Three Cases of Radiation-induced Temporary Alopecia with Hair Microscopic Examination: “Coudability Hair” Might Not be Specific for Alopecia Areata

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ABSTRACT
Endovascular interventional procedures are widely used for the treatment of intracranial vascular lesions. However, they sometimes produce reversible alopecia, known as radiation-induced temporary alopecia, depending on the radiation dose. Radiation-induced temporary alopecia manifested as rectangular alopecic patches without signs of inflammation, reflects damage to the keratinocytes in the hair matrix of anagen hair follicles, due to the sensitivity of these cells to radiation. The characteristics of radiation-induced temporary alopecia are similar to those of alopecia areata as follows: (1) clinical findings of well-defined alopecic patches and (2) dermoscopic findings of yellow dots, black dots, and short vellus hairs. The two conditions can be distinguished according to whether there is any history of endovascular interventional procedures, and by the shapes of the lesions and the inflammation status on histopathologic examination. A hair microscopic examination is a useful diagnostic tool in patients with hair loss disease, but the features of radiation-induced temporary alopecia have not been well described. Here, we report three cases of radiation-induced temporary alopecia preceded by endovascular procedures, including stent insertion and coil embolization.

Key words: Alopecia, anagen effluvium, radiation

INTRODUCTION
Endovascular interventional procedures are being used increasingly for the treatment of intracranial vascular lesions. Although hair loss following tumor radiotherapy has been extensively reported in the literature, this is not the case for hair loss after endovascular procedures, referred to as radiation-induced temporary alopecia. In addition, differentiating this condition from alopecia areata (AA) is challenging due to the similar clinical and dermoscopic findings. Here, we report three cases of radiation-induced alopecia, including microscopic examinations of the pulled-out hairs.

CASE REPORTS
Case 1
A 33-year-old male patient presented with asymptomatic rectangular-shaped alopecic patches on the left parietal scalp region of 3-week duration [Figure 1a]. He had undergone fluoroscopic imaging before the embolization of an arteriovenous malformation (AVM) 14 days before the hair loss. The total procedure time was 161 min. On physical examination, the hair-pull test was positive. Dermoscopic examination revealed yellow dots, black dots, and short vellus hairs [Figure 2a]. Microscopic examination of the pulled-out hair on the hair-pull test showed a marked distortion of the proximal hair and the absence of typical telogen hair [Figure 2b].

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temporary alopecia was made based on the clinical findings. The patient was treated with four courses of triamcinolone intralesional injection (TA ILI) and 5% minoxidil solution for 12 weeks. Sixteen weeks after the onset of hair loss, his scalp hair had grown back completely [Figure 1b].

**Case 2**

A 51-year-old female patient presented with asymptomatic alopecic patches on the left parietal and left occipital scalp of 1-week duration [Figure 1c]. She underwent embolization of AVM located on left anterior internal frontal artery using fluoroscopic imaging 17 days before hair loss. The total procedure time was 51 min and her hair-pull test was positive. There was no family history of similar problems. Microscopic examination of the pulled-out hair revealed abrupt narrowing of hair diameter with clubbing [Figure 2c]. On the histopathologic examination, increased numbers of catagen and telogen hairs were seen, but there was no inflammatory cell infiltration around the hair follicles [Figure 3]. Based on the clinical findings, the patient was diagnosed with radiation-induced temporary alopecia. She was treated with a 5% minoxidil solution, and hair regrowth started 5 weeks after the onset of hair loss. Although the patient did not return for further follow-up visits, in a telephone conversation, she reported that her scalp hair had grown back completely within a few weeks.

**Case 3**

A 46-year-old male presented with an asymptomatic, well-defined alopecic patch on the occipital region of the scalp of 3 days duration [Figure 1d]. He underwent embolization of AVM at the basilar tip artery using fluoroscopic imaging 15 days before hair loss. The total procedure time was 250 min. On physical examination, the hair-pull test was positive. The patient had a history of androgenetic alopecia for many years. He had no history of similar problems in the family members. Microscopic examination of the pulled-out hair revealed abrupt narrowing of the diameter of hairs without clubbing [Figure 2d]. Based on the clinical findings, he was diagnosed with radiation-induced temporary alopecia. He was treated with topical corticosteroid for 12 weeks, a 5% minoxidil solution for 12 weeks, and three courses of TA ILI. Twelve weeks after the onset of hair loss, his hair-loss patch was completely filled in.

**DISCUSSION**

Endovascular interventional procedures are increasingly being used for the treatment of AVM and ischemic stroke. Hair loss following radiotherapy of head and neck tumors is a well-known side effect and reported extensively in the literature, but hair loss after endovascular interventional procedures is rarely reported in dermatologic literature. It is called as various terminology, including radiation-induced temporary alopecia, transient rectangular alopecia, and square alopecia. Radiation-induced temporary alopecia might occur in cases of radiation exposure ranging from 3 to 6 Gy, but the risk of permanent alopecia is high if the radiation dose exceeds 7 Gy. According to the International Commission on Radiological Protection, approximately 7% of endovascular interventions reach the threshold for radiation-induced temporary alopecia.

Radiation-induced temporary alopecia starts at 2–5 weeks after the endovascular interventional procedures and presented with a characteristic configuration. The rectangular-shaped alopecic patches with no signs of inflammation located on the occipitoparietal regions of the scalp are common findings. This peculiar configuration is assumed to be the result of three-dimensional radiation exposure and the prolonged fixed position of the patient during the procedure. Mooney et al. concluded that the most common position of the head during coil embolization of an AVM is posteroanterior, which may explain why the most frequent location of radiation-induced temporary alopecia is the occipitoparietal scalp. All three patients in our report had patches of hair loss on the occipitoparietal scalp region.

The development of radiation-induced temporary alopecia has been attributed to the high radiation sensitivity of anagen follicles. The actively dividing matrix cells of the follicles are damaged by the administered radiation, which results in hair loss (a condition called anagen effluvium). Radiation damage occurring in late-anagen subphase hairs induces early entry into the catagen phase and thus a prolonged period of hair shedding.

In the absence of information on a recent endovascular intervention, radiation-induced temporary alopecia is difficult to distinguish from AA because of the similar clinical manifestations. The dermoscopic findings revealed yellow dots, black dots, and short vellus hairs in this study, all of which are a common feature of AA. The histopathologic finding of sparse perifollicular inflammatory infiltrate in a patient with a strongly positive hair-pull test may be helpful in the differential diagnosis as intensive perifollicular infiltration occurs in the acute stage of AA.
reported previously. Among our cases, case 2 and 3 showed similar features (such as tapering of the proximal hair shaft, hair breakage, and hair shaft surface undulation) reported in AA in both previous reports and our unpublished data. The presence of coudability hair—defined as normal-looking hair that initially kinks easily when bent or pushed inward, but later tapers at the proximal but not the distal end (as determined on trichoscopy) is generally considered to be a specific sign for AA. However, the microscopic findings of the affected hair of case 2 were similar to those of plucked coudability hair, as described in a previous report. This may reflect a common pathogenesis, probably related to the decreased dividing activity of the hair matrix in the anagen hair follicle, rather than to specific inflammation in AA. On the other hand, marked and irregular distortion of the proximal hair shaft found in case 1 was different from common features in AA, which indicated that hair shaft examination could be helpful in differentiating AA in some cases. Further study is required for validation.

In summary, the timely diagnosis of radiation-induced temporary alopecia will contribute to an improved prognosis and avoid the intensive treatment often required for AA. In a patient presenting with a localized patch of hair loss, obtaining a thorough history is crucial for a correct diagnosis. Dermatologists and interventionalists should be aware of the specialized characteristics of radiation-induced temporary alopecia.

Declaration of patient consent

The authors certify that they have obtained all appropriate patient consent forms. In the form the patient(s) has/have given his/her/their consent for his/her/their images and other clinical information to be reported in the journal. The patients understand that their names and initials will
not be published and due efforts will be made to conceal their identity, but anonymity cannot be guaranteed.

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Conflicts of interest
There are no conflicts of interest.

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