

HOW TO EVALUATE PATIENTS USING USING HAIR BUNDLE CROSS-SECTION MEASUREMENT

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UNDERSTANDING HAIR MASS, HAIR LOSS, AND HAIR GROWTH

Hair *mass* is determined by the density (the number of hairs) and their diameter. Hair loss and growth result from changes in density (n/cm^2) and diameter (μ). In *shedding*, the *density* is reduced because hairs of normal-sized diameter fall out. The skin surface becomes more visible. In *thinning*, the *diameter* is progressively reduced. The miniaturization continues with each cycle and follows a recognizable sequence that spares the postero-lateral scalp. The phenomenon is called male pattern hair loss or androgenetic alopecia (AGA). As the hairs become smaller, the skin surface becomes more visible. Eventually the hairs vanish and a bald area appears. Under the influence of minoxidil and finasteride, hair growth can result from telogen to anagen conversion and/or progressive diameter enlargement. In both shedding and thinning, hair *mass* must be reduced 50% before the underlying skin surface is visible to the naked eye.⁽¹⁾ Hair length is not considered when measuring hair *mass*, because it varies with hairstyle.

THE FRUSTRATIONS OF HAIR LOSS MANAGEMENT

There's a medical maxim, "If it can't be measured, it can't be managed." Hair loss might be a problem for many patients, but it's a problem for many doctors as well. They struggle with the clinical measurement of AGA, especially in its early stages. They have no convenient means for detecting loss, measuring severity, tracking the loss over time, or evaluating its response to therapy. Office diagnostics include AR genetic testing, clinical photography, and video microscopy; but all have significant limitations. Sophisticated quantitative measures have been limited to research facilities.

THE LIMITATIONS OF PHOTOGRAPHY

Office photography is commonly used to track hair loss and growth -- but consistency in hairstyle, length, color, photo-illumination, etc. is essential. Photographs do not provide a quantitative values -- one simply compares the patient's "before" to the patient's "after" photograph. Photos take considerable time to shoot, download, view, compare, and file. And photography is illogical for detecting and tracking early-onset hair loss. Marritt showed that 50% of the hair must be lost *before* the loss is visible to the naked eye.⁽¹⁾ A patient who *has* no visible hair loss will have a photograph that *shows* no visible hair loss. Therefore, if the patient has *less than* 50% hair loss when the photographs are taken - comparing the "before & afters" will not provide a meaningful assessment.

WHY DOES HAIR BUNDLE CROSS-SECTION MEASUREMENT MAKE SENSE

The principle of hair bundle cross-section measurement is simple. Growth and loss are the result of changes in hair density as well as changes in hair diameter. Measuring hair *diameter* alone would require sampling a very large number of hairs. Not only that, each hair has a large and small diameter -- the hair is oval in cross section; so it would be unclear which of the diameters was being measured. Measuring the *number* of hairs per cm of scalp, if performed alone, would also be problematic. Hair would be cut, and the remaining stubble on the scalp would be counted. But in cases of thinning there are a wide variety of hair diameters. A hair of 40 micron diameter, and a hair of 70 micron diameter would each be counted as "one hair."

A solution to the problem would be to measure the cross sectional area of a bundle of hair that is growing within a premeasured cross-section of scalp. By expressing this value as mm^2 of hair per cm^2 of scalp, one would be measuring the hair *mass* -- or more specifically, the bundle cross-section as determined by both the number of hairs and their diameters. A device, called the Cross Section Trichometer, was therefore designed to measure

the cross-sectional area of the hair bundle.^(2,3) A four-legged inked template marker was designed to mark a premeasured area on the scalp. The hair within the premeasured area was then isolated and placed into the Trichometer for the purpose of measuring its cross sectional area.

WHAT IS HAIRCHECK TECHNOLOGY?

HairCheck is the commercially-available version of the Cross-Section Trichometer prototype.^(2,3) It is a hand-held instrument that measures the cross sectional area of an isolated bundle of hair. It generates a single value called The Hair Mass Index (HMI) and establishes *how much hair* is present in a selected area of the scalp. Changes in density and diameter = changes in HMI = hair loss or growth. The HMI can be used to detect early non-visible AGA, years before it becomes visible to the naked eye. It can monitor and measure the rate of loss in AGA, determine if the loss has been stabilized, and determine whether or not the treatment is effective. HairCheck can be used to monitor the recovery from telogen effluvium (shedding). HairCheck can also detect and quantify breakage - an underappreciated cause of hair loss in longhaired women.⁽³⁾ Examples of how HairCheck is used in these situations and others are listed below.

"HairChecking" is quick and easy to perform. An assistant can perform the measurement in 3 minutes (a training DVD video is included). No hair is cut. HairCheck provides an instant and meaningful measurement of *how much hair* the patient actually has. Unlike surface hair counts, which measure *density* alone, HairCheck simultaneously measures *density and diameter* - the respective hallmarks of shedding and thinning. The value on the LED screen may be used to make predictive assumptions and manage the patient's entire treatment course.

INCORPORATING HAIRCHECK INTO YOUR PRACTICE

If the HairCheck device is substituted for a camera, the management of the hair loss patient becomes simplified. The issues of early detection and predicted severity become easy to understand, quantify, and explain. A *how much hair* score (the HMI) is immediately generated. The following examples detail how the HairCheck device may be used to manage patients with *any* form hair loss -- shedding or thinning, visible or non-visible.

EXAMPLE #1: VISIBLE & NON-VISIBLE AGA

Situation: A 20-something year old man, with a strong family history of balding, is fearful of hair loss, He has *no visible hair loss*, but suspects he has less hair in the mid-frontal area. A HairCheck is performed at one site in the area of suspected loss, and at one site in the permanent fringe. The tab sites are noted.

Results: The suspected (mid-frontal) area has an HMI of 83. The mid-occipital fringe has an HMI of 95. 95 becomes the patient's *control*. If the patient had fine hair, or a density less than 100,000 hairs, his control value would be lower. If he had coarse hair, or a higher density, his control value would be higher.

Conclusion: The patient has a 13% loss in the suspected (mid-frontal) area. $(95-83/95 \times 100)$. The HMI reduction is due to early diameter reduction - too subtle to be appreciated by hair counts or video microscopy. The patient knows exactly where he stands in Marritt's *non-visible range of hair loss less than 50%*. If the patient had presented with *visible hair loss*, only the affected area would be measured, and a control site measurement would not be required.

Follow up: The patient returns in 6-12 months. The area of non-visible (suspected) or visible (affected) area is measured at the same tab site. On this visit, the mid-frontal HMI has dropped from 83 to 79. The discussion goes something like this.

"Your hair loss is still not visible. However the frontal area is 5% worse than it was last year $(83-79/83 \times 100)$. We can measure the site once or twice a year to see if it stabilizes, improves, or continues to worsen. Over time, we can even average your annual rate of loss. On the other hand, we can start minoxidil, finasteride, or laser and see what effect they have on your loss. The treatment is maximally effective when started as early as possible."

Summary: The patient with *non-visible* loss knows *how much hair* he has in the *suspected* area and what percentage he has lost. The patient with a *visible* loss knows *how much hair* he has in the *affected* area. Depending on this value, the patient might be motivated to start treatment early. If he chooses no treatment, he has the opportunity to track the rate at which he is losing his hair. Certainly, an annual loss of 3% has different predictive implications than an annual loss of 23%. If he chooses to begin treatment, both he and his physician will know exactly how well the treatment is working, and how well the loss has been stabilized.

EXAMPLE #2: RESPONSE TO HAIR LOSS TREATMENTS

Situation: A 37-year-old man has moderate visible balding in the mid-frontal area. A HairCheck is performed in the affected area along the midline, and the tab site is noted.

Results: The affected area has a baseline HMI of 32. The patient is started on Propecia 1mgm per day. Protocol would be the same for minoxidil, laser, biotin, or any hair *growth* treatment.

Follow up: The patient returns in 12 months. A HairCheck is performed at the same tab site. The HMI is now 40.

Summary: In one year, the patient has improved 20% ($40-32/40 \times 100$) over baseline on Propecia therapy.

EXAMPLE #3: WOMEN WITH SHEDDING

Situation: A 35 year-old woman presents with complaints of shedding and hair loss. She's convinced she has less hair than she had 2 years ago. There has been no fever, childbirth or hormonal changes in the past 3 years. On examination the loss appears distributed evenly over the scalp. When parted down the center, no Xmas tree sign can be seen. A "pull test" is negative. On video-microscopy, there are no miniaturized hairs. A HairCheck is performed and the tab site is noted.

Results: HMI is 67 in the mid frontal area. Blood tests are ordered and thyroid functions return abnormally high. The patient is referred to an endocrinologist who prescribes medication for hyperactive thyroid disease. On the basis of the lab and history, it appears that her shedding is due to an overactive thyroid... same scenario if the lab work had revealed an iron deficiency (low serum ferritin) instead.

Follow up: The patient returns in 8 months. She reports that her shedding has decreased. A HairCheck is performed at the same tab site. The HMI is now 80.

Summary: The patient's shedding appears to have responded to the endocrinologist's treatment. She has improved 16% over baseline ($80-67/80 \times 100$). To differentiate *pattern* balding from *diffuse* shedding, two zones would be measured as in Example #1. If the HMI's were essentially the same, the conclusion would be *shedding*. If the frontal area were lower than the occipital, the conclusion would be pattern balding or *thinning*.

EXAMPLE #4: WOMEN WITH HAIR BREAKAGE

Situation: A 35 year-old woman presents with complaints of hair *loss*. Her dark-rooted hair is straight, bleached and dyed blonde. The hair is 18 inches long hair and lacks luster. She uses a hot iron to straighten every other day. She was evaluated by a dermatologist and was told that all tests were "normal." A HairCheck breakage test is then performed on a random-sized bundle of hair.⁽⁴⁾ The 2 X 2 cm area does not need to be isolated. The hair is 16 inches long, so the bundle is measured proximally, then distally at 8 inches... at a site 50% along its length. The distal distance is arbitrary, and *any* distal distance may be used, provided it is the same each time the measurement is performed. The distal site is typically at 50% of the hair length. The results are expressed as "percent breakage at 8 inches" (or at 20cm, 6 inches, or whatever)

Results: The screen displays a Hair Breakage Index (HBI) of 36% at 8 inches. Translation: The woman has 16-

inch long hair, but 36% of her hair is no longer than 8 inches!

Conclusion: This woman has significant breakage. The average HBI for undamaged hair is less than 10% at a site 50% of its length. Very fine, *undamaged* hair averages about 15%. The patient is instructed to discontinue the hot irons, try to eliminate the bleach, use wide tooth combs and brushes, plenty of conditioners, gently handle the hair when wet, air dry rather than hot blower, etc. A deep protein conditioning treatment at the salon may be recommended as well.

Follow up: The patient returns in 4 months. Although it is preferable to repeat the HairCheck at the same site on the scalp, it is not essential. The size of the bundle is not important, but the distal measurement must be 8 inches. The HairCheck displays an HBI of 27%.

Summary: The patient has developed better hair care habits and her breakage has been reduced from 36% to 27%. She has improved 25% ($36\% - 27\% / 36\% \times 100$). Each month the fullness improves, the length increases, and she literally, has *more* hair. No *medical* treatment was required.

HOW TO DIFFERENTIATE DIFFUSE FROM PATTERN HAIR LOSS

Not infrequently, a woman will present with complaints of hair loss. On gross examination, it is unclear whether or not the loss is distributed over the entire scalp or simply on the top in an androgenetic distribution. A quick examination with a video microscope will often point one in the right direction if miniaturized hairs are seen. If there are miniaturized hairs on top of the head, and no miniaturized hairs in the occipital and parietal areas, the diagnosis is clearly pattern balding. But frequently the examination is not clear-cut and further steps are required. In that case simply measure the HMI on the top of the head, and at a site in the occipital area as well. Then compare the two values

Crown = Occiput suggests diffuse hair loss (shedding) or no pathology
Occiput > Crown suggests pattern hair loss (thinning)
Crown > Occiput suggests diffuse hair loss or no pathology (explanation below)

NORMAL DISTRIBUTION OF HAIR ON THE HEAD

There would be no confusion when differentiating pattern from diffuse hair loss, if the hair were naturally distributed *equally* over the entire scalp. But, hair density distribution in children, for example, is often highest on the top of the head, and *not* equally distributed over the scalp. Because physicians deal with pattern loss so frequently, many simply assume that the *normal* density is greatest in the occipital area. This is not the case. This distribution discrepancy must be taken into consideration when using the device to differentiate pattern from diffuse loss in women. It should be considered normal if the HMI of the crown is greater than the HMI in the occiput. If the HMI in the crown and occiput are both *both* reduced, then shedding or a state of ultrafine hair should be considered. (See ultrafine hair below.)

As men and women become older, there is general and diffuse reduction in both density and hair diameter. The disorder is called senile alopecia. Senile alopecia can occur simultaneously with states of shedding and thinning (pattern hair loss).

THE "SUPER-HAIR" SYNDROME

There appears to be a subgroup of women with a variant of "hair loss" that has not been previously described. Their chief complaint is essentially this, "I have much less hair than I used to have." The etiology of their loss appears to be a gradual reduction toward *normal* density, from what previously was an unusually *high* density.

The normal scalp hair density is 180 to 280 hairs per square cm of scalp. The average density is 230. A bell-shaped distribution curve assumes that some individuals have a hair density greater than 280. One could reasonably assume that those with densities greater than 280, might eventually drift to the center of the bell-shaped curve. This unique group of patients will experience significant hair loss and present themselves to the physician for diagnosis and treatment.

Although we have not performed a formal study, we have developed a general profile that describes those individuals with what we call Super-hair Syndrome. These women describe unusually “thick” hair as a teenager, difficult to comb and brush, with drying times that took forever, the envy of friends, and the delight of stylists. They are typically long-haired, brunette, well-groomed women between the ages of 25 and 40. Their loss has occurred over a period of 5-15 years and was not abrupt in onset. They’ve had extensive (and expensive) medical evaluations, and their history and lab results are completely negative for disorders associated with thinning and shedding. When density counts and hair bundle cross-section measurements are performed, the results are well within normal limits, often in the *high normal* range.

These distraught women are indeed actively losing hair, and may in fact continue to lose hair. In spite of this, they have a normal density. We suggest they compare their hair's fullness to that of their friends, to confirm how "normal" density looks and feels. We also suggest they return in 6 months for repeat hair count and/or bundle measurement... on the outside possibility that their loss might be an early indication of another disorder. We assure them that their density is normal, and has been scientifically confirmed by hair count and/or hair bundle measurement. In spite of our best efforts, they often leave the office unhappy, because they have much less hair than they previously had.

ULTRAFINE HAIR... REASONS FOR MEASURING THE AVERAGE HAIR DIAMETER

Many individuals are born with hair that is simply ultrafine. Fine hair is 60 microns; but the average diameter of ultrafine hair is actually 40 to 50 microns. The hair looks and feels like baby’s hair and breaks easily. The scalp skin is often visible when the hair is wet. A significant number of women present with complaints of “hair loss,” when in fact, these women simply have ultrafine hair. The HMI in the occipital region is essentially the same as the mid-scalp region, but both HMI’s are below the normal range of 75-100 (fine to coarse caliber hair).

Therefore, if the HMI in the occipital area is less than 75, one should measure the average diameter of the hairs in the *occipital* region. Do not take hair samples from the crown (a subclinical case of pattern balding may co-exist and the *normal* average hair density will not be obtained). Simply take a sample of 12 hairs from the occipital region and measure their diameter with an electronic micrometer. List the 12 values, discard the highest and lowest, and average the remaining 10. If the average hair diameter is less than 60, use the chart below to determine what the normal HMI would be for your patient with “ultrafine” hair.

100 microns = HMI 120 ultra-course
80 microns = HMI 100 coarse
70 microns = HMI 87 average
60 microns = HMI 75 fine
50 microns = HMI 63 ultra-fine
40 microns = HMI 50 super-fine

THE CONCEPT OF BASELINE VS CONTROL SITE HMI

Because the HairCheck device measures *both* the density and diameter of hairs in the captured bundle, the *normal* value for each individual will vary with the diameter of that patient’s hair. Ninety percent of patients with no hair loss have an HMI in the range of 75 to 100 – representing fine to coarse caliber hair. When evaluating patients for hair loss, the initial HMI measurement becomes the *baseline*. Compare subsequent measurements to the *baseline*. If the HMI increases or decreases, one may conclude there is growth or loss. An HMI less than

50 would be expected in an area of *visible* loss.

A *control site* measurement is only required when loss is *suspected* in the crown or vertex, but the loss is not yet visible. Remember... an individual must lose 50% of the hair mass before any loss is visible to the naked eye.⁽¹⁾ Therefore, one should perform a control site measurement when screening for hair loss in individuals with *normal-looking* crown and vertex. If the crown or vertex HMI is lower than the control HMI, one may conclude that there is early pattern loss, i.e. diameter reduction, not yet visible to the naked eye. With this method, it is possible to detect 5-49% hair loss, 10-15 years before the loss is visible to the naked eye.

If the HMI is less than 75 in the control site, the cause might be naturally ultrafine hair, or a state of shedding that co-exists with a pattern hair loss. In this case an average hair diameter measurement is suggested and should be performed using the above method. (see Ultrafine Hair)

NORMAL VALUES FOR THE HAIR BREAKAGE INDEX (HBI)

To evaluate hair breakage, isolate a random bundle of hair gathered from any area, where breakage appears. A 2cm. x 2cm. area does not need to be marked. Instructions regarding proximal, distal, and HBI readings are included in the device instructions and in Example #4 above. Measure the hair proximally near the scalp and distally, 50% out along its length.

What constitutes *significant* breakage? An HBI of 10% is considered normal for healthy, luxurious, shiny, hair. This 10% "breakage" value is actually the discrepancy in length resulting from the synchronization phases in a population of growing hairs. It is not unusual for healthy, unprocessed, *fine and ultrafine hair* to have an HBI of 15%. This otherwise healthy low caliber hair simply lacks the integrity of coarse high caliber hair, and breaks more easily.

HBI's greater than 15% should be considered as significant breakage. The tendency toward breakage is greatest when the hair is fine, ultrafine, chemically processed, poorly handled, hot ironed, bleached, dyed, sun-exposed, very long, very curly, with tendency to tangle.

False positive readings of significant breakage (greater than 15%) may be seen when:

- The patient is recovering from telogen effluvium. The newly re-growing, short hairs are interpreted as "broken" hairs by the device. In these situations, postpone HBI measurements for 18 months following childbirth, discontinuation of birth control pills, or any episode of significant shedding.
- The patient has a layered cut hairstyle. In these situations, the distal reading should be taken at least one cm below the length of the shortest layer -- otherwise the short cut layers will be interpreted as "broken" hairs by the device.

THE ECONOMICS OF HAIRCHECK

HairCheck evaluations do not require the physician's time. Any assistant in the office can learn to perform the three-minute measurement. (Instructional DVD is included) Patients with hair loss want to know the status of their loss -- if for no other purpose than knowing all is well and within normal limits. But they expect *real* numbers -- like cholesterol and blood pressure -- not their doctor's vague visual impressions. With HMI hair mass data, you'll feel more confident in your consultations, and you'll provide the patient with meaningful information. His/her questions will be easier to answer. Your proficiency as a *cosmetic* dermatologist will be enhanced.

Hair loss patients provide a steady income stream. Balding men, who present with otherwise unrelated problems, will frequently ask about their hair loss prognosis and treatment options. Sound medical practice

demands the establishment of *baseline* values before commencing with *any* medical management. Would you start a patient on a weight reduction program without having the patient step on to a scale? Patients accept the notion of tracking blood pressure, glucose, and cholesterol... and hair loss is no different. Once they know their HMI, they are highly motivated to return for follow-up hair mass measurements. Since AGA is a *cosmetic* disorder, these encounters may be billed as *cosmetic* services.

HairCheck evaluations may be performed on women with post partum effluvium. These patients are generally anxious and gain comfort knowing when their loss is no longer progressive. Many women with long hair are diagnosed with shedding, when in fact their predominate problem might be breakage (or breakage *and* shedding). Breakage is an easily treated disorder, and proper identification could reduce costly medical work-ups. Office visits for hair breakage may be billed as *cosmetic* services.

Men and women with hair loss are exposed to scams, deceptive marketing schemes, and exaggerated claims on the Internet, TV, etc. Each year, vulnerable patients spend millions for these questionably effective *hair growth* lotions and devices. With HairCheck, *you* can provide these misdirected patients with evidence as to whether or not their product of choice is actually working.

UNUSUAL CLINICAL CIRCUMSTANCES

In order for HairCheck to operate properly, the hair must be at least 1 inch long. If the patient's hair is less than 1 inch, simply have him/her return when it is of sufficient length. Hair grows at the rate of one half inch per month.

When used to measure breakage, specific circumstances might generate false positive data. This might occur if the patient is recovering from telogen effluvium. The newly re-growing, short hairs are interpreted as "broken" hairs by the device. Therefore, postpone HBI measurements for 18 months following childbirth, discontinuation of birth control pills, or any episode of significant shedding.

Breakage measurement should be cautiously performed in women with layered cut hairstyles. The distal reading should be taken at least one cm below the length of the shortest layer -- otherwise the short cut layers will be interpreted as "broken" hairs by the device.

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**HairCheck is a mechanical hair-measuring device.
The diagnosis and treatment of hair loss requires evaluation by a medical professional,
and should not be based on HairCheck data alone.**

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and

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