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REVIEW ARTICLE **OPEN ACCESS**

A Clinical Review of Trichorrhexis Nodosa

Craig G Burkhart[1,2,*]

[1]*Internal Medicine, College of Medicine, University of Toledo, Toledo, United States*
[2]*College of Osteopathic Medicine, Ohio University, United States*

Abstract:
Trichorrhexis nodosa is the most common form of hair breakage with a diagnostic splayed paint brush bristle appearance under light microscopy. It is classified into congenital and four acquired forms. Defects in the hair cuticle and hair keratin have recently been clarified better with more refined instrumentation. The congenital form can be seen in several childhood diseases and syndromes. There are four types of acquired TN that leave hair less protected from environmental irritants. The form with proximal damage in African Americans is by far the most frequent type. Treatment for trichorrhexis nodosa involves avoiding factors that contribute to hair breakage, such as minimizing heat styling and using gentle hair care products. The FDA may initiate sanctions on the use of formaldehyde and related chemicals presently used in hair straightening and keratin hair treatments. This would markedly alter the status quo in treatment for this condition.

Keywords: Trichorrhexis nodosa, Hair breakage, Formaldehyde, Hair straightening, Keratin hair treatments, Oil hair treatments.

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*Address correspondence to this author at the Internal Medicine, College of Medicine, University of Toledo, Toledo, United States and College of Osteopathic Medicine, Ohio University, United States; E-mail: cgbakb@aol.com

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1. INTRODUCTION

Trichorrhexis nodosa (TN) is a hair shaft disorder characterized by the presence of nodular swellings along the hair shaft [1, 2]. These nodules represent weak points in the hair fiber that are prone to breakage. It is the most common structural hair abnormality. The breakage is caused by trauma to the hair and is often a result of hair styling, excessive brushing or combing, heat, chemical treatments, or overuse of hair products [1-4]. Patients may also complain of an inability for hair to grow over a certain length, split ends, or friable hair. These nodular swellings are filled with air and lead to easy breakage of the hair. Microscopic examination of broken hair reveals that these nodes have a splayed paint brush bristle appearance as if two brooms were thrust into each other. It can be diagnosed by examining hairs under a light microscope or with a dermatoscope with non-polarized light [5]. More expensive diagnostic tools include trichoscopy, optical microscopy, and scanning electron microscopy [4-6].

Hair is filamentous, consisting mostly of keratin, which is mainly proteinaceous. The medulla of the hair is surrounded by the cortex, which, in turn, is encased by the cuticle. These layers are bound together by a cell membrane complex. The outer layer of the cuticle, referred to as the epicuticle, is a lipoproteinaceous membrane. The cuticle consists mostly of keratin with layers of dead, overlapping cells in a scale-like fashion. This keratin is a structural and protective protein. It acts as a shield against humidity, sun exposure, environmental stresses, styling, and chemical treatments. When it is altered, the damage causes exposure of underlying hair fibers to environmental irritants, initiating hair fracture. Such porous spots in the cuticle are similar to potholes in a road.

Traditionally, it has been stated that the intercellular cement substance binding cells together is damaged causing the distortion of the protective cuticular cells [7]. Using more refined instruments, there is clarification on specific types of alterations in the anatomical structure. One defect in the hair cuticle is referred to as type L, in which the cell membrane complex is split and the cuticle lifts up [8]. Another form, denoted as type E, occurs when the endocuticle (the fragile substructure of the cuticle cell) is broken. Type E damage is more common as one age after years of daily grooming stresses. In this alteration, X-ray microdiffraction has revealed a rod-matrix structure with α-helices oriented almost perpendicular to the growth axis, adding to the protective layer of the fiber [9]. A protein in the endocuticle, namely S100A3, increases with age, becomes citrullinated, and adds to the rigidity of the endocuticle with time [8]. Other structures have also been identified recently as part of the interface between the cuticle and cortex of hair. For example, there is a cuticle structure named CARB, which is composed of high levels of glycolipid and cystine. It is normally a highly resistant structure, but with alteration, its barrier function is impaired [10].

It is worth noting that the presence of nodular swellings in hair is not rare when examining hair for any reason. It is seen with age, split ends, and any other activity that causes hair friction. With any mechanical, chemical, and or thermal injury to hair, one is likely to find some nodules on hair shafts. Genetics, systemic diseases, and certain drugs may also affect cuticle function. Examining hair from patients with split ends has revealed a reduction in cystine amino acid in the more distal portions of the hair [11]. The authors suggested that this 'weathering' structural defect, along with a reduction in the cuticle cell coverage, was responsible for the selective location of nodule formation [11].

Trichorrhexis nodosa is classified into (1) congenital (tendency present at birth) and (2) acquired forms.

1.1. Congenital Trichorrhexis Nodosa

Congenital trichorrhexis nodosa is rare and is usually associated with certain genetic disorders. These diseases make the hair shaft susceptible to hair breakage with the splayed paint brush bristle appearance. These congenital forms are seen with argininosuccinic aciduria, citrullinemia, and several syndromes, including tricho-hepato-enteric, multiple carboxylase deficiency, Menkes syndrome, Goltz, Netherton, Noonan's, wooly hair, and trichothiodystrophy [12-14]. Different anatomical abnor-malities are surfacing, explaining the friability of hair with these various entities. For example, in trichothiodystrophy using transmission electron microscopy, aberrant marginal bands and exocuticle layers with shortened keratin microfibrils were found, suggesting a paucity of high sulfur components and an imbalance in protein content and organization in the hair unit [14].

1.2. Acquired Trichorrhexis Nodosa

Acquired trichorrhexis nodosa is presently divided into four basic categories: proximal, distal, localized, and defects in keratin formation.

Proximal trichorrhexis nodosa is the most commonly discussed form of TN, given the noticeable reduction in hair length and the extent of hair loss in such patients. It is common in African Americans who use caustic chemicals (relaxers) and/or heat straightening techniques [1, 2]. The typical nodes in the hair occur a few centimeters from the scalp surface. Friction from combing and head movement while sleeping accentuates the problem. The breakage causes discernible patches of hair loss. There are individual differences in the susceptibility of different individuals to this phenomenon.

Returning to the hair straightening market, it is estimated that nearly $800 million worth of products will be sold by 2028 [15, 16]. The methods of hair straightening include physical or thermal straightening agents (hot comb, hair dryer, and flat iron), alkaline straighteners (hydroxides, thiols), and acid straighteners (formaldehyde, glyoxylic acid, and its variants) [17]. In terms of formaldehyde-containing or releasing products (*e.g.*, formaldehyde, formalin, methylene glycol), the FDA is contemplating restricting them, given concerns about their long-term safety profile with reports of carcinogenic, pulmonary, endocrine, and renal complications [17-23]. Glyoxylic acid-containing products may also be affected by an FDA ban.

Distal trichorrhexis nodosa is often referred to as split ends which appear as the end of unraveled rope due to excessive hair grooming. Exposure to extreme weather conditions and hair care techniques, such as blow drying, cumulative brushing, bleaching, straightening, chemicals, and curling, may cause longitudinal splitting (trichoptilosis). In other cases, nodular swellings are observed. Nodes and breakage do not occur near the scalp but are several inches down the hair shaft, producing hair that appears dull, dry, brittle, frayed, and uneven.

Localized trichorrhexis nodosa presents as a circumscribed patch of hair loss. Its size is often several centimeters and could affect the scalp, moustache, or beard. Patients affected also often have a pruritic dermatosis in the impacted area. It is caused by mechanical trauma, such as chronic scratching or rubbing, excessive or repeated trauma, or after minimal trauma if there is an inherent defect in keratin synthesis causing abnormally brittle hair [24-26].

Malnutrition, iron deficiency, hypothyroidism, and certain drugs may increase one's propensity for the acquired forms of TN listed above [27-29].

The fourth type of acquired TN involves defects in keratin formation, thereby affecting hair fragility. The number of such cases will increase as more technological studies are utilized to determine the cause of hair fracturing. An example is the finding of abnormal alpha-keratin chains revealing low cystine levels within the hair cortex associated with multiple vacuoles in the endocuticle [30].

1.3. Treatment of Trichorrhexis Nodosa

Treatment for trichorrhexis nodosa involves avoiding factors that contribute to hair breakage, including physical

and chemical exposures. Patients should be encouraged to utilize wide-toothed combs and eliminate frequent brushing of hair and scratching of the scalp. Heat styling tools and chemical treatments should be reduced to the minimum.

In most cases of TN, topical treatments or supplements may be recommended to improve the strength and condition of the hair. Such products would be the addition of pomades, conditioners, and/or oils to hydrate the hair, and/or keratin treatments to restore this filamentous structure.

In terms of oil treatment, they provide immediate moisture and protection to the hair. Oils utilized in hair products are made from plant-based oils and include avocado, argan, coconut, olive, jojoba, grapeseed, and rosemary. These products strengthen, moisturize, and protect the hair. There are different ways to introduce these external products to the hair and one's specific hair-care routine. Typically, they are applied after washing hair, which allows for better absorption. These treatments are used every other day or once weekly.

Oral minoxidil has been suggested in a case report to help trichorrhexis nodosa by improving both the density and length of hair [31]. More cases will be needed before this becomes an established practice.

Keratin treatments are intended to replenish the hair with a high concentration of keratin. Such treatments smooth and shine the hair and reduce split ends. Such treatments offer smoothing, strengthening, and longer-lasting effects. Of note, most keratin treatments have formaldehyde as one of their constituents, but not all formulations. Thus, if the FDA does act to outlaw formaldehyde in straighteners, it will accordingly eliminate many of the common keratin hair treatments as well.

Besides certain keratin treatments, there are other alternative options to formaldehyde for hair straightening, including glyoxylic acid, which forms imine bonds with hair follicles [32]. Cysteine and carbocysteine treatments both utilize amino acids to alter the disulfide bonds of hair. These non-formaldehyde alternative treatments are generally safer medically, but hair damage can occur with them if not used properly and/or in moderation [33].

Further research may offer other treatment avenues. Phosphorylation and acetylation of keratin aggravate trichorrhexis nodosa, but one can target and block these processes with a posttranslational modification on keratin proteins. In this process, one is altering the structure and function of keratins at a molecular level, improving hair integrity [34]. Additionally, animal models have been shown to block mutant krt75 keratin genes *via* RNA interference from causing structural hair shaft defects [35]. Next-generation sequencing technologies may advance to the point of being able to outline the exact genetic basis of trichorrhexis nodosa and pave the way for future translational therapies [36].

CONCLUSION

Trichorrhexis nodosa is a common cause of dermatological visits. There are categorically recognized congenital forms as well as four acquired types. Treatment for trichorrhexis nodosa involves avoiding factors that contribute to hair breakage, such as minimizing heat styling and using gentle hair care products. If the FDA does sanction the popular formaldehyde and related chemicals for hair straightening, there will be major ramifications in products used for hair straightening and keratin hair treatments. Moreover, ongoing genetic studies and research on keratin have identified new therapeutic targets and approaches, such as targeting PTMs and using RNA interference, which hold promise for treating trichorrhexis nodosa.

AUTHORS' CONTRIBUTION

The author confirms sole responsibility for the following: C.G.B.: Study conception and design, data collection, analysis and interpretation of results, and manuscript preparation.

ABBREVIATION

TN = Trichorrhexis Nodosa.

CONSENT FOR PUBLICATION

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CONFLICT OF INTEREST

The author declares no conflict of interest, financial or otherwise.

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REFERENCES

[1] Haskin A, Kwatra SG, Aguh C. Breaking the cycle of hair breakage: Pearls for the management of acquired trichorrhexis nodosa. J Dermatolog Treat 2017; 28(4): 322-6. http://dx.doi.org/10.1080/09546634.2016.1246704

[2] Burkhart CG, Burkhart CN. Trichorrhexis nodosa revisited. Skinmed 2007; 6(2): 57-8. http://dx.doi.org/10.1111/j.1540-9740.2007.06044.x PMID: 17342017

[3] Phillips TG, Slomiany WP, Allison R. Hair loss: Common causes and treatment. Am Fam Physician 2017; 96(6): 371-8. PMID: 28925637

[4] Ankad BS, Shah S. Trichoscopy of an isolated trichorrhexis nodosa: A case report. Indian Dermatol Online J 2017; 8(5): 386-7. http://dx.doi.org/10.4103/idoj.IDOJ_396_16 PMID: 28979886

[5] Turra N, Navarrete J, Magliano J, Bazzano C. Acquired trichorrhexis nodosa: How to diagnosis it? Dermatol Online J 2018; 18: 13030. http://dx.doi.org/10.5070/D32411042012

[6] Jindal R, Chauhan P, Bhardwaj N, Chugh R. Acquired trichorrhexis nodosa secondary to trichotillomania: Prompt diagnosis using trichoscopy. Int J Trichology 2022; 14(1): 34-7. http://dx.doi.org/10.4103/ijt.ijt_64_19 PMID: 35300104

[7] Yang FC, Zhang Y, Rheinstädter MC. The structure of people's hair. Peer J 2014; 2: e619. http://dx.doi.org/10.7717/peerj.619 PMID: 25332846

[8] Takahashi T, Mamada A, Kizawa K, Suzuki R. Age-dependent damage of hair cuticle: Contribution of S100A3 protein and its

citrullination. J Cosmet Dermatol 2016; 15(3): 211-8.
http://dx.doi.org/10.1111/jocd.12202 PMID: 26710891
[9] Breakspear S, Ivanov DA, Noecker B, Popescu C, Rosenthal M. Cuticle – Designed by nature for the sake of the hair. Int J Cosmet Sci 2022; 44(3): 343-62.
http://dx.doi.org/10.1111/ics.12782 PMID: 35478184
[10] Takahashi T. A highly resistant structure between the cuticle and the cortex of human hair III: Characterzation of the structure CARB. Int J Cosmet Sci 2021; 43(2): 254-62.
http://dx.doi.org/10.1111/ics.12691 PMID: 33527469
[11] Rushton DH, Norris MJ, James KC. Amino-acid composition in trichorrhexis nodosa. Clin Exp Dermatol 1990; 15(1): 24-8.
http://dx.doi.org/10.1111/j.1365-2230.1990.tb02013.x PMID: 2311275
[12] Nagamani SCS, Erez A, Lee B. Argininosuccinate lyase deficiency. GeneReviews. University of Washington 1993.
PMID: 21290785
[13] Kane J, Berrebi K, McLean R, *et al*. Noonan syndrome with loose anagen hair associated with trichorrhexis nodosa and trichoptilosis. Clin Case Rep 2017; 5(7): 1152-4.
http://dx.doi.org/10.1002/ccr3.1011 PMID: 28680615
[14] Ioannidis AD, Khan SG, Tamura D, *et al*. Trichothiodystrophy hair shafts display distinct ultrastructural features. Exp Dermatol 2022; 31(8): exd.14614.
http://dx.doi.org/10.1111/exd.14614 PMID: 35615778
[15] Heymann WR. The global hair straightener market. Dermatol World Insights Inquir 2024; 6(14)
[16] Global Hair Straightener Market Valued at $587.9 Million in 2022, Expected to Reach $759.9 Million by 2028. 2023. Available from:
https://www.globenewswire.com/news-release/2023/11/01/2771332/28124/en/Global-Hair-Straightener-Market-Valued-at-587-9-Million-in-2022-Expected-to-Reach-759-9-Million-by-2028.html
[17] Barreto T, Weffort F, Frattini S, Pinto G, Damasco P, Melo D. Straight to the point: What do we know so far on hair straightening? Skin Appendage Disord 2021; 7(4): 265-71.
http://dx.doi.org/10.1159/000514367 PMID: 34307473
[18] Cohen R. FDA move to ban formaldehyde in hair straighteners called too little, too late. 2024. Available from: https://www.npr.org/sections/health-shots/2024/02/06/1229421257/formaldehyde-hair-straighteners-curl-relaxers-cancer-risk-fda
[19] Bnaya A, Abu-Amer N, Beckerman P, *et al*. Acute kidney injury and hair-straightening products: A case series. Am J Kidney Dis 2023; 82(1): 43-52.e1.
http://dx.doi.org/10.1053/j.ajkd.2022.11.016 PMID: 36610611
[20] Abu-Amer N, Silberstein N, Kunin M, Mini S, Beckerman P. Acute kidney injury following exposure to formaldehyde-free hair-straightening products. Case Rep Nephrol Dial 2022; 12(2): 112-6.
http://dx.doi.org/10.1159/000525567 PMID: 36160636
[21] Ahmed HM, Rashad SH, Ismail W. Acute kidney injury following usage of formaldehyde-free hair straightening products. Iran J Kidney Dis 2019; 13(2): 129-31.
PMID: 30988250
[22] Mitler A, Houri S, Shriber L, Dalal I, Kaidar-Ronat M. Recent use of formaldehyde-'free' hair straightening product and severe acute kidney injury. Clin Kidney J 2021; 14(5): 1469-71.
http://dx.doi.org/10.1093/ckj/sfaa272 PMID: 33959274
[23] Robert T, Tang E, Kervadec J, Zaworski J, Daudon M, Letavernier E. Kidney injury and hair-straightening products containing glyoxylic acid. N Engl J Med 2024; 390(12): 1147-9.
http://dx.doi.org/10.1056/NEJMc2400528 PMID: 38507759
[24] Sloan B. June 2022: Trichorrhexis nodosa of the beard associated with mask use. J Am Acad Dermatol 2022; 86(6): 1231-2.
http://dx.doi.org/10.1016/j.jaad.2022.03.051 PMID: 35381297
[25] Gangal A, Heuring EL, MacKelfresh JB. Mask-associated acquired trichorrhexis nodosa of the beard. JAAD Case Rep 2022; 21: 101-2.
http://dx.doi.org/10.1016/j.jdcr.2021.12.033 PMID: 35155726
[26] Smith RA, Ross JS, Bunker CB. Localized trichorrhexis nodosa. Clin Exp Dermatol 1994; 19(5): 441-2.
http://dx.doi.org/10.1111/j.1365-2230.1994.tb02707.x PMID: 7955512
[27] Mathur M, Thakur N, Jaiswal S, Maharjan S. Acquired trichorrhexis nodosa in association with hyperthyroidism. Int J Dermatol 2023; 62(11): e598-9.
http://dx.doi.org/10.1111/ijd.16798 PMID: 37458485
[28] Sakthibalan R, Menon R, David BG. Severe iron deficiency anemia causing trichorrhexis nodosa: An unusual presentation. Int J Dermatol 2023; 62(5): e283-5.
http://dx.doi.org/10.1111/ijd.16560 PMID: 36518006
[29] Mahendran P, George SMC, Farrant PBJ. Trichorrhexis nodosa: A distinctive presentation after tumour necrosis factor-α inhibitor therapy. Clin Exp Dermatol 2016; 41(3): 313-4.
http://dx.doi.org/10.1111/ced.12727 PMID: 26206274
[30] Leonard JN, Gummer CL, Dawber RPR. Generalized trichorrhexis nodosa. Br J Dermatol 1980; 103(1): 85-90.
http://dx.doi.org/10.1111/j.1365-2133.1980.tb15842.x PMID: 7426408
[31] McFeely O, Meah N, Sinclair R, Wall D. Trichorrhexis nodosa improving with oral minoxidil: A case report. Clin Exp Dermatol 2023; 48(5): 554-5.
http://dx.doi.org/10.1093/ced/llad019 PMID: 36656753
[32] Boga C, Taddei P, Micheletti G, *et al*. Formaldehyde replacement with glyoxylic acid in semipermanent hair straightening. Int J Cosmet Sci 2014; 36(5): 459-70.
http://dx.doi.org/10.1111/ics.12148 PMID: 24962464
[33] Miranda-Vilela AL, Botelho AJ, Muehlmann LA, *et al*. An overview of chemical straightening of human hair: Technical Aspects, potential risks to hair fiber and health and legal issues. Int J Cosmet Sci 2014; 36(1): 2-11.
http://dx.doi.org/10.1111/ics.12093 PMID: 24102549
[34] Li P, Rietscher K, Jopp H, *et al*. Posttranslational modifications of keratins and their associated proteins as therapeutic targets in keratin diseases Curr Opin Cell Biol 2023; 85: 102264.
http://dx.doi.org/10.1016/j.ceb.2023.102264
[35] Liu Y, Snedecor ER, Zhang X, *et al*. Correction of hair shaft defects through allele-specific silencing of mutant Krt75. J Invest Dermatol 2016; 136(1): 45-51.
http://dx.doi.org/10.1038/JID.2015.375
[36] Doolan BJ, Rayinda T, Chiu FP, McGrath JA, Onoufriadis A. A review of genotrichoses and hair pathology associated with inherited skin diseases. Br J Dermatol 2023; 189(2): 154-60.
http://dx.doi.org/10.1093/bjd/ljad102 PMID: 36978220