FOLLISCOPIC EVALUATION OF HAIR CALIBER AND DENSITY IN DIFFERENT ANATOMICAL AREAS OF THE SCALP

SUBMITTED FOR PARTIAL FULFILLMENT OF MASTER DEGREE IN
DERMATOLOGY, VENEREOLOGY AND ANDROLOGY

BY

May Emad Abdel Mohsen
(M.B., B.Ch.)
Faculty of Medicine – Ain Shams University

Under supervision of

Prof. Dr. Mohamed Abdel Rahim Abdallah
Professor of Dermatology, Venereology and Andrology
Faculty of Medicine – Ain Shams University

Prof. Dr. Ranya Lotfi
Professor of Dermatology, Venereology and Andrology
Faculty of Medicine – Ain Shams University

Ain Shams University
Faculty of Medicine

2013

Abstract

Hair is a physical expression of personality and social role. For many, hair is central to feeling of attractiveness and self esteem. Few previous studies also compared between 2 or 3 different scalp areas regarding density and caliber. However, in this study we compared between 5 different areas, which was not studied before.

The Folliscope is a small, simple Universal Serial Bus (USB) based phototrichogram system for hair and scalp analysis, easily portable and operated by means of a computer screen as an interface, with a high definition microscopic camera and exclusive software that measures hair density, hair caliber, and export data to excel files.

In the present study, we compared the mean value of hair density and caliber in 5 different anatomical scalp areas of 130 completely healthy female subjects, aged 17-35 years, using folliscope device.

Fourteen locations on the scalp in 5 different scalp areas were chosen for analysis by means of the folliscope, without hair clipping or tattooing.

Three points of measurements were taken in each measurement line, one point in each side of right and left temporal recession area.

FOLLISCOPIC EVALUATION OF HAIR CALIBER AND DENSITY IN DIFFERENT ANATOMICAL AREAS OF THE SCALP

SUBMITTED FOR PARTIAL FULFILLMENT OF MASTER DEGREE IN
DERMATOLOGY, VENEREOLOGY AND ANDROLOGY

BY

May Emad Abdel Mohsen
(M.B., B.Ch.)
Faculty of Medicine – Ain Shams University

Under supervision of

Prof. Dr. Mohamed Abdel Rahim Abdallah
Professor of Dermatology, Venereology and Andrology
Faculty of Medicine – Ain Shams University

Prof. Dr. Ranya Lotfi
Professor of Dermatology, Venereology and Andrology
Faculty of Medicine – Ain Shams University

Ain Shams University
Faculty of Medicine

2013

Introduction

Hair is a physical expression of personality and social role. For many hair is central to feeling of attractiveness and self esteem. Hair exerts a wide range of functions including thermoregulation, physical protection, sensory activity and social interaction ***(Schneider et al., 2009).*** The hair follicle is a unit formed of interaction of epithelial cells, nerve endings and stromal cells ***(Lee, 2011).*** The hair follicles vary considerably in size and shape depending on their location, but they all have the same basic structure ***(Dawber and Van Neste, 2004).*** Development of hair follicle and the future phenotype of each is established during fetal life and it is controlled by epidermal-mesenchymal interactions, particular spacing and allocation of follicles are determined by genes that are expressed very early in morphogenesis of the follicles ***(Yoo et al., 2010),*** no extra follicle are added after birth ***(Kratochwill et al., 1996).***

Hair growth occurs in a cyclic manner, but each follicle functions as an independent unit, the hair follicles undergo a cycle of developmental events: the growth period "anagen", regression period "catagen" and quiescence period "telogen" ***(Jiang et al., 2010).***

The human scalp, eyebrows, and lashes consist of long, thick, medullated and pigmented terminal hair shafts, whereas the body is covered with short, thin and often unpigmented vellus hairs. Each displays an estimated total number of 5 million hair follicles, of which 80.000 to 150.000 are located on the scalp ***(Krause, Foitzik, 2006).*** The thickness of the hair shaft is related to the size of the hair bulb which in turn is dictated by the volume of the hair follicle's mesenchymal component ***(Dawber, 1997).*** Hair shaft diameters show relatively little variation (16-42 μm); the highest shaft diameter is observed in sural (42μm) and thigh (29 μm) regions, with the lowest on the forehead (16 μm) ***(Otberg et al., 2004).*** The highest average hair follicle density is found on the forehead (292 follicles/cm^2).

Numerous methods are currently available in the clinic for evaluation of hair ***(Chamberlain and Dawber, 2003).*** Both handled dermoscope and video-dermoscope can be utilized allowing visualization of hair follicle at higher magnification and combine automatic image analysis ***(Rudnicka et al., 2011).*** Trichoscopy enables analysis of all important parameters of hair growth, density and diameter ***(Hoffman, 2005).***

The Folliscope is a small, simple Universal Serial Bus (USB) based phototrichogram system for hair and scalp analysis. It is easily portable and operated by means of a computer screen as an interface. The Folliscope has a high definition microscopic camera and exclusive software that measures hair density, hair caliber, growth rate and hair distance and export data to excel files ***(Lee et al., 2012).*** Few studies have utilized the Folliscope to assess different hair measures in different anatomical areas in the same individual.

Aim of the Work

The aim of the current thesis is to evaluate the normal values of hair density and caliber in different anatomical areas of the entire scalp of the same individual.

Biology of Hair

Function of Hair:

Hair has many useful biologic functions, including protection from the elements and dispersion of sweat-gland products (e.g., pheromones). It also has psychosocial importance in our society, and patients with hair loss (alopecia) or excessive hair growth often suffer tremendously.

Hair has the additional function of extending the sensory capability of the skin beyond its surface, as each hair has a nerve fiber going to the bulb of the hair follicle, thus mechanical displacement of each hair causes a sensation that translates into an awareness movement on the skin surface ***(Stenn and Paus, 2001).***

Hair plays a role in the defense mechanisms of most fur-bearing animals. In man, with relatively sparse body hair, a tiny muscle called the arector pili connects the lower portion of each hair shaft with the underside of epidermis. Upon exposure to frightened situations, cold or anger, these small muscles contract causing the hair to stand on end ***(Jakubovic and Ackerman, 1985).***

Each hair shaft also contains a small gland, the sebaceous gland, located next to the hair shaft. Sebaceous gland makes a yellow fatty substance called sebum that lubricates the hair and skin. Each time the erector pili muscle contracts, the gland is squeezed and a small amount of lubricant is applied to the surface of the hair and passes to the skin through the passage of the hair shaft ***(Stenn and Paus, 2001).***

Hair, along with skin pigmentation, is the major natural protection that we have against the harmful ultra-violet rays (UVR) of sun. Hair also plays an important role in preventing mechanical trauma to the skull. Hair acts as "a dry lubricant" in areas that rub such as the axillae and the groin and serves to disperse pheromones (body secretions that are involved in sexual attraction) in animals ***(Bernstein, 2005).***

Special functions of certain hairs include eyelash hair which is very important in protecting the eye from dust and debris, and eyebrows that channel away sweat and other fluids, and help to reduce any excessive glare from sunlight entering the eyes ***(Hess et al., 1990).***

Types of Hair

Three different hair types were described; primary, secondary, and tertiary hair. These categories are based on the length and diameter of the hair follicles in the skin ***(Jakubovic and Ackerman, 1985).*** Primary hair is produced in the very first cycle of hair growth, described as lanugo hair. The secondary or vellus hair gradually replaces the primary hair and depending on position of hair follicles in the body, it may turn to tertiary or terminal hair ***(Vogt et al., 2005).***

Types of hair as described by ***Jakubovic and Ackerman, (1985)*****:**

(A) Lanugo hair: Lanugo hair are vellus in character, but often longer than the vellus shafts of the adult. It begins to grow about three months after the baby's conception. The hairs are fine and soft, and they grow all over the baby's body. They all grow at the same rate, so the hairs are the same length. Some prematurely born babies are still covered with these downy hairs. Around the eighth month of development this hair is usually shed.

A second generation of lanugo hairs then starts growing and lasts until the first three or four months of extrauterine life are completed ***(Dawber and Van Neste, 1995).*** After all lanugo hairs have disappeared, two types of hair emerge: vellus and terminal ***(Jankovic and Jankovic, 1998).***

(B) Vellus hair: Vellus follicle is defined as a small follicle that extends no deeper than the upper dermis and produces a shaft no wider than its inner root sheath. Although vellus follicles may lack arrector pili muscles in some areas, vellus follicles are associated with these structures on the face ***(Stenn and Paus, 2001).***

Vellus hairs are thin (< 0,1mm), occasionally pigmented, and short hairs, only a centimeter or two long (< 2cm). The follicles that produce them do not have sebaceous gland, and never produce any other kind of hairs ***(Dawber and Van Neste, 1995).*** All skin is covered with vellus hairs with the exception of skin on the palms, soles, volar side of fingers, penile glans and labia minora et majora (only on internal side). Under the influence of diverse local and systemic factors vellus hairs are in certain regions transformed to terminal hairs ***(Jankovic and Jankovic, 1998).*** While terminal hairs are composed of medulla, cortex and cuticle, vellus hairs lack a medulla ***(Jankovic and Jankovic, 1998).***

(C) **Terminal hair:** Terminal hairs are thick (up to 0,6mm), long (> 2cm), pigmented and medullated. Terminal hairs are the long hairs that grow on the head and in many people on the body, arms, and legs too. They are also found on the scalp, eye brows, eye lashes and also on the pubic, axillary and beard areas. They are produced by follicles with sebaceous gland. In people who have inherited tendency to baldness the hairs in these follicles gradually become thinner and shorter until they look like vellus hairs ***(Dawber and Van Neste, 1995; Jankovic and Jankovic, 1998).*** They originate as vellus hair; differentiation is stimulated at puberty by androgens ***(Gawkrodger, 1997).***

With maturity and exposure to androgens, regional human hair follicles switch in morphology to terminal follicles that produce terminal hair shafts. The inverse terminal-to-vellus switch occurs on the scalp of the genetically susceptible androgenic alopecia individual after exposure to androgens ***(Stenn and Paus, 2001).***

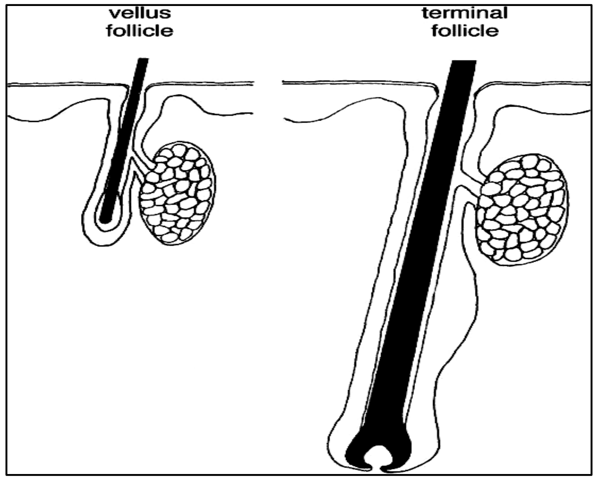

Figure (1): Vellus and terminal hair follicles **(Vogt et al., 2005)**.

Hair Fiber Variations:

The variabilty of the morphological, physical and chemical properties of human hair in each race is greater than the variability of hairs on single individual's head ***(Verhoeven, 1972)***.Human hair can be characterized into three major race groups (or major population groups) that include Caucasoid (principally of European ancestry), african type (race of Africa) and Asian (i.e. Mongols, American Indians and Eskimos), ***(Robbins, 1994; Houck and Budowle, 2002)*** . The population of Indian subcontinent are allied with the European populations in terms of anthropological kinship and closely allied with the hair type of the east Asian populations ***(Ogle and Fox ,1999).*** Numerous studies have described the physical differences in hair from people of different ethnicities ***(Feughelman, 1997; kreplak***

et al., 2001; Speakman, 1927; Garcia et al, 1977; Kamath et al., 1984 and Lindelof et al., 1988). fiber curvature and crosssectional shape vary between the three major races, from 40-120 micrometer in diameter.

Asian hairs have a greater diameter (69-86 µm; mean 77 µm) with the circular cross section, are usually straight to wavy in curvature, round to slightly oval and dark brown to black.Caucasian hairs have an intermediate diameter (67-78 µm; mean 72 µm), are generally straight to curly in curvature, round to slightly oval in crosssectional shape and blond to dark brown in color. African hair type fibers have a high degree irregularity in diameter (54-85 µm; mean 66 µm); are wavy to woolly, are the most elliptical in cross-sectional shape and brown black in color ***(Robbins, 1994; Wolfram, 2003; La Torre and Bhushan, 2005 and Franbourg et al., 2003).***

Embryology of Hair:

Hair follicles start developing between 9 and 12 weeks gestational age. They are derived from the ectodermal and mesodermal layers of the embryo. The ectoderm gives rise to the hair matrix cells and the melanocytes responsible for the pigmentation of hair. Two buds form off of this layer. One bud gives rise to the sebaceous gland and the other bud forms the area of attachment for the arector pili muscle. The erector pili muscle, the hair dermal papilla, the fibrous follicular sheath and feeding blood vessels all arise from the mesoderm. Hair follicle epithelial growth continues down into the mesoderm until the follicle has reached its full size. Once this occurs, matrix cells begin dividing and pushing upward, eventually forming a hair shaft. Hair production can typically be seen by 16 to 20 weeks gestation, forming fine lanugo hair. Some of the lanugo hair will be shed around 32 to 36 weeks and after this time more substantial hair may develop on the scalp, eyebrows and eyelashes ***(Barrera, 2002)***.

During this time, the precise distribution of hair follicles over the surface of the body is established and the future phenotype of each hair (e.g., long scalp hair and short eyebrow hair) is determined. Many of the molecular signals that control these events were first discovered in drosophila (fruit flies) ***(Chuong, 1998, St-Jacques et al., 1998)***.

Embryologic studies have shown that the mesenchyme of the scalp crown, face, and anterior neck are derived from the neural crest while the frontal,temporal and occipital scalp regions are derived from cephalic or somatic mesoderm. It is notable that in clinical hair disorders such as male pattern baldness and alopecia areata the respective regions are dramatically circumscribed and differ substantially in their clinical course and prognosis; in the former, the bald area corresponds to the neural crest mesoderm, whereas in the latter, the bald area corresponds to the somatic derived mesoderm. The basis for hair follicle heterogeneity, may result from signals arising very early in development, which are expressed by a complex of patterning genes ***(Stenn & Paus, 2001).***

The total number of follicles in an adult man has been estimated at about 5 millions, of which about 1 million are on the head and perhaps 80,000 to 150,000 are located on the scalp. There appear to be no significant sexual or racial differences in follicle number ***(Krause and Foitzik, 2006)***.

On the cheek and forehead, the average density of follicles has been recorded as around 800/cm². The greatest density of vellus hairs occurs on the forehead where there are an average 400-450/cm² in young adults of both sexes. However, lower densities of 50-100/cm² are found on the chest and back in both sexes, and only 50/cm² on the thigh and leg. So when the body surface increases, there is a decrease in the actual density of follicles ***(Lee et al., 2002)***.

In adults aged 20-30 years an average of 615/cm² has been noted, but between 30 and 50 years the mean density falls to 485/cm², and by 80-90 years it is only 435/cm². There is undoubtedly a long-term decrease in follicles in baldness; a comparison of bald with hairy scalps for the whole range of 30-90 years gave means of 306/cm² and 459/cm² respectively ***(Loussouarn, 2001).***

No additional follicles are formed after birth, although the size of the follicles and hairs can change with time, primarily under the influence of androgens. The precise spacing and distribution of the follicles are established by genes that are expressed very early in the morphogenesis ***(Yoo et al., 2010)***.

Anatomy of the Scalp

The scalp is made up of five layers. The outermost layer is the skin. The connective tissue layer contains fat, vessels, lymphatics and nerves. The galea aponeurosis is a tendon-like structure to which the frontalis muscle inserts anteriorly and the occipitalis muscle inserts posteriorly.

Loose connective tissue lies between the galea and the pericranium, which is the periosteum of the skull. The scalp has a rich blood supply derived from both the internal and external carotid systems. Venous drainage mirrors the arterial flow. The emissary veins and the ophthalmic veins are of special anatomic note as they drain intracranially and have the potential to allow spread of infection to this space. The supratrochlear and supraorbital branches of the ophthalmic division of the trigeminal nerve innervate the forehead and frontal scalp. The maxillary division, via the zygomaticotemporal branch, supplies the temple region. Sensation of the lateral scalp is provided by the mandibular division's auriculotemporal nerve. The cervical plexus contributes to the great auricular and lesser occipital nerves that innervate the postauricular area. Finally, the occiput and vertex are innervated by the greater occipital nerve. Motor innervation of the frontalis, occipitalis and auricular muscles is provided by the facial nerve.

Anatomy of Hair