitled 'What your hair breaths' [8]. He conducted a scalp analysis of 300 volunteers from July 2007 to April 2008, to have a yearly average. The concentration and deposition of particulate matter and heavy metals on the hair was one and half times more than levels in the air and deposition on the scalp was double the levels in the air [5]. The pollution in Mumbai, Delhi [14,15] and in most Indian metros is many times higher than the levels in Milan. Traffic pollution has been a known cause for respiratory and skin ailments [16] the same inflammatory process affects hair follicles as well.

WHO criteria for pollution levels

WHO recommended highest PM should be 100 ng/m³. The average particle matter (PM) in Mumbai varies from 238 ng/m³ to 643 ng/m³ [14]. Delhi levels of PM vary 398 ng/m³ to 760 ng/m³, being highest during Diwali fireworks and winter smog [15]. Rising levels of sulfur dioxide (SO₂), nitrogen dioxide (NO₂), ammonia (NH₃) and other gases are between 11-48%, these can adhere to the hair shafts causing damage, the levels can be 3-5 times higher during winter smog and Diwali [14,15].

Mechanism of hair loss caused by pollution

Vierkötter et al. studied the effects of airborne particles on skin aging using a SCINEXA score to catalogue external skin aging [17]. The study describes that the nano-size of suspended air particle matter (PM) itself causes oxidative stress apart from the biological interaction with the cells. It has been postulated that these particles can serve as carriers for organic chemicals and metals capable of localizing in the mitochondria and generating reactive oxygen species. The highest concern is polycyclic aromatic hydrocarbons (PAHs). The PAHs are released from vehicle exhaust, asphalt roads, burning wood, industrial smoke and industrial waste. PAHs can remain active in air, soil and ground water. PAHs get adsorbed on the surface of suspended PM in the air of urban areas. PAHs can activate xenobiotic metabolism, which converts PAHs to quinones. Quinones are redox-cycling chemicals, which produce reactive oxygen species, acting as the key compounds in PM toxicity [17]. Repeated exposure to increased levels of PM itself can lead to skin penetration, transepidermally or through the hair follicles [17].

Philpott demonstrated in his experiments that pollution levels increase oxidative stress on the hair follicle cells, leading to increased hair shedding, similar to the mechanism seen in persons suffering from androgenic alopecia (AA) [18]. Which implies that pollution induced



Figure 4a: Hair loss in a person working on Petroleum transport ship.



Figure 4b: Improved hair growth in 4 months with antioxidant therapy and hair care program.



Figure 5a: Hair loss in a female architect working in dust and cement.



Figure 5b: Improved hair growth in 4 months with antioxidant therapy and hair care program.

hair loss mimics AA and may be difficult to distinguish clinically unless suspected and confirmed by the treating doctor.

Hair as a marker of pollution

Human hair has long been used as a biological marker for assessment of environmental pollutants, toxins, drug abuse and exposure to pesticides in farmers [19-21]. Renewed interest in the common man was triggered from an article by Jasper Coppings in the *Telegraph* [22]. Areas of mining and construction activity show higher concentration of PM. Concentration of mercury, zinc, lead, heavy metals can be determined from the air, dust and hair of the residents living around mining areas, indicating these as a cause of hair damage [23,24].

Hair loss from Indoor pollution in closed building environments

You need not be exposed to open air pollution to get scalp irritation and hair loss. Several household goods we use release Volatile Organic Compounds (VOCs) into the air. Today we spend 90% of our time in closed buildings with artificially controlled air environments. Cooling & Heating systems also release VOCs [1,2]. The compounds are carried and recirculated in closed environments finally getting deposited over the scalp and hair causing irritation and hair loss [3]. Continued exposure to VOCs can cause skin inflammation [25].

Benefit from antioxidants

Since formation of reactive oxygen species is one of the main mechanisms of hair damage due to pollutants, use of oral vitamins,

mineral and antioxidants provides good relief and results in hair regrowth. The author has earlier reported better hair growth with combined use of antioxidants, vitamins and minerals along with the use of minoxidil and finasteride for the treatment of hair loss [26,27].

Role of coconut oil

Use of coconut oil can protect the hair from damage [10-12]. Coconut oil is a triglyceride of lauric acid which has high affinity for keratin protein in the hair. Coconut oil can help in repair of hair shaft lipids and also, act as mechanical barrier over the hair. Due to linear polymer chain structure and low molecular weight, the coconut oil can penetrate inside the hair shaft. The oil soaks into the hair. The oil thus occupies the internal spaces in the hair and prevents entry of dust, dirt, pollutants, chemicals, into the hair shaft, thus preventing the hair damage [10-12]. Oiling the hair well is also recommended before the festival of colors, Holi and celebration with fireworks during Dussera and Diwali. The same is true for protection from winter smog. If coconut oil is not available, a good leave on conditioner could help in coating the hair shaft and preventing damage.

Conclusion

Pollution is on the rise all over the world and more so in Indian metros. Air pollution can contribute to scalp irritation, redness, itching, excessive sebum secretion, dandruff, pain in the hair roots and hair loss. The combination is defined as sensitive scalp syndrome. The condition can mimic or overlap androgenic alopecia. The possibility should be suspected to be discovered. Use of antioxidants, frequent scalp wash with mild shampoos, use of special EDTA shampoos and use of coconut oil or hair serum, are the remedies that can protect the hair from environmental damage.

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