Assembling a Hand-Held Trichotillometer and Determination of Epilation Force in Normal Individuals

Abstract

**Aim:** To assemble a simple, inexpensive hand-held trichotillometer and to determine the epilation force (EF) required to pluck the anagen hair and telogen hair from four regions of the scalp in healthy volunteers. **Materials and Methods:** A simple hand-held trichotillometer was assembled by modifying a laboratory spring balance, and the instrument was calibrated after attachments. EF was measured in 30 healthy individuals on four regions of the scalp. **Results:** A total of 30 volunteers were included in the study, among them 15 were males and 15 were females. A total of 1200 hairs were examined. The mean EF in our study was 70.15 grams (g). The mean EF required to pluck the anagen hair was 86.61 g and telogen hair was 53.69 g. **Conclusion:** The assembled-hand held trichotillometer is a simple and reliable device. Tricotillometer is a useful device to measure the EF in various physiological and pathological conditions and may have diagnostic, prognostic, and therapeutic value in various hair diseases.

Keywords: Anagen hair, epilation force, trichotillometer

Introduction

Hair loss is a common problem encountered either due to pathological causes or nutritional deficiencies. There are various tests available to investigate hair loss such as hair pull test, hair pluck test (trichogram), phototrichogram, digital phototrichogram, unit area trichogram, hair diameter assessment, and trichotillometry. Trichotillometer is a device that is used to determine the force required to pluck the hair. Trichotillometer is not available commercially. We devised a simple and inexpensive hand-held trichotillometer to assess the epilation force (EF) in normal individuals.

Materials and Methods

A simple hand-held trichotillometer was assembled by modifying the laboratory spring balance. A laboratory spring balance (1 newton (N)/100 grams (g)) 16 cm long and 3 cm diameter was selected for the study. The loading hook of the spring balance was replaced with a paper clip of 2 cm length. The spring balance had a range of 1 N (100 g) with a resolution of 2g. Two holes were drilled on diametrically opposite locations on the sides of the spring balance, at a distance of 4.5 cm from the top edge of the cylindrical barrel. Two nylon cords were introduced through these holes and a hand-made paper cup was cemented to the end of these cords. This paper cup with a diameter matching the inner diameter of the barrel serves as a non-return marker. The width of the paper cup was 1 cm. Two slots were provided at the diametrically opposite points of the indicator cone to allow the nylon cord to pass through freely [Figure 1]. The trichotillometer was calibrated with analytical weights for accuracy before and after the modification.

Thirty healthy volunteers who did not complain of hair loss were recruited for determining the EF. Volunteers were advised not to wash the scalp at least three days prior to the date of EF estimation. For estimating the EF, volunteers were made to sit on the stool and the clip at the lower end of the trichotillometer was attached to the distal end of a single hair shaft and the spring balance was pulled manually, upward gently at the top end with the help of the ring attached to its top till the hair snaps from the scalp [Figure 2]. Force indicator slides down the inner
wall of the spring balance and stops at the point when the hair is detached from the scalp; the force in g was noted and taken as the EF [Figure 3]. The force indicator was pulled to the base line by the nylon thread and trichotillometer was set for assessing the EF of another hair. If the hair shaft broke during the process of pulling the spring balance, then another hair shaft was selected for the estimation of EF. The root of the plucked hair was examined under microscope to determine whether the follicle plucked was in the anagen or telogen phase. The EF required to pluck 5 anagen and 5 telogen hair from 4 regions (frontal, vertex, occipital, and parietal) on each volunteer was determined separately. Subsequently, the mean force required to pluck the anagen hair and telogen hair from each area was calculated. This study was sponsored by the IADVL L’Oréal research grant.

Results
A total of 30 volunteers (15 males and 15 females) were included in the study. A total of 1200 hairs were examined. The mean EF in our study was 70.15 g. The mean EF required to pluck the anagen hair was 86.61 g and telogen hair was 53.69 g [Table 1]. In females, the mean EF for anagen hair was 88.55 g and mean EF for telogen hair was 53.55 g, and the mean EF for females was 71.05 g [Table 2]. In males, the mean EF for anagen hair was 84.67 g and mean EF for telogen hair was 53.83 gm, and the mean EF for males is 69.25 g [Table 3]. In frontal area, the mean EF required to pluck the anagen hair was 83.44 g (SD: 10.46) and telogen hair was 49.04 g (SD: 9.61). In vertex area, the mean EF required to pluck the anagen hair was 83.46 g (SD: 10.21) and telogen hair was 51.46 g (SD: 11.67). In parietal area, the mean EF required to pluck the anagen hair was 84.04 g (SD: 11.14) and for telogen hair was 50.02 g (SD: 10.91). In occipital area, the mean EF required to pluck the anagen hair was 95.50 g (SD: 4.70) and telogen hair was 64.24 g (SD: 7.01).

Discussion
EF for the anagen hair was higher than that for the telogen hair on all the regions of scalp in our study group. The
Smelser et al. determined the usefulness of trichotillometry under field conditions by measuring hair EF of 69 subjects at a hospital in Nigeria, the mean force was 36.5 ± 9.5 g.[4] El Rifaie et al. calculated the shear strain of the follicle rather than the EF alone on different regions of the scalp and separately for men and women.[5]

The mean EF in our study group was 70.15 g, which is higher than the previous reports. In our study, the EF was calculated separately for the anagen and telogen hairs in various regions of scalp and for a larger sample size; this could explain the variations in the findings. The force required to pluck hair is likely to vary throughout the different stages of growth, over the different regions of scalp, and in different races and these biological variations might contribute to the differences in EF in our study compared to the others.

The mean EF for males and females were comparable in our study group. The mean EF of anagen and telogen hairs was higher in occipital region than other regions of the scalp. The mean EF of anagen and telogen hairs were comparable in other regions of the scalp. These different behaviors of occipital and frontal/parietal follicles may result from the embryological derivation of the dermis in these two regions.[6] Dermis of the frontal/parietal scalp is of neural crest origin, whereas the dermis of the occipital scalp is of mesodermal origin.[6] It is a common observation that the occipital hairs are retained in Hamilton-Norwood scale owing to its androgen independent nature compared to the other regions on the scalp. El Rifaie et al. reported that the shear strain of plucking the follicles is not different in anagen and telogen hairs on the various regions of the scalp and there was no difference between men and women.[5]

The variations in EF among the individual and the observers has been reported in previous studies.[3] This variation could be due to mechanical error in the instruments.[3] In order to obtain a reproducible and representative mean hair pluckability measurement, an adequate amount of individual hairs need to be plucked and a standard instrument needs to be designed.

Limitations of our study are patient discomfort during the repeated plucking of hairs; other hair parameters such as the growth rate, density, hair diameter, and the shear strain during the follicular plucking were not estimated. Even though our device was calibrated with analytical weights, the final reading may not be as accurate as a digital reading.

**Conclusion**

Our device was assembled by modifying a spring balance and the method described can be easily replicated. Tricotillometer is a useful device to measure the EF in various physiological and pathological conditions and may have diagnostic, prognostic, and therapeutic value in various

### Table 3: Mean EF for anagen and telogen hairs on various regions of scalp in males

| Area     | ANAGEN mean in g | TELOGEN mean in g |
|----------|------------------|-------------------|
| Frontal  | 81.28            | 47.86             |
| Vertex   | 81.04            | 51.41             |
| Parietal | 80.64            | 50.16             |
| Occipital| 95.73            | 65.83             |
| Total    | 84.67            | 53.83             |

G: Grams

EF of anagen hair has been reported to be higher than the telogen hair in previous studies.[1] Mechanical resistance encountered during the plucking of anagen hair could be due to the deeper location of the anagen follicle, the firm attachment of the dermal papilla to the fibrous sheath, and the close apposition of inner root sheath to the hair shaft.[1]

Force required to pluck the hair in normal healthy volunteers using a hand-held trichotillometer has been reported in few studies.[2-4] Chase et al. reported that the average observed range among well-nourished patients, when plucking 10 individual hairs, was 36.0 ± 12.4 g. Wyness et al. reported that mean hair pluckability measurements for the 12 participants obtained by three observers were 39.5 g, 41.2 g, and 32.7 g, respectively.[3]
hair diseases. The tensile strength of the hair shaft can be estimated in various disorders using a trichotillometer.

**Financial support and sponsorship**

This study was sponsored by IADVL Loreal research grant 2013.

**Conflicts of interest**

There are no conflicts of interest.

**References**

1. Chapman DM. The anchoring strengths of various chest hair root types. Clin Exp Dermatol 1992;17:421-3.
2. Chase ES, Weinsier RL, Laven GT, Krumdieck CL. Trichotillometry: The quantitation of hair pluckability as a method of nutritional assessment. Am J Clin Nutr 1981;34:2280-6.
3. Wyness LA, McNeill G, Prescott GJ. Trichotillometry: The reliability and practicality of hair pluckability as a method of nutritional assessment. Nutr J 2007;6:9.
4. Smelser DN, Smelser NB, Krumdieck CL, Schreeder MT, Laven GT. Field use of hair epilation force in nutrition status assessment. Am J Clin Nutr 1982;35:342-6.
5. El-Rifaie AA, Abdel Wehab AM, Gohary Y, El-Rifaie AE. The trichotillometry: A technique for hair assessment. Skin Res Technol 2016;2:15-9.
6. Ziller C. Pattern formation in neural crest derivatives. In: Dvan Neste, Randall VA, editors. Hair Research for the Next Millenium. Amsterdam, The Netherlands: Elsevier Science; 1996. p. 19-23.