The Donor Area

This is a detailed discussion of the donor region, its science, and how we approach it from a diagnostic, as well as, surgical point of view. This is very detailed for the discriminating consumer, which is who we cater to.
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»Introduction

This chapter was co-written by John Cole and Walter Unger. Both authors will refer to themselves as third persons throughout the chapter because their views and practices are not always the same. References to "Unger" and "Cole" should be understood to represent the views of only that co-author unless otherwise indicated. In addition, both authors contacted many practitioners, privately, and their opinions are presented as "private communications" after obtaining their approval.

Perhaps the most important factor in predicting successful hair restoration surgery is appropriate patient selection by the physician and physician selection by the patient. There are four elements to this selection process: understanding the patient’s goals, the physician’s ability to meet the patient’s goals, conveying those abilities to the patient, and the patient’s physical examination. Three of these elements involve communication skills and a psychological or personal assessment, but are meaningless without the physical exam of both the recipient and potential donor areas, which is in fact the basis of a scientific approach to hair restoration surgery. This chapter deals with the examination and management of the latter.
Every donor region has specific characteristics that allow the informed hair restoration surgeon to customize an approach to the individual patient. Failure to recognize these individual characteristics does not always doom the hair restoration process, but it does limit the physician’s ability to precisely control it.

At one time, few truly objective findings were included in the assessment of the donor area. This is no longer the case. Alt, Unger, Rassman, and Bernstein might be considered the "fathers" of modern donor area assessment. Alt and Unger researched the limits of the safe donor area. Unger championed the concept of multiple donor sites for a variation in hair caliber and color. .1 Rassman introduced the need for an accurate measurement of the donor hair density and attempted to accurately quantify the available donor area. Bernstein introduced the important concept of hair volume. Collectively, their work has laid the foundation for the scientific assessment of the donor area and more accurate predictions of anticipated coverage. Unfortunately, despite their efforts, few physicians seem to recognize the importance of accurate donor area measurements.

Donor area management may be broken into the following individual components: delineating the "safe" donor area, the physical examination of the "safe" donor area and recipient area, the method of harvest and closure, subsequent procedures, efficiency of technique, and complications. Present knowledge as it relates to each component is presented in this chapter but it is worthwhile emphasizing that each requires further study.

» The ‘SAFE" Or "PERMENT" Donor area

This subject was presented in the third edition of Hair Transplantation, which was edited by Unger, and is reproduced below with slight alterations. It retains its importance without need of significant change:

The objective in all patients is obviously to use only donor hair that would have been permanent in its original site. What is less obvious is how one can be certain of this likelihood. Alt, in the second edition of this textbook, suggested that a line drawn perpendicularly from the external auditory canal should define the anterior border of this "safe" area. .1 The superior border was a more complicated affair, however. In most patients, his safe donor area began on the anterior border where it was 6.5 - 7.0 cm wide and steadily narrowed as one moved posteriorly. In the midline of the occipital area, he stated that the ultimate donor area is substantially narrower than it is superior to the external ear. (This is contrary to Unger’s study that will be discussed later.) Alt suggested that a horizontal line be drawn from a point 2 cm superior to the reflection of the skin of the external ear and the scalp. The point at which this horizontal line intersects the midline of the occiput was to be the superior border of the safe donor area at that location (Fig.1a). He noted that, obviously, in some individuals, the donor area might be wider or narrower at various points, but believed the foregoing perimeters would be valid for most individuals. In addition, he counseled – and we agree – that at least 2.5 cm of unharvested permanent hair be left superior to the most superior donor areas to provide adequate long-term camouflage of scar lines.

When deciding on the inferior border in the donor area, it is wise to remember that male pattern baldness (MPB) also affects the inferior aspects of the rim hair; therefore, one should leave an unharvested margin of safety at this level, as well as superiorly. Thinning inferiorly occurs later and less markedly than thinning elsewhere, but it is generally accepted that it usually does not occur to a cosmetically significant degree inferior to a line drawn horizontally from the inferior reflection of the skin of the external ear and the scalp to the midline of the occipital area. The inferior border, of course, should be decided upon after taking into account the patient’s age, family history, and findings on physical examination (see below), but if one accepts Alt’s superior border for the "safe" donor area, one would in many cases be left with only a 20 mm width of usable donor tissue as the ultimate in safety.

There are no substitutes for taking a careful history of the extent of baldness in family members and for carefully examining a prospective patient’s scalp for evidence of areas of future thinning. Wetting the hair is especially useful in delineating areas that, in the future, may be affected by MPB. The younger the patient is, the wiser it would be to keep within the borders suggested by Alt. As we shall see below, however, such a course may represent ultimate safety but is overcautious to a substantial degree in a large majority of patients. In particular, for at least the last 33 years, Unger has often gone further anteriorly in the temporal area than Alt's safe anterior margin.1 Age is an important factor in deciding how much of the temporal area (or other areas) can be used. The older the patient, the more confident one can be. However, Unger and others are grateful that many other surgeons appear to have agreed with Alt's advice. The temporal areas are often a largely untouched reserve of donor tissue in patients seen for repair of transplanting done by others.

In 1994, Unger et al reported on a study on 328 men aged 65 years or older. 1 The patients were subdivided into the following age groups: 65-69 years, 70-74 years, 75-79 years, and older than 80 years. The degree of alopecia (class I – VII Hamilton/Norwood) was noted for each. "Acceptable" donor sites in these individuals included only areas containing eight hairs or more per 4 mm diameter circle. The widest inferior-to-superior measurements of zones containing this hair density were recorded in temporal and parietal areas, as well as in the midline of the occipital area. In individuals with type I and II alopecia, the height of the donor area was arbitrarily limited to that of the individual with the greatest height in type III MPB. In addition, the distance anterior or posterior to Alt's safe anterior border, where acceptable density was found, was noted and is recorded under the title "anterior". (Table 1).

One can view the findings from two vantage points: (a) all men in the sample and (b) the majority of men in the sample that a transplant surgeon would most likely treat. The latter group might reasonably exclude those with types I and II MPB (although there are occasional exceptions), and to produce results that would be meaningful for most patients might exclude all type VII also. Why? If one analyzes Table 1 and excludes patients with types I and II from the sample, one would find that (a) in the age group 70-74, 57 of the remaining 69 patients (82.6%) have types III-VI MPB and (b) in the age group 75-79, 52 of the remaining 62 patients (83.9%) have types III-VI MPB.

It is worthwhile noting: (a) the average life span of a man in most parts of the world is less than 80 years of age; (b) more than 80% of the men between 70 and 79 who would likely be treated by transplant surgeons have types III-VI MPB (the percentage drops to 70.5% in the group 80 years or older but still represents a substantial majority); and (c) if one were to include patients with types I and II MPB, the percentage of patients with less than type VII MPB would be even higher. These figures should provide some comfort to many of us who have feared that a majority of our patients would progress to type VII MPB before they died. While there is no way of accurately predicting everyone who will fall into the latter group – no matter how small it is – it therefore appears it would be inaccurate to make this assumption for over 80% of our patients. If all of them were treated as if they were going to evolve into a type VII MPB, this would be patently unfair to them. There is no doubt that MPB is progressive for the lifetime of any patient. What should be reassuring is that only a smaller than expected minority live to the point where they reach class VII MPB.

Table 2 outlines the findings from the vantage point of all 328 subjects in the study: 55 aged 65-69 years; 81 aged 70-74 years; 73 aged 75-79 years, and 119 aged 80 years or more. Table 3 outlines the findings from the vantage point of those approximately 80% of patients with types III-VI MPB. There were a total of 216 patients in these categories: 33 aged 65-69 years, 57 aged 70-74 years, 52 aged 75-79 years, and 74 aged 80 years or more.

There are many ways one could use the figures shown in the tables to delineate a "safe" donor area. For example, one could take the lowest numbers for each parameter regardless of the age group in which it occurred. This, of course, would be the safest "safe" donor area but would also almost certainly be far more restrictive than a large majority of patients would require. One could also average the findings in patients 65-79 years of age (Table 3). This would also be an extremely safe donor area for over 80% of patients (under the age of 80). Such an area would consist of more or less a parallelogram in the parietal-occipital area whose inferior border would be chosen by the surgeon on the basis of, for example, 10 or more hairs per

4 mm diameter circle, the patient’s age, and the family history. The number "10" would provide a "cushion", allowing for a subsequent decrease in density with aging to eight hairs to 4 mm diameter circle. The number of hairs per 4 mm diameter circle could be increased if one wanted to approach the donor area in an even more conservative fashion. The superior border of the parallelogram would similarly contain at least 10 hairs per 4 mm diameter circle and would angle somewhat inferiorly, parallel to the post-auricular superior hair margin, as one moved from its anterior to mid-occipital borders. As I will show later in this chapter, this area alone is more than sufficient to provide for as many as six sessions. A narrower more or less parallelogram would sit on the inferior one, with its posterior border beginning in the mid-parietal area. Its anterior border could be 28.6 mm anterior to a line drawn vertically from the tragus and would be parallel to the anterior temporal hairline unless there were good reasons to suspect the area anterior to the tragus would not remain sufficiently dense over the long term. This superior parallelogram would be 10 mm high – again subject to clinical findings and family history. Its superior border would drop somewhat inferiorly as it progressed posteriorly to meet the midline point of the safe occipital donor area (Fig.1b). Lastly, in the mid-temporal area, the "safe" donor area could extend 55 mm superior to the superior parallelogram and then descend to meet the safe donor area in the mid-parietal area. A third way of using Table 3 would be to use the figures for patients 75-79 years of age and the dimensions shown in Fig.1b. This is, in fact, the "safe" donor area the authors prefer, as it seems to be a good compromise between caution and over caution. Each reader, however, is free to choose one’s own balance and one’s own "safe" donor area.

It is important to point out that this design incorporates permanent hair whose long-term density would be eight or more hairs per 4 mm diameter circle, but that according to this study, less dense permanent hair would persist superior and inferior to these boundaries in virtually all patients. Some of this less dense hair, in some patients, could be used as additional donor material if it were necessary. While eight hairs per 4 mm diameter circle might be a wise minimum if standard grafts were being harvested, transplanting with standard grafts has essentially ceased to exist. A minimum requirement of eight hairs per 4 mm diameter circle is probably too high a minimum density if one is using strip harvesting for follicular unit transplanting (FUT) and micro-minigrafting. In such cases, one is usually looking for grafts containing only one to six hairs, and the physician can simply increase the width of the strips to produce the desired number of FU or minigrafts. Thus, the acceptable donor area for strip harvesting for FUT and micro-minigrafting is almost always larger than that suggested by the above figures.

Unger believes that if one combines a) Alopecia Reductions (AR) or scalp extensions, b) total excision techniques in donor area harvesting as described in this chapter, and c) FUT or micro-minigrafting (to produce less dense coverage that still looks natural), with appropriate planning one can now reasonably expect to satisfactorily treat the entire area of MPB in a majority of patients. This is a remarkable advance from 10 years ago! His position is intentionally provocative and no doubt will lead to much debate. Key requirements are reasonable patient density objectives, a well-experienced surgeon, and a staged treatment of the recipient area using no more donor tissue than is absolutely necessary in any region.

It is important to emphasize, again, that a family history and clinical examination are necessary to confirm that the boundaries of the proposed "safe" donor area would be likely to apply to the individual being treated. One should always err on the side of caution. For example, 14 of Unger et al’s study patients did not have acceptable donor area density anterior to the tragus. In a very few cases, narrower parallelograms would be more appropriate or no acceptable donor area might be present. On the other hand, in many more patients, wider parallelograms would be warranted. The above-noted boundaries are not suggested as perfectly safe for all patients but represent the implications of the only objective scientific evaluation of this area ever done. Based on that investigation, they would be very safe in approximately 80% of patients under the age of 80 years. More restrictive areas can be chosen, for example, if one prefers to plan for patients who might live to 80 or more years or if the patient has a father or maternal grandfather with type VII MPB. Obviously, it bears repeating that the older the patient, the more certain one can be of the "safe" donor area.

» Physical Examination

There are several functions of the physical examination: (a) It should support the diagnosis of androgenetic alopecia, (b) It should qualify the patient for hair restoration surgery, (c) It should allow you to estimate the total amount of movable hair, the maximum width of excision for any particular procedure and the amount of donor tissue required for a particular procedure, (d) It gives you the opportunity to assess the impact of prior hair restoration surgery. The evaluations should ideally include, donor hair density (one or more areas), hair shaft diameter (one or more areas), scalp laxity, thickness of the scalp, degree of hair loss, color of the hair, skin color, hair wave, appearance of existing grafts, and results from any previous AR, percentage of miniaturized hairs and percentage of telogen hairs. The percentage of telogen and miniaturized hairs is obtained when a strip of hair bearing scalp is excised from the scalp and examined with 6 to 10x magnification. These percentages may, in future, prove to have practical value but at present their significance in hair restoration surgery is unknown. Recording all of the above parameters will allow for the development of the most scientific evaluation of donor tissue potential but, unfortunately at present, is carried out in its entirety by few practitioners. Each will be discussed separately below. In addition, the size and symmetry of the head can impact the procedure significantly. Asymmetry, for example, may have a positive, negative or neutral impact. A head, which is large in the donor area relative to the recipient area, may have a positive effect on the donor to recipient area ratio. A head, which has a broad forehead without a correspondingly large donor area, would have a negative influence on the donor to recipient area ratio. It should be clear from the preceding that although this is a chapter on the donor area, examination of the donor area alone without an examination of the recipient area at the same time, clearly does not provide sufficient information. Therefore, if one wants to accurately predict what can be accomplished with hair restoration surgery, a careful examination of the recipient area must also be conducted. This examination should include, like the donor area examination, such things as the shape, size, and asymmetry of the recipient areas as well as the degree of hair loss and the state of any previous hair restoration surgery. In this regard, it is important to also note that a circle and a square with the same circumference have markedly different surface areas. The circle’s surface area is much larger. Therefore, as you increase a more or less round or oval alopecic area’s circumference, it has an exponential effect on its surface area. While predicting coverage, with 100% accuracy is not currently possible, a thorough examination establishes realistic expectations. Future work should, therefore, focus on improving our methods of objective evaluations and calculations of donor and recipient areas.

» Donor Area Hair Density

There are three different densities we should consider in donor area assessments. The first is the number of hairs in a given surface area of scalp, the hair density. The second is the number of hairs per FU, the calculated density (See Chapters 6 & 11) for a description of the FU). The third is the number of FU in a given surface area, the Follicular Unit Density (FUD). Each parameter reveals specific information and will assist you in customizing your procedure to the individual patient.

Hair Density:

Many physicians subjectively assess the amount of donor area hair by simply combing the hair apart at various points in the proposed donor area and making an estimate based on previous experience. However, it obviously is much more accurate and meaningful to objectively measure the previously noted hair densities. There area several commercially available instruments that can help you in this taskto measure hair density. These include the Rassman Densitometer, the Welch Allyn Trichoscope, and the Kahn Densitometer. The viewing surface area of the Rassman Densitometer is approximately 10 mm2; while the Welch Allyn and Kahn are 12.56 mm.2 It is therefore easier to convert the density to hairs per mm2 with the Rassman Densitometer. The number of visible hairs in the 10 mm2 surface area is simply divided by 10. For instance, if 21 terminal hairs are counted, the density is 2.1 hair/mm2. The Rassman Densitometer also contains a light source and magnification, making it is easier to count hairs. This same instrument is available at Radio Shack (30x Microscope,Cat No. 63-851). The Kahn Densitometer has the same magnification as the Rassman Densitometer. However, it has no light source and because the viewing area is larger, there are more hairs to count. The latter two factors reduce the probability of an accurate hair count. It should be noted that all densitometers are commercially produced and not subject to strict scientific standards in their manufacturing. Therefore, it is possible that the viewing orifice is slightly different than presumed. The physician should verify the surface area of his/her densitometer prior to its incorporation into his/her practice. More recently, a number of other dermatological instruments have been developed and can be used to measure density. The most expensive and technologically advanced instruments use light electromagnetic waves and advanced computer programming to count surface structures.

Over the years, many physicians have attempted to determine the average hair density in the donor area. Unfortunately, there is a wide variation in their findings. The difference in values results from the difficulty in counting hairs, the extreme difficulty in measuring a defined surface area and a lack of standardization in the method -- for example, how many sites are examined and their locations. Table 4 notes the differences in hair densities reported by various investigators:

TABLE 45
Hair Densities according to Different Physicians

Wilson 1.54 hairs per mm
Pecoraro et al. 1.75 to 3.0 (Occiput 2.4 hairs per mm2)8.
Cottington et al. 2.11 hairs per mm2 in the left temporal area8.
Nordstrom 1to 2.4 hairs per mm2 (average 1.8 hairs per mm2)8.
Stough and Haber 1.44 to 1.76 hairs per mm2 (Average)
Rassman and Carson 2.0 hairs per mm2 (average density) Range 1 to 4 hairs per mm2.3Jimenez and Ruifernandez 1.24 to 2.00.
Cole 1.9 to 2.1 hairs per mm2 (average mastoid density).

Hair density usually decreases as we move toward the ear and increases as we move toward the occipital area in most individuals. (See below). Excising a donor area exclusively from the occipital area would, therefore, theoretically contain much more hair than the usual pattern of donor area harvesting. Bernstein recommends we measure density 5 cm lateral to the mid-occipital regions. Cole recommends measurement of density over the "mid-mastoid" area if a single site is assessed. This region is roughly half way between the occipital protuberance and the auricle. The measurement assumes you will remove a donor strip extending from near the ear to a line drawn vertically through the occipital protuberance (either unilaterally or bilaterally). However, because hair density varies from the mid-occipital region to the supra-auricular area, it is more accurate to measure density in more than one location along the proposed strip; a minimum of three locations is recommended. These three points are called reference points(Figure 3). With the head in the Franklin plane, they are located a) in the mid-sagittal plane at the occipital protuberance, b) three centimeters superior to the reflection of the helix on a line drawn superiorly from the external auditory meatus, and c) at a point half-way along the line connecting points a) and b) over the ipsilateral mastoid. This line is generally between 14 and 15 cm long, putting the mid-point between 7 and 7.5 cm from either endpoint. The three reference points serve as sites for all density measurements and are an attempt to standardize the examination of the donor area.

Using a Rassman Densitometer, Cole measured the hair density, hair diameter, and FU density in the aforementioned three reference points in 40 patients. He then calculated the hair densityhairs per follicular unit, calculated density, in each region. Table #5 6summarizes his findings, which confirm that hair density and FU density in "virgin" donor areas is generally highest in the mid-occipital region and least in the supra-auricular area. The density in the mid-mastoid area is usually somewhere between these two measurements. (Table 56).

	Left Auricle	Left Mastoid	Inion	Right Mastoid	Right Auricle
Density in mm2	1.8	2.1	2.4	2.1	1.8
Follicular Groups / 10 mm2	8.2	8.7	9.9	8.6	8.1
Diameter in m m	73.5	78.5	72	76.6	73.5

Rassman and Bernstein suggest the "safe donor area" consists of approximately 25% of the scalp and that only half the donor area can be removed without over-depleting it. They also contend the hair-bearing scalp is 80 inches2 or 51,613 mm2 and that the average scalp contains approximately two hairs per mm2.12 Thus, the average scalp contains approximately 100,000 hairs (51,613 mm2 x hairs per mm2).12 Based on these contentions, they have proposed Table 76 for quantifying the effect of donor area hair density on the number of hairs that are available for transplanting. This table is useful in helping the physician and his patients to understand the limitations of their donor areas and to customize the approach for each individual. It should, however, not be construed as absolutely accurate or obligatory since it is based on several assumptions and averages. In addition, as discussed previously, great variations exist with regard to the size and shape of the scalp, the size of the "permanent" donor area and even the number of hairs/mm2.

Donor Density hairs/mm2	Total Hair in Permanent Zone	Hair Must Remain in Permanent Zone	Moveable Hair	% Change in Density	% Change in Moveable Hair
1.0	12,500	12,500	0	-50%	-100%
1.3	16,250	12,500	3750	-35%	-70%
1.5	18,750	12,500	6,250	-25%	-50%
1.8	22,500	12,500	10,000	-10%	-20%
2.0	25,000	12,500	12,500	0	0
2.2	27,500	12,500	15,000	+10%	+20%
2.5	31,250	12,500	18,750	+25%	+50%
2.7	33,750	12,500	21,250	+35%	+70%
3.0	37,500	12,500	25,000	+50%	+100%

Table 7 - The effect of changes in donor area hair density on movable hair.

» Calculated Density (CD)

The average number of hairs in each FU or calculated density is an important quotient. The method used in obtaining or "calculating" it is described later. This number represents the mean number of hairs a person will receive with each FU, with each graft containing multiple FU and therefore with each procedure. For instance, if a person averages 2.3 terminal hairs per FU and you transplant 1000 FU, the patient will receive approximately 2300 hairs. The average 2 mm2 graft with a 2mm diameter contains between four and six FU. Hence, 100 grafts that are 2 mm2 in size2 mm in diameter, averaging 2.3 hairs per follicular unit and an average of 5 FU, would transfer 1150 hairs. The calculated density also helps to define the size of each graft. As the number of hairs in each FU increases, the size of the FU graft increases while if grafts containing multiple FU are being used to transplant a specific number of hairs per graft, this type of graft can contain fewer FU in order to reach that number, and can, therefore, be smaller. Grafts containing more than one FU can also be smaller than average if they are "cherry-picked" to include only sections of skin in which FU are closer together than average. (See Chapters 11 & 12). Furthermore, in FUT it allows the surgeon to customize the transplant by using FU containing different numbers of hairs in different locations. The calculated density combined with a determination of the FUD (see below) also assists you in predicting the amount of tissue you will require from the donor area. The calculated density also predicts the ratio of follicular units with a particular hair count. Table 8 outlines how the percentage of natural 1, 2, 3, 4, 5, and 6 hair follicular units changes as the calculated density changes. Knowledge of the calculated density allows the surgeon to customize the size of his receptor sites based on the anticipated number of natural follicular units of a particular size. A low calculated density predicts fewer grafts containing four or more hairs. In this case the surgeon would need to cut grafts containing multiple follicular units if a larger number of more dense grafts is desired. Conversely, the surgeon might consider single follicular units more appropriate when the calculated density is higher.

Table 8.

	%1	%2	%3	%4	%5	%6
Density 1.4	59	41	0	0	0	0
Density 1.5	47	52	8	0.2	0	0
Density 1.6	45	47	1	0.2	0	0
Density 1.7	38	53	9	0.3	0	0
Density 1.8	34	53	13	1	0	0
Density 1.9	30	52	16	2	0.02	0
Density 2.0	26	51	20	3	0.1	0
Density 2.1	22	51	22	5	0.1	0.02
Density 2.3	18	47	25	10	1	0.06
Density 2.4	15	44	29	10	1	0.2
Density 2.5	14	41	29	14	2	0.4
Density 2.6	11	38	31	18	1	0.5
Density 2.7	11	36	32	14	4	2
Density 2.8	9	32	33	19	6	1

» Follicular Unit Density (FUD)

The follicular unit density (FUD) is important because it helps you predict the number of FU you will transfer from a given amount of excised donor tissue. To determine the FUD, count the number of FU in the surface area of your densitometer. Extrapolate these numbers to a square centimeter. This value gives you an estimate of the number of FU per square centimeter at that specific reference point.

If your strip is limited to the mid-occipital area, you will need to know only the FUD in the mid-occipital area. Should your strip extend from the mid-occipital region to the supra-auricular area, you should take the average of the three FU densities at the three reference points referred to earlier. This number will give you a reasonably safe estimate of the number of FU per square centimeter in your donor strip. Now you are prepared to calculate the number of FU in the tissue you propose to excise. Suppose your donor strip extends from 3 cm superior to the right auricle at the external auditory meatus to the occipital protuberance with the head in the Franklin position and the length of your strip is 15 cm (see below). You measure the density of hair in the mid-occipital, mid-mastoid, and supra-auricular regions as 260 hairs per square cm, 210 hairs per square cm, and 140 hairs per square cm, respectively. The FU density at each reference point is 100 FU/ cm2 in the mid-occipital region, 80 FU/ cm2 in the mid-mastoid region, and 60 FU/ cm2 in the supra-auricular region. The calculated densities in the mid-occipital, mid-mastoid, and supra-auricular areas are 2.6 hairs (H) per FU, 2.63 hairs (H) per FU, and 2.33 hairs (H) per FU, respectively.

The average number of FU or groups in this 15 cm area is the average of the three FU densities (100 + 80 + 60) / 3 or 80 FU per square cm, and a 15 cm will yield approximately 80 FU per square cm. A 15 cm strip excised with a 2-bladed scalpel set at 1 cm between the blades will therefore yield approximately 1200 FU. If you take the average of the three calculated densities (2.6 H/FU + 2.63 H/FU + 2.33 H/FU / 3) or 2.52 H/FU, you may estimate the number of hairs you will be moving. This formula involves multiplying the average number of H/FU by the total number of FU in the donor strip. In this case, the number of hairs is safely estimated at (2.52 H/FU X 1200 FU) or 3024 hairs.

Suppose you want to obtain 300 single hairs from this tissue. If all single hairs are removed from the most medial region of the scalp, and the average number of hairs/FU in that area is 2.6 H/FU, you may divide the number of desired single hairs by mid-occipital area calculated density (300 / 2.6 H/FU = 115) to obtain the number of FU required to produce this number of single hair grafts by dividing all FU into single follicles. You must subtract this number of FU from the predicted total and add the number of single hair grafts to determine the total number of grafts in the donor strips. In this case, (1200 FU – 115 FU + 300 single hair grafts) or 1385 grafts can be expected from the excised donor tissue. To this number you must also add the number of grafts and hairs from the tapered ends. Generally, we find approximately 30 to 50 additional FU in each tapered end and these ends are usually mirror images of each other. If you use the trapezoid closure (described later in this Chapter) the two triangular-shaped ends can be combined to form a 1 cm2 (Figure #). In the example we have been using, the average number of FU from the two ends is {(100 FU + 60 FU) / 2} or 80 FU. Therefore, we could anticipate approximately 1465 grafts (1385 + 80 FU), or 3226 hairs (1200 FU x 2.52 hairs/FU) + (80 FU x 2.52 hairs/FU).

The following formulas are useful in understanding the three types of density and estimating the total number of hairs transferred:

Density = D = The total number of hairs in a given surface area or (Hair/ cm2)

FUD = FD = total number of follicular units in a

given surface area or (FU) / (cm2)

Calculated Density = CD = {(D) / (FD)} = Hairs / FU

Total Hairs Transferred = THT = (Mean CD) (Mean FD) (cm2 excised)

Which simplifies to:

Total Hairs Transferred = THT = (mean density) (cm2 excised)

Counting hairs is much more difficult with the Rassman densitometer and other type of densitometers than with a microscope. Therefore, it is more accurate to count the number of hairs/FU (CD) after excising the tissue from the donor area. Counting larger entities such as follicular clusters or FU is much easierprecise with a densitometer. It follows that the most accurate means of estimating the total number of hairs transferred would result from noting the FU density with a densitometer and the calculated density with a microscope.

The CD is noted for up to three reference points along the strip. FU density and hair density estimates, after donor excision, are not accurate because the donor tissue shrinks an estimated 5 to 10% following its removal from the donor area. A 5% reduction in the surface area of the aforementioned strip would increase the density of the 1200 FU to 89 FU/cm2 from 80 FU/cm2 (an 11% increase). A 10% reduction in surface area would increase the FU density to 99 FU/cm2 (a 24% increase). Therefore, the densities increase proportionately (11 to 24 %, and sometimes more) after donor tissue removal.

In this instance, the mean FD is noted in the three reference points with a densitometer, whose surface area is known. The reference points are then circled with a marker. Once the strip is excised, the reference points are noted. Within each reference point the total number of hairs from a given number of FU is counted with the aid of a microscope set at 10x to 20x. The total number of hairs is divided by the sum of the FU investigated. The quotient is the CD. This FD and CD are plugged into the formula for THT to arrive at a more accurate estimate.

Summary:

In summary, hair density quantifies the number of hairs per unit of area. It suggests how many hairs and grafts are available from part or all of the donor area. A high CD suggests that FU grafts may be larger simply due to more hairs and their associated perifolliculum while grafts containing multiple FU may be smaller if a fixed number of hairs/grafts is desired or if such grafts are "cherry-picked". HairCalculated density also suggests how many hairs are present in any size graft. As noted earlier, despite all this potentially useful information, currently, few physicians measure hair density during the donor area examination. The previous discussion is intended to provide a template for maximum accuracy and for investigators, but many clinicians would find such measurements and calculations cumbersome and too time consuming (although they could be assigned to a trusted assistant). An easier method to estimate the total number of hairs moved is to simplify the equation by taking the average of the three densities and multiplying this by the surface area removed from the donor region. In our example case, the surface area is 15 cm2 (plus the tapered ends) and the average density is 2.033 hairs / mm2. This corresponds to 203.3 hairs per square cm. Hence, the surface area would yield an estimated 3253 hairs [(15 cm2 + 1 cm2 for the tapered ends) (2.03

hairs/cm2)] or only 27 more hairs than the more accurate calculations. Finally, it is very useful to record (a) the number of h, FU, and grafts obtained after graft preparation is completed and (b) the length and width of the excised strip. In subsequent sessions, one can then maintain or alter these numbers by taking the new donor strip directly adjacent to the scar from the earlier harvest(s), and by excising a strip that has the same, less or more length and/or width.

» Other Methods Of Estimating And Obtaining Required Donor Tissue

The evolution of FUT and mass marketing in medicine has led most physicians to quote costs for hair transplanting as being determined, at least partially, by the number of grafts transplanted. In addition, patients are better informed about the procedure via advertisements and the web. These sources may or may not be misleading and intelligent individuals will arrive at the consultation with specific questions and often some level of skepticism. The result of the foregoing is that one of the most common questions asked, is "How many grafts do I need to have transplanted?"
This of course is one of the most important questions a hair restoration surgeon needs to answer for himself in order to be able to estimate how much donor tissue he has to excise to create the desired effect. Unfortunately, this number is dependent on numerous factors that will include the patient’s objectives, hair/skin color contrast, hair caliber, wave, curl, etc. – and the types of grafts the physician intends to use. In an attempt to come to some type of concrete and consistent way of making this estimate, a number of operators have arrived at different techniques for estimating a) the size of the recipient area and b) at least the number of FU they must harvest to treat that area; they are described below.

As a by-product of that estimate physicians also then have a way of conveying the likely cost of the treatments and the coverage that number of FU will produce. It is important to emphasize again, however, that even very careful estimations of the number of FU required, are subject to the aforementioned variables, as well as to changes in the patient’s density or coverage objectives as a number of sessions are carried out. Thus, calculations for the above-noted purposes should always be clearly conveyed to the patient as only "estimates".

The less scientific "estimates" of the size of the recipient area and the number of FU necessary to produce a desired effect in that area as described below by Bessam Farjo and Steven Chang, are useful for conveying general concepts to patients and physicians and they are easy to carry out, making them more practical for most practitioners than Cole’s method which has just been described. There is, of course, another purpose to most accurately estimating the number of FU a given size of donor tissue contains; it provides a mechanism for calculating the skill of you and your technicians in producing the hoped for 100% yield of FU from that strip – both before preparation and insertion of the FU and after the FU have been given the opportunity to regrow in the recipient area. In other words, a very accurate estimate of the number of FU in the donor strip is the best way of furthering the scientific basis of hair restoration surgery. Cole’s method is a better one for this purpose than either Farjo’s or Chang’s.

Once again, in hair transplanting, different techniques have different strengths and weaknesses.

It is also worthwhile keeping in mind that although it is widely believed that the density of scalp FU is a consistent 1 FU/mm2, this is not true according to Cole's studies.14, FU density in the mastoid and temporal regions is often less than the 1 FU/mm2 which is often found in the vertex and mid-occipital regions.14 Thus, what is required in some areas to produce an appearance of "normal" density may be greater or less than the often quoted "50% of original density" or 50% of 1 FU/mm2. In addition, depending on hair characteristics, 50% of original density may or may not be necessary to create this effect.

The Chang Method:

Chang begins his method of estimating the number of grafts necessary to treat a recipient area by marking the proposed recipient area on the scalp of his patient with a "china marker". He then applies a transparent sheet (plastic food-wrap) over the scalp and traces the area to be covered on the transparent sheet. (Interestingly, three years earlier, Cole described assessment of the recipient area for purposes of donor area assessment by tracing its outline on a transparent sheet. This transparent sheet is then placed over a specially designed graphic paper that has been divided into large and small squares (Fig. #). Each small square is 1 cm2 and each large square is 4 cm2. By doing this one can estimate the approximate recipient area size in square cm. A digital photograph of the scalp with the recipient area marked in by china marker is taken and kept on file in the patient's chart as is the photocopy of the transparent sheet. A copy of the graphic paper that Chang uses can be downloaded from the website: http://www.hairtransplant.com/Spencer.pbf. Chang states that 90% of his patients are satisfied with 50% of the donor site density, although he also notes that this, of course, depends on the patient's hair color/texture, skin color, contrast between skin and hair color and the patient's age. However, for the average patient, they attempt to reproduce the 50% density in two sessions. In an alopecic patient, for example, they attempt to create this 50% density in two sessions of 25% density each. Thus, if the bald area is 100 cm2 they must harvest 25 cm2 of donor area in each session in order to produce 25% of the donor area hair. The number of grafts that can be obtained from this amount of donor tissue is easily calculated. Based on the assumption that there is one FU per mm2 (as noted earlier, this is not an entirely accurate) 1 cm2 can therefore be expected to produce 100 grafts and 25 cm2 2500 grafts. Chang is careful to not tell patients how many grafts are contained in 1 cm2 of their donor strip. They are told only that he will deliver 25% of their own density per session. Using the previously noted example, in order to cover 100 cm2 of alopecia he harvests 25 cm2 of donor tissue. This should produce 25% density and there is no need to count how many hairs are present in the donor strip in order to reach 25% of the donor strip density. The advantages of this approach are listed in an article published in Hair Transplant Forum in July/August 2001 (Chang, Stephen, estimate number of grafts and donor area, Hair Transplant Forum International 2001, Vol. 11 No. 4, pgs. 97-102).
The Farjo Method:

Bessam Farjo has described a different method of estimating the size of the recipient area and therefore the number of FU necessary to treat it. (Farjo, Bessam, estimating graft numbers made easy for the recipient site, Hair Transplant Forum International 2001, Vol. 11, No. 4, pg. 101). His method is based on conceptualizing the recipient area into simple geometric shapes, essentially triangles, rectangles, squares, or circles. For example, the frontal forelock shown in Fig.#4a can be conceptualized as a triangle. As shown in Fig. #b4b, the area of the double-line triangle will provide a good estimation of the area of the forelock. The area of the triangle = A x B, where A is the distance between the anterior and most-posterior point of the base of the triangle in the mid-line (not the base of the forelock) and B is equal to half of the base of the triangle. For example, if A=10 cm and B= 5 cm, then the area of the triangle and the isolated frontal forelock would be 10 x 5 = 50 cm2. Cole first described the triangular method of assessing the surface area of the recipient area using triangles in 1998, at the Orlando Live Surgery workshop. For transplanting a moustache.* with moustache hair restoration at the 1999 Orlando live surgery workshop. When dealing with the vertex area the shape is conceptualized as being a circle (Fig. #6) and the area is equal to radius 2 x Pi. For example, if the diameter of the circle is 10 cm then the area = 5 x 5 x 3.14 = 78.5 cm2. In estimating a total recipient area, which includes both the frontal mid-scalp and crown area, Farjo accepts Cole's suggestion to conceptualize the recipient area as a long oval (Fig. #5). The surface area of a long oval is equal to (A/2) x (B/2) x Pi.17 If only half of the recipient area is to be treated, for example, either the anterior or posterior half, then the total area is simply divided by 2.
It is worthwhile repeating that Cole's method of estimating the number of FU contained in a donor strip is far more complicated than those of Change and Farjo, but it is also considerably more accurate and more useful for scientific investigation.

» Estimating Donor Tissue For Grafts Larger Than FU

While the above discussion addresses methods of calculating the number of FU that are required, many practitioners employ a combination of graft types. When round trephines were used to remove grafts it was easy to predict graft counts. If fifty 4 mm standard size round grafts were removed, this resulted in fifty 4 mm grafts, 100 "hemi-grafts", or 200 "quarter grafts". The advent of strips of various sizes and ellipses made accurate estimates more difficult to achieve. To complicate matters further, the size of grafts decreased and the number of grafts increased.
Although Cole no longer employs the multiple strip technique, he has used it successfully in the past for what is now commonly referred to as "micro-minigrafting" and total follicular unit transplantation. His multi-FU grafts consisted of up to six hairs (rarely seven hairs) while his FU consisted of predominantly one to three hairs with an occasional four-hair graft. With multiple strip excisions, he produced the results shown in Table 7 with minimal waste.

TABLE 79

Unger routinely records the number of different types of grafts produced from the strips obtained during the first session of transplanting – the details of which are described later in this chapter. This record, which is kept in the patient’s file, then serves as a guide as to what size strips, both length and width, are necessary to achieve the objectives of later sessions. Most of his patients are treated with micro-minigrafting, and neither he nor they, are as concerned with the ability to very accurately anticipate the number of grafts created and transplanted per session as it appears most physicians employing exclusively FU seem to be. If too few are obtained from the initial harvest, he simply goes back and excises a small extra donor area, or makes up for the "shortfall" in a subsequent session. If more than the desired number of grafts is obtained, he treats a slightly larger area of the present or future areas of hair loss. With experience, neither of the above occurs with any significant frequency. There are, in his opinion, too many variables in technique and staff skill, to provide any consistently accurate estimating mechanism for all surgical teams.

Finally, all of the preceding discussion has dealt with various concepts of estimating the number of hairs that are being transplanted, but hair "bulk" or "mass", and therefore the apparent fullness of hair, is due not only to the number of hairs transplanted, but also the diameters of the hair shafts. This is discussed in the following section.

HAIR SHAFT DIAMETER

The importance of the hair shaft diameter cannot be overstated. It is the most important predictor of "coverage" in hair restoration surgery. To understand its effect, we must first define "coverage". "Full coverage" may be defined as reflection of light waves corresponding to the wavelength of the hair. Thinning may be defined as reflection of light waves corresponding to the wavelength of both the scalp and the hair. Alopecia is defined as reflection of light waves corresponding predominately to the color of the skin. The greater the surface area of the transplanted hair, the greater the coverage resulting from the transfer of a specific amount of hair.

Surface area of a hair is defined by the formula:

Area = 2 p r2 + 2 p rh

Where r is the radius of the hair shaft and h is the length of the hair.

Since only approximately one half of the hair shaft reflects light, the formula may be simplified to:

Area = p r2 + p rh

Variations in surface area are smaller than variations in volume. For this reason, it is easier to mathematically appreciate see the significant changes in volume from slight changes in hair diameter.

Volume (V) of a hair is defined by the formula:

$$V = p\ r2h$$

Where r is the radius of the hair shaft and h is the length of the hair.

The total hair volume, resulting from a specific amount of hair transferred, would by defined by the formula:

$$V = (THT)\ p\ \grave{}\ r2\ h$$

Where THT is the total hair transferred and ` r2 is the mean radius squared.

Notice that by doubling the mean diameter you quadruple the hair volume. By doubling the length or the number of hairs transferred, you merely double the hair volume transferred. Therefore, diameter is far more important than any other factor in predicting coverage from any given amount of hair transferred. Hair length, however, is a variable controlled by the patient, unlike his hair diameter and total donor hair "bank". Hair length can be hextuppled or even grown longer, which offers the patient a means to significantly increase his/her hair volume. Hair length is the second most important factor in predicting coverage, but only as long as the added length is within the bald surface area (see later in chapter).

Hair shaft diameter can be measured with a number of commercially available micrometers. The Starret Digital Micrometer (Sears and Roebuck Catalog), which Cole began using in 1996, is useful for rough estimates, and the Mitutoyo Digital Micrometer for more accurate measurements (Micro Enterprises, Norcross, GA). It is also possible to use a micrometer attached to a microscope. Fine-textured hairs generally allow for more dense packing and smaller recipient sites. As a result, they may or may not result in less coverage. More coarse hairs usually require larger recipient sites, possibly fewer grafts in a given recipient area, and produce better coverage per hair but if planted more sparsely than fine hair, may not produce better overall coverage.

Scalp "compliance" plays a role in the choice of how closely grafts can be placed, as well. Inserting grafts into the scalp always increases the tissue volume. If the scalp has minimal "compliance", the increased volume of each graft exerts pressure laterally, thereby decreasing circulation somewhat and also making the insertion of grafts into adjacent recipient sites more difficult. As scalp compliance increases, the size graft or the number of grafts a given recipient site will accept increases. Scalp compliance is subjective, and understanding it only results from experience. A clue to scalp compliance is derived at the time the donor strip is excised. If you notice that the skin has a tough, leather-like nature during excision and/or that donor area closure seems surprisingly tighter than you expected, it is important to perform test sites and insert some grafts prior to making all the recipient sites. If you undermine the donor strip with a scalpel blade and the blade becomes relatively dull during the excision, this is also a good indicator that the tissue is "harder" than average and the scalp may have a lower compliance.

According to Bernstein, scalp hair diameters range from 60 to 140 micrometers. ** Cole has found a much wider range of scalp hair diameter: 20 micrometers to 128 micrometers. He rarely sees scalp hairs greater than 110 micrometers and the largest mean diameter of donor hair measured to 2001 was 105 micrometers. In a study of 40 patients, using 45x magnification, Cole looked at the regional variation in hair diameter at the three reference points described in the section on hair density in this chapter. He found the following mean diameters: left supra-auricular area 73.5 micrometers, left mastoid area 78.5 micrometers, mid-occipital area 72 micrometers, right mastoid area 76.6 micrometers and right super-auricular area 73.5 micrometers.

This regional variation suggests there is a predominance of finer textured hairs in the mid-occipital and supra-auricular regions, and a predominance of coarser hairs in the mid-mastoid area. Unfortunately, the mid-occipital area contains not only the finest hairs, but also often contains the highest number of hairs per FU. (It also tends to contain the highest FU density and thus the highest calculated density). It therefore becomes more difficult to isolate single hairs for the hairline when the follicular unit densities and calculated densities are higher. Hair caliber also tends to decrease as one moves anteriorly towards the supra-auricular region and inferiorly in both parietal and occipital areas.

Hair in these latter areas may become finer with the passage of time, but usually there are some finer textured hairs in both sites that one can be reasonably sure will not do so to any significant degree. Unger has recommended such hairs, for many years, for transplanting the frontal hairline. * In the days before micrografting, excellent hairlines could be constructed with grafts taken from such sites because of their somewhat sparser and finer hair. (Fig.#7) These hairlines only improved with age. IF the hairs in these areas became progressively finer, and/or some were lost entirely, the hairline became more ragged and natural looking.

From the preceding discussion, it should be obvious that you cannot determine mean hair diameter by looking at a single hair. One must look at a minimum of 10 hairs and preferably 20 or more hairs in making this determination. (The more hairs, the more accurate the figure.) In determining mean diameter, Cole also does not include any hairs that are less than 50 micrometers in diameter unless they are the predominate type of hair in the group. If, for example, he were looking at 20 hairs, he would not include a single hair measuring 42 micrometers. Furthermore, he disregards hairs that are well over the prevailing measured diameter, unless there are a significant number of them (for instance greater than 25% of the sample). If the majority of hairs measured were between 55 micrometers and 72 micrometer, he would, for example, discard a measurement of 95 micrometers. In this way, the predominate width of hairs is measured and a measurement closer to the true mean is determined.

Cohen argues that the variability in hair diameters makes it difficult if not impossible to determine an "average" or "mean" diameter. * Cole disagrees with this assessment and believes that if the sampling of hairs is large enough it is possible to arrive at a meaningful mean hair diameter for that individual. Furthermore, while it is impossible to identify a person by a single hair, it is often possible to rule out a person if sufficient hairs are sampled. Some people, for example, have generally finer hair, while other people have generally coarser hair. Therefore, mean hair diameter assessments must have some predictive value. Seager, on the other hand, feels the mean diameter is the same regardless of the donor area location.* Cole again firmly disagrees but, of course, the measurement of multiple hair samples is necessary to most accurately determine the mean hair diameter. Furthermore, he claims that the variability in diameter is so striking that it is possible to visualize the differences between individuals with only a Rassman densitometer.

Vellus hairs have been defined as being less than 30 m m in diameter, of limited length, and reduced color. *15 The effect of these hairs on total hair surface area and volume is so limited that it seems to make little sense to include them in calculations of the mean hair diameter. For the same reasons, as noted above, one should probably not routinely include hairs that are less than 50 m m in diameter. Generally, the proportion of these hairs in the overall number of hairs moved is small. It would be of value to quantify these hairs to reinforce these or modify these suggested principals of calculation, because their exclusion does not mean that they have no impact on the illusion of coverage. Rather, the finer ones have a more limited impact, while the larger ones have a more marked impact on volume. In addition, both because of their size and lesser pigmentation, the smaller hairs are much more difficult to count during the graft production phase. As a result, they are often not included in the final hair count. This is particularly true when the epithelium is removed from the grafts.

According to Whiting, there are seven terminal hairs for every one vellus hair in the normal crown. * This represents14.3% of hair at that site or 143 vellus hairs for every 1000 terminal hairs. If this trend held true in the donor area, it is likely that most technicians would not see or count 14.3% of the hairs present in the donor tissue. There are, of course, other hairs whose diameters are greater than 30 m m and less than 50 m m, which also are less pigmented than average. These hairs would have a reduced probability of being included in a technician's hair count. In studies Cole has performed in his office, technicians did not include as many as 20% of the hairs that he had originally counted in the donor area. Some of the missed hairs may not have been counted due to trans-section, however, he believes that the majority were not counted as a result of their limited size and pigmentation. Of course, it is more difficult to count miniaturized hair in Cole's office because he prefers to remove the epithelium from his grafts. Thus, in a patient with non-pigmented hair, the disparity in true hair count and technician count would almost certainly widen.

» Classification of Hair Diameter

Hair diameters may be grouped into several categories: very fine, fine, medium-fine, medium, medium-coarse, and coarse. The following chart attempts to numerically define them according to mean hair diameters.

Very Fine	Fine	Medium-fine	Medium	Medium-coarse	Coarse
< 60 m m	60 – 65 m m	65 – 70 m m	70 – 75 m m	75 – 80 m m	> 80 m m

As noted earlier, it is possible to calculate hair surface area and hair volume and predict coverage based on this calculation. Patients with mean hair diameters greater than 70 m m and a Norwood Classification less than or equal to V are generally much better candidates for the illusion of full coverage from hair restoration surgery. When treating patients with a mean hair diameter less than 70 m m, it is often better to limit transplanting to only the frontal area or the frontal and midscalp areas because they have less total hair mass to move and, therefore, one is often unable to achieve the illusion of as much coverage. A number of variables can affect this generalization: (a) a high FUD and calculated density improve the potential coverage (b) wavy, curly or kinky hair can improve the illusion of coverage (c) a smaller color contrast between the hair and skin create the illusion of denser hair (see also below) and (d) hairs sometimes change their characteristics after transplanting – for example, becoming more wavy – and thus, may increase the impression of greater than actual hair density.

Despite the foregoing, Unger has pointed out at several medical meeting, that one of the most remarkable phenomenon in hair transplanting is the fact that one is actually usually transferring a very small amount of hair per session and yet, one can achieve the appearance of full, or nearly full coverage, over a relatively large portion of the area of MPB. The reasons for this are discussed later in this chapter. The photo shown in Fig. 8# demonstrates the amount of hair clipped from a typical donor area by Unger (approximately 1.2 cm x 24 cm), prior to excising most, but not all, of the area. (Usually, the tissue actually excised is only 8 to 10 mm wide). This relatively small amount of hair is typically expected to produce acceptable coverage after two or three sessions to the frontal area of a man with, for example, type V or sometimes, even type VI MPB. As noted in Chapter 6 it will also be used to treat not only presently evident thinning but also areas that currently have hair that is expected to be lost in the future. Examples of the type of coverage that can be expected with this approach are shown in Figure #Y,9 and elsewhere in this text.

As an extreme example, the patient shown in Fig. #Y9 had type VI MPB and a donor area with dense hair, but that was only approximately 5 cm wide before transplanting began. A wide zone of very sparse hair was present inferior to the area with dense hair, but was totally unusable for transplanting because of both its sparseness and the fine texture of the hair within it. A single donor area was used, with the scar from previous sessions being excised as part of each new harvest. He is shown in Fig. # after five sessions (and two AR's) with light, but effective, coverage over the anterior three-quarters of his original area of MPB (his chosen objective). How was it possible to create this illusion with so little hair? For that matter, how is it possible to do so much better in most patients who have better donor/recipient area ratios but in whom we are, in fact, only transplanting per session, the hair shown in Fig. #8. A small amount of hair somehow goes a long way. As noted in Chapter 6, part of the reason so much apparent coverage is possible is because the hair in the recipient area will usually be grown longer than the hair that is clipped in a typical donor area. This extra length not only results in more hair volume, but also because of its length, can be layered hair over hair in the same way as one shingles a roof. Wherever such layering is not present, for example, at the "part" or center of the whorl of the vertex, the illusion falls apart and the area must be treated more often to create an appearance of coverage equal to that of adjacent areas that are layered. Patients who complain of being able to "see the scalp" at such sites must be reminded of this fact, but of course should be forewarned of it during the initial consultation.

SCALP LAXITY

Scalp "laxity" and elasticity are not synonymous although these terms are frequently misused in that fashion. Gerard Seery has described, "scalp laxity" as being composed of two distinct components. His description of these and their implications are worthwhile quoting:

"The first component of scalp laxity is the ability of the scalp to slide or glide on the underlying pericranium. This is possible because the loose fibroareolar tissue in the subgaleal compartment allows the scalp to be moved on the cranium. This has nothing to do with the stretching or the elastin content of the skin and is simply a mechanical movement of the scalp on the pericranium. In a scalp with a high capacity to slide/glide, an excision of 4 cm or more (if made parallel to Langer’s lines) may be possible and closure easily effected. Operations that take advantage of the scalp’s capacity to glide, rather than stretch, are virtually complication-free and result in negligible topographical distortion of tissues. (The analogy of pulling a carpet over a polished floor comes to mind. The carpet and the furniture are moved but their topographical relationships to each other are not changed nor are the physical components of the carpet altered). Scalp surgery that utilizes the scalps facility to glide is highly effective and minimally traumatic to tissues. The relatively restricted width of donor strip excision in the temporal area is the result of the lateral extremity of the subgaleal space not extending that far laterally i.e. the galea blends with the temporalis fascia and results in only three layers of tissue being present in the temporal area.

The second property of scalp laxity is its extensibility or ability to stretch. It is reiterated that this is independent of the sliding phenomena. Some scalps are highly elasticized and reasonably wide strips can be removed by undermining and stretching but this is relatively much more detrimental to tissue viability, and often the formation of fine scars, than sliding.

The net consequence of the above is that notably wider horizontal strips can be taken from the superior donor area (because the subgaleal fibroareolar layer allows the gliding described above) than in the lower area. As much as a 2 cm width or more may be taken in the higher regions of the occipital scalp and closure effected without difficulty. In the inferior donor area, where there is no subgaleal fibroareolar layer, the width of the strip taken is determined by the skin extensibility (loosely termed elasticity) and subcutaneous tissue. Here a horizontal strip as narrow as 1 cm may result in difficulty with closure. It must also be remembered that some scalps have relatively poorly developed fibroareolar layers i.e. are "tight scalps" in which the gliding phenomenon is minimal. This is easily determined by simply placing the pulps of the examining fingers on the scalp and moving them on the underlying pericranium. The orientation of the lines of minimum tension (Langer's lines) also play a part in determining the width of the strip that can be taken.*

At the midscalp, crown and going down into the scalp's upper donor area, Langer's lines are largely vertical and allow generous excision of tissue taken in a vertical axis. Conversely, there is an associated relative limitation in excision widths in the horizontal axis (because here Langer's lines proceed are cross-cut), but this is more than compensated by the tissue laxity provided by the fibroareolar layer in the upper donor region. As Langer's lines proceed inferiorly into the mid donor area, they increasingly assume a too horizontal orientation and in the inferior part of the donor area are entirely horizontal. This facilitates a relatively wider donor strip excision in the inferior donor area than would otherwise be the case but this does not nearly compensate for the absence of the "gliding" subgaleal fibroareolar layer present in the upper donor area.

Bosley outlined a method of objectively assessing scalp laxity for AR. He quantified the decrease in distance between two dots on either side of the alopecic area following manual compression between both thumbs and index fingers. * Norwood proposed a somewhat similar means of evaluating scalp laxity. He counted the number of folds created on the alopecic scalp as a result of manually compressing the temporal regions of the scalp toward one another*.

Scalp laxity of the donor area, unfortunately, still remains entirely subjective. One can estimate scalp laxity at that site by manually compressing two anatomically different regions toward one another, or the skin can be moved up and down to get a sense of laxity, but a standard and objective method of assessing laxity in the donor area is still required. Until one has evolved, we can, at least, suggest grading scalp laxity as "tight, moderately tight, slightly tight, average, slightly loose, moderately loose, or loose".

In general, a tight scalp requires a longer, narrower incision to move a given amount of hair than a loose one because the donor wound should ideally be closed with minimum tension. Limitations in the width of donor area excisions are reduced further with multiple excisions in the same donor region as part of subsequent sessions (see below). Failure to recognize a tighter than average scalp may compromise the surgeon's ability to close the donor area without significant tension. If the excision width exceeds the combined laxity and elasticity of the donor region, it may even be impossible to approximate the margins of the wound. Such instances may require undermining of one or both wound flaps and/or the use of mechanical creep by approximating the wound edges as closely as possible with towel clips or staples, for 30 to 60 minutes or longer, before attempting final closure. In the worst scenario, even with undermining and the use of mechanical creep, it may not be possible to approximate the margins with reasonable tension. Galeal sutures or "deep plane fixation" described by Seery, at the end of this chapter, should then be used. If necessary, the edges must be left with a slight gap at one or more points along the course of the wound closure. The gap(s) will fill in by secondary intention and the resulting scar(s) may be cosmetically improved at a later time. It is, of course, wise to err on the side of a conservative assessment of what is a reasonable maximum width for the donor strip and to avoid such situations.

It follows from the preceding, that a tight donor scalp limits the amount of donor area, which may safely be moved to the recipient region during each session. In a patient with a greater degree of hair loss, it may not be possible to achieve the coverage both the patient and physician desire or it may require unacceptable numbers of sessions. In patients with more severe degrees of MPB, it may be possible to produce the coverage objectives, but not without multiple smaller than usual sessions. Thus, it is imperative that the patient and physician understand the consequences of limited scalp laxity prior to beginning hair restoration surgery, in order to prevent unrealistic expectations. Scalp laxity nearly always varies from area to area, and frequently is greater on one side of the head than the other. Thus, the maximum width of any donor strip can be greater or smaller at various points along its length. Most commonly, from a scalp laxity point of view, it can be wider in the temporal and occipital areas. However, because the "permanent" donor hair zone in the occipital and temporal areas are not as wide as in the parietal area (Fig. #10), you may not want to excise maximum widths at those sites, despite adequate laxity to do so. One of the disadvantages of the elliptical donor strips used by many hair replacement surgeons is that it is typically widest in the occipital area, where the "permanent" rim hair is approximately 10 mm narrower than in the parietal area. Most of the parietal area is usually lax enough for quite wide donor strips, however, the post-auricular areas nearly always are the least lax and donor strips should accordingly be narrowed – sometimes substantially – in that region. Taking into account both scalp laxity and the varying widths of the "safe donor area": a) if elliptical donor strips are employed, it would seem wisest to use ellipses whose widest points are in the mid-parietal region and narrow as they approach the post-auricular and occipital areas, with the tapered ends overlapping each other in the midline (Fig. #), b11) if the strip extends from ear to ear, a single bladed knife can be used to excise the strip in an undulating pattern that is wider at some points than others. Alternately, two-bladed knives of various widths (according to scalp laxity) can be used along the length of the donor area, with gaps of intact skin between them. The gaps can then be incised with a single-bladed knife to join the sections (Fig. #12). This approach is discussed later in the chapter.

» Hair color

Light-colored hair on "fair" skin results in a lower contrast between the hair and skin color. Because the two are closer in color, the reflected light waves are more similar in length, and the alopecic spaces between the hairs are therefore less noticeable. As a result, it generally takes the transfer of less hair mass to result in the illusion of coverage when the contrast between hair and skin color are lower. Conversely, the greater the contrast between hair and skin color, the greater is the difference in their respective wavelengths of reflected light. Therefore, it generally takes the transfer of more hair mass to the bald or thinning area to produce the illusion of full coverage, when the color contrast between the hair and skin is greater. Darker pigmented skin can also work to the advantage or disadvantage of a patient. Dark hair and dark skin results in a lower color contrast, and the ability to achieve the illusion of coverage improves, while light hair and dark skin results in a more negative color contrast.
It is also important to note that as the contrast between hair and skin color increases, the more visual impact each hair will have. In areas in which there will be fewer hairs, such as the hairline, the visual impact of each individual hair will have a greater potential to detract from the illusion of both density and naturalness. This contrast becomes more marked as the calculated density increases or as the hair shaft diameter increases. Therefore, one might strongly consider "cherry-picking" more finely textured single hairs for the hairline and fractionating FU (to reduce the average number of hairs per graft immediately posterior to the single hairs) especially when the patient has high contrast, high-calculated density, and greater hair shaft diameter.

As a patient ages, the hair often begins to lose its pigment. This is because tyrosinase activity decreases in the follicular melanocytes. As this metamorphosis occurs the contrast between the hair and skin changes. This can work in favor of the individual with prior high contrast, but slightly against the individual who previously benefited from his darker skin.

As noted earlier, there is a wide variation in scalp hair color in any single individual. There also may be variations in hue depending on whether the hair is medullated or not. The absence of pigment or "white" hair is particularly important to the graft production phase of the transplant. "White" hairs reflect or transmit all light waves and have no color. It is difficult to see a white hair in the yellow adipose tissue and technically much more difficult to dissect them into grafts. The risk to these white hairs increases as the size of the graft decreases. Grey hairs, on the other hand, although not particularly common, have color and are easily seen against the yellow adipose background.

Scalp hairs typically begin to lose their pigmentation first in the temporal areas. Individuals with predominantly white hair also often retain a larger percentage of pigmented hairs in the occipital region. This has significance because it is technically easier to dissect small grafts such as FU and single hair grafts, when hair pigment is present. Because harvests from the temporal areas in individuals with predominately white hair, will often contain a greater percentage of white hair, the graft production phase can be technically more challenging from this harvest if one is only using FU. Keene has recently suggested immersing donor tissue containing white hair in a .2% methylene blue solution before preparing grafts.* The methylene blue stains the follicles and surrounding tissue to different degrees and allows for far visualization of the FU. Unfortunately, this technique only works well with "slivers" of donor tissue that are one FU wide, so it is not helpful with the initial "slivering" One must be careful of employing blue stains because blue stain applied to yellow tissue has the potential to absorb all wave lengths of light resulting in black. Although methylene blue has been used previously in vivo, all stains have potential toxic effects to the stained hairs and the patient, not to mention significant hurdles achieving FDA approval. More recently Cole has described a technique using monochromatic wavelengths of light, refraction, and color subtraction to create contrast between white hairs and the surrounding tissue. (See Chapter 11). It is, however, a step in the right direction. However, harvests from the temporal area as well as the occipital region, results in a nice mixture of future hair color for the frontal recipient region.* Harvests limited to the occipital region might result in cosmetically inappropriate amounts of darker hair in the recipient area at a point when the majority of the adjacent temporal hairs are grey or white. A harvest from both the occipital region and the temporal area produce a potentially more natural mix of hair color in the frontal areas as the patient ages.

WAVE OR HAIR "BODY"

Straight hair follows a straight-line path along the scalp. It reflects light along this path. The reflected light of this particular wavelength results in the illusion of coverage along the line. As the amount of wave or curl increases, the hair begins to undulate and to reflect more light waves over a greater surface area of alopecic or thinning scalp. This principle explains why the illusion of "body" or coverage increases as the amount of hair wave or curl increases. "Kinky" hair, which is common in African Americans, is capable of producing massive quantities of reflective power. It is noteworthy that the reflective power of any hair is beneficial to the illusion of coverage only as long as it is over the alopecic or thinning scalp. Once the length of the hair extends beyond the thinning or alopecic area, it maintains reflective power, but its benefit to the illusion of coverage ceases.

It is possible to clarify these principals in a graph form (Fig. 13#). One can see the equation for a straight-line $y = mx$, results in much less surface area coverage than the equation for a curly hair, which becomes more sinusoidal ({such as $y = \sin t$ (wavy hair) or $y = 2 \sin t + \cos 2t$ (kinky hair))}. To more clearly understand these concepts, add additional straight lines to the graph of straight hairs and additional sinusoidal lines to the graph of curly hair or kinky hair. The addition of these lines corresponding to the equation of curly and kinky hair with varying points of origin, results in considerably more coverage of the surface of the paper than a similar number of straight lines with varied points of origin. Or merely consider the amount of shaded surface on the chart, which is covered by the corresponding lines.

This chart is at the end of the chapter

SCALP DEPTH

As a general rule, the matrices of finer hairs are closer to the skin surface than those of coarser hairs. Conversely, as the mean diameter of the hairs increases, their depth of penetration into the subcutaneous tissue increases. Thus, the depth of incision required for donor areas with coarser hair must be greater, as must the depth of recipient sites for the resulting grafts. Therefore, it is more likely that arteries and veins in the deeper layers of the subcutaneous tissue will be inadvertently cut when the hair is coarser. In addition, generally, individuals with a higher percentage of body fat have this fat deposited deep to the bulbs of the hair follicles. The additional fat adds a greater cushion between the hair follicles and the vessels in the deep subcutaneous tissue. By contrast, individuals with a lower percentage of body fat have less distance between their hair bulbs and vessels. This reduced distance increases the probability that one of the larger vessels will be incised during donor incisions or undermining of the donor wound edges and will negatively impact healing of the wound. In a 40-patient study, Cole has also found that scalp depth was greater in the mid-occipital donor region than the virgin mid-sagittal superior aspect of the scalp at the level of the external auditory meatus. The scalp mean scalp depth in the inion was 8.7mm and the mean scalp depth on the top of the scalp was .48 mm. Incidentally the acute mean angle of hair growth to the scalp at the inion was 52 ° and 39 ° on the top of the scalp.

» The Technique

Donor area harvesting is much more than a simple excision of tissue from the "permanently" hair-bearing scalp. There are numerous factors to contemplate, including the location of the donor strip, whether multiple donor sites will be used or only one, whether one blade will be used or multiple blades, whether to close the donor region in one or two layers, whether staples should be used or sutures, and if the latter, which sutures, whether one wants to create only one donor area scar or is unperturbed by multiple donor scars. In addition, many physicians, though not all, tumesce the donor region to different degrees. All of these are discussed below.

DONOR SITE PREPARATION:

Most physicians have the patient wash their hair and scalp with an antiseptic such as Betadine, Hibiclens, Technicare, or a regular shampoo the night before and morning of surgery. As noted in Chapter 6, it is helpful to wet the hair to clarify the "safe" donor area and to look for any signs of future loss such as shorter, finer, or lighter-colored hair. The hair immediately superior to the area that you will be excising should be combed superiorly, reducing its obtuse angle to the scalp. This will better expose the area you wish to excise. Wetting the hair will also often help you to do this. The hair that is combed superiorly is held in place with hair clips, rubber bands, or tape. The hair in the proposed donor area is then trimmed to a 21-3 mm length using small electric clippers such as those used for the beard and sideburns, large clippers, or curved Metzenbaum scissors. Its width should be 1 or 2 mm wider, both inferiorly and superiorly, than the width of the strip you want to excise. Bear in mind that the wider the extra width of the trimmed area, the more difficulty your patient may have in concealing the donor region in the immediate post-operative phase. Some practitioners leave the hair in the donor strip slightly longer than 2-3 mm. They feel the longer length aids them in maintaining the scalpel blade parallel to the angle of hair growth.* Once the donor region is trimmed the cut hair is combed away. The inferior aspect of the donor region can be covered with a wrapped gauze, surgical towel, absorbent sponge, chux, or a feminine hygiene pad. These assist in absorbing blood as it runs inferiorly from the donor wound.

TUMESCENCE OF THE DONOR AREA:

The subject is fully covered in Chapter 9. Donor tumescence has been used since the days of punch grafting. The amount of tumescence and the method of infiltration have changed as the means of donor area extraction have changed. Saline tumescence results in vasoconstriction through the vascular compression produced by the high volume of infiltrate in the extra-cellular space. In addition to this tamponade effect, tumescence lifts the hair follicles off the underlying vascular bed and reduces the risk of trans-section of deeper and larger arteries and nerves, provided the depth of incision is controlled. Some practitioners, including Unger and Cole, add lidocaine and epinephrine to the saline when preparing their tumescent solution. (See Chapter --). The lidocaine increases anesthesia and the epinephrine helps to improve hemostasis. Follicle trans-section is also decreased by tumescence as a result of its spreading the follicles within the donor tissue farther apart, stabilizing the tissue, and making the angle of hair growth more consistent. The importance of rigidity of the tissue in preventing trans-section is more significant with scalpels containing more than one or two blades. The depth of the incision should be 4 to 7 mm or just below the depth of the hair follicles. As noted earlier, in general, fine-textured hairs typically do not extend as deeply into the subcutaneous tissue as coarser hairs. It is possible to make deeper incisions below the dermal papillae, but the risk of nerve or artery injury increases.

There are different planes to consider in the donor area: the epidermis, the dermis, the subcutaneous fat, which contains the follicular bulbs, and the subcutaneous fat deep to the bulbs, as well as the region between the galea and the skull. Tumescence in each of these planes has a different effect on the hair follicles. Tumescence in the sub-galeal plane alone might act to compress and distort hair follicle exit angles. Infiltration in the subcutaneous plane alone would increase the distance between the hair follicles and the neurovascular bundles but would not create the degree of rigidity that is optimal for donor area excision. Tumescence in the upper dermis alone would create a firm, flat surface, reduce follicle density, and perhaps decrease follicle trans-section rates, but would do little to lift the follicles away from the underlying nerves and vessels. It is therefore beneficial to infiltrate both the subcutaneous tissue and the dermis to a maximum or near maximum degree, in order to produce their ideal level of rigidity.

There are those who believe that infiltration of epinephrine into the donor region may decrease hair survival or increase the risk of necrosis in the donor area. Both Unger and Cole disagree, unless the wound has been closed with too much tension -- in which case it may play some role in increasing the chance of necrosis. Cole has injected 5 cc of solutions containing concentrations of epinephrine as high as 1:30,000 into the donor area of over 1000 patients with no adverse effects being noted at that site. This results in excellent hemostasis. However, tumescent infiltration with lower concentrations of epinephrine is superior in all the other respects including hemostasis. discussed earlier.

It would seem logical to assume that because the follicles are spread farther apart by tumescence that the same surface area of skin will contain fewer follicles and, therefore, the yield of follicles will decrease with tumescence if the same width of tissue is being excised. Unger uses large amounts of tumescent fluid immediately before he places "blade to skin" and accepts the concept of perhaps obtaining slightly fewer follicles in return for less follicle trans-section. Cole furthermore believes that maximum tumescence in the average office expands the donor region by only 0.5 mm, and that this is generally partly compensated for by the point-to-point distance of the surgical blades. The point-to-point distance of the Arnold knife, for example, is 0.2 mm greater than the distance between the two blades. (fig. 14). This relationship partially negates the effect of saline infiltration on reducing the follicular yield. Infrequently, maximum tumescence can expand the donor area by up to 5 mm but he feels the dynamic properties of the, which are especially characteristic of this type of elastic skin, reduce this effect to a very short duration as the skin rapidly returns to normal. Obviously, how much fluid is infiltrated by any given practitioner, and how rapidly the strip is thereafter incised, will affect the degree of any potential lower FU yields. The amount of tumescence used, has increased significantly over the years. It is common to employ 75 cc or substantially more to infiltrate the typical donor region. Arnold has recommended that infiltration should result in a "plateau" in the donor area rather than merely a raised area like a "hill", * and Unger strongly agrees with this advice. Blugerman goes further and advises that this "plateau" should extend to at least 1 cm beyond the proposed area of incision. * (Jul-Aug 1996 Hair Transplant Forum International, page 10.)

Beehner’s technique is to infiltrate 10 to 15 cc into the subcutaneous tissue using a 10 cc Disposajet syringe (Byron).* He then injects additional fluid into the more superficial dermal layer every 3 cm, utilizing two 5 cc syringes with 22-gauge needles. On average, he tumesces the donor area with a total of 70 to 80 cc of normal saline containing 1:85,000 epinephrine. After incising the parallel edges of the strip, he tumesces both extremities of the strip for a third time and incises its tapered ends.

The optimal amount of fluid infiltration varies from one donor region to another. Some donor areas require very little, while others accept much larger volumes. In a large majority of instances, it is possible to achieve a firm "plateau"-like surface, but in some areas it is impossible to accomplish this. The elasticity and reabsorbing capacity of the tissue is so great that the effects of large fluid volumes are lost almost immediately and the benefits are minimized. It is important to recognize such situations because the risk of trans-section with a multi-bladed knife increases, and therefore, only single or double-bladed knives should be utilized in such areas.

» Excision Of The Donor Strip

Coiffman was the first to propose the advantages of a "block excision" of the donor area.* Initially, he had described a technique that left no hairs between excised round grafts.* Later, he proposed a block excision of a solid donor area leaving a single donor scar (Coiffman F. Use of Square Scalp Grafts for Male Pattern Baldness, Plastic

Reconstructive Surgery, 1977, 60:228-32 + 1979 Unger Text). In retrospect, it is both remarkable and sad that it took as long as it did for this concept to become widely adopted, but in the last decade, the scalpel has essentially replaced the punch for donor area harvesting.
As will be discussed later, either a single or multi-bladed knife may be employed. The first physician to describe the use of a double-bladed knife was Vallis,* but there are now various knife handles available from a host of vendors such as Ellis Instruments, A-Z Instruments, George Tiemann and Company, Robbins Instruments, Mediquip, etc., that can incorporate three or many more blades (See Chapter 20). Number 15 or 10 blades are generally utilized in these handles, with those produced by Persona preferred by most operators because of their excellent sharpness. The single or multi-bladed knife is inserted into the donor region parallel to the direction of hair growth, and is then drawn along the length of the proposed donor strip. To decrease the risk of follicle trans-section, it is advantageous to check your incision periodically, and to modify the angle of the blade to conform to the continuously changing hair angles as the strip is cut.

There are two incision surfaces you can evaluate during these assessments; the superior and inferior one. Upon close inspection of the inferior surface, should you fail to the follicular bulb, you should modify the angle of your incision so that it becomes less acute, by moving the handle of the scalpel cephalad. Should you see trans-section of the upper fractions of the hair follicle, you should move the scalpel handle more acutely or caudally. This led Kadach to propose the following pneumonic "roots angle up, no roots angle down".* Novices should ideally begin with one or no more than two blades spaced 4 or 5 mm apart. This is because when the angle of the blades is not parallel to the hair shafts, the percentage of follicle trans-section increases as the number of blades increases. A wider strip and only two blades keep the hairs in the middle of the strip "out of harm’s way" and, thereby insures, a higher yield of intact follicles. In addition, the more blades in the knife, the more resistance one can expect to encounter. Therefore, the more blades in the knife, the more important it is that they are extremely sharp. Laying the cutting edge of a five-bladed scalpel down forcefully, on a hard surface, for example, may be all that is necessary to dull the edges sufficiently that the incision is made substantially more difficult. Mangubat has also noted that downward pressure on a multi-bladed knife makes the movement of the instrument across the donor area easier.*

Various practitioners have developed quite different preferences for the type of instrument they prefer to use for excising donor strips and the widths of the latter. Using a single blade (with or without a depth guard) to excise an ellipse from the donor area is the method of harvesting demanded by those who tend to exclusively utilize FUT and who wish to define FUT stringently. It is the approach preferred by Cole, Gandelman, Hugeneck, Limmer, Sandavol, Seager, Swinehart, Ramos, Uebel, and others. Their rationale is that a single blade decreases the number of surgical margins but of course this applies only to multi-bladed knives with more than two blades. Perhaps a more important reason to employ a single blade is the variation in hair growth angles on two different planes of the curved skull. The farther apart the most superior and most inferior blades are, the greater the difference in the angle of growth will be at the incision lines.

Griffin has suggested that the trans-section rate for one strip surface should be multiplied by the number of blades on your knife to obtain the total trans-section rate for any multi-strip harvest.* In fact, the trans-section rate is almost certainly always greater than this due to the above-noted different hair growth angles in different planes of the scalp. The mean trans-section rate for a single-bladed knife, in Cole's on-going studies, is generally between 1 to 2%. Interestingly, the trans-section rate for the first incision line is much lower than the trans-section rate for the second incision line. The mean trans-section rate for a two-bladed knife set at 1 cm to 1.2 cm between the blades is generally between 2 and 4% 2.6% of all the hairs in the strip. Pathmovitch's trans-section rate, using his approach to elliptical excision is 1.9%.* Reed projected the trans-section rate from harvesting five, 2 mm wide strips at 8%.* Unfortunately, he determined this rate by taking a section of each strip, containing approximately 200 hairs each and counting the number of transected hairs on only one side of the strip. In this way trans-sections were not counted twice, but, as noted earlier, it is very likely the trans-section rate on the uncounted side would have been different than that on the counted side. Limmer has reported the trans-section rate with his method of elliptical harvesting and donor area dissection to be between 2 to 5% and to usually be 2 to 4%.* On the other hand, he found the trans-section rate for strip excision and graft production from two, 3 mm strips (using 3 scalpel blades) to be 13%8% to 15%16% when all transected hairs were actually counted instead of estimated.* Limmer also notes the typical trans-section rate for a single blade ellipse is 1 to 2% with a range of 1 to 4% depending patient variability.44

Transplanting all transected, as well as intact, hairs in the donor tissue, may produce fewer, the same number, or more growing hairs depending on the study you review. This has been referred to previously in this chapter and is discussed in more detail by Reed in Chapter 12. Therefore, the importance of minimizing trans-section rates, although instinctively attractive, is not clear. All the same, those hairs that grow from transected follicles often have reduced caliber and transected hairs are also more likely to be discarded by technicians. For this reason, it is important to know how many hairs are actually transplanted into the recipient area when hair survival studies are carried out - as they periodically should be, in all offices. Limmer has studied his staff's efficiency and believes his technician's typically fail to return to the recipient area only 1% to 3% of all hairs removed from the donor area. *

Bernstein has reported that he can produce 3017% more FU hair from the same amount of donor tissue since switching to single bladed elliptical double blade harvesting and stereomicroscopic dissection.* Bernstein also noted a greater yield with less trans-section from the production of follicular units upon switching from a triple blade to a double blade scalpel. Bernstein et al noted the trans-section rate for a four bladed scalpel with three spacers of 3mm each ranged from 12 to 16%. Unger and Reed have questioned, at least, the size of this figure in view of the fact that a) perfectly matched original sections of donor tissue are impossible to find for comparison purposes, and were therefore not used, and b) the skill of technicians not only varies from person to person, but also in the same individual with the passage of time. He used the same technicians in the earlier studies of multi-blade harvests that he had used for studies of single-blade harvests carried out a year or more later, when they were more experienced. The study in which Bernstein based his figure was also flawed in several other important respects.* More importantly, hair counts are notoriously difficult to carry out accurately, even when stereo-microscopes are used. Two excellent and experienced technicians from each of Seager's and Unger's offices were unable to agree on the number of hairs in grafts being examined in a two-office hair survival study done by them in 2001, until multiple counts were carried out on the initial grafts. The hair counts nine months later, done by the same four technicians, using whatever magnification each individual thought they needed, could not be entirely agreed upon by any of the four, despite multiple counts. The results of the study were reported at the 2001 ISHRS annual meeting, and one of the conclusions of that study was that scientifically valid data is unlikely to be arrived at by these studies, even ignoring the fact that only two or three patients are being evaluated.

Beehner, Mangubat, Khan, Unger, and Shapiro use multi-bladed knives for the production of minigrafts. Unger and Shapiro obtain most of their FU from donor strips excised with a double-bladed knife, but some FU are also easily produced from the strips created by multi-bladed knives. The method of donor harvesting they use, is to some extent dependent on the type of graft they are producing. In their view, it is acceptable to use a multi-bladed knife if you are producing minigrafts, as long as all of the transected follicles are transplanted with the intact ones. It is easier to consistently make minigrafts of a specific size from narrow strips of consistent widths, as are obtained with a multi-bladed excision, than from an ellipse. A consistent minigraft size, in turn, makes the creation of the appropriate size of recipient sites easier. They also feel than an ellipse coupled with microscopic dissection is more appropriate when you want to produce predominantly FU, and therefore in this regard, they are in agreement with Cole, Gandelman, Nugenek, Limmer, etc.

Pathomvanich believes that all the current methods of donor harvesting are "blind" with regard to hair angle, in at least one dimension. Therefore, he developed a new technique based on the principle, "cut what you see, and see what you cut".*40 First, he marks the area he plans to excise. After a tumescent anesthetic is infiltrated, he makes a superficial horizontal incision with a #15 blade, between several follicles. This incision, which is approximately 1 cm long, is then opened with skin hooks exposing the path of the hair follicles toward the subcutaneous fat. He then continues the incision with the #15 blade, first to the left and then to the right and eventually deeper, until the entire marked area is incised. Hemostasis is paramount to his technique, so that visualization of hair follicle angle and direction is optimized. Cotton swabs and a small roll of damp gauze are also utilized to keep the field clear of blood. As he dissects, he alters his course around the irregularly spaced FU and individual follicles in an effort to minimize trans-section. The ellipse may be removed in several sections or as a "block". Excision in sections, allows the remainder of the staff to begin dissecting the ellipse into smaller pieces that are1 to 3 mm wide. The procedure is more time consuming than current methods, but with experience he has learned to perform the entire excision of the donor area in 10 to 15 minutes. The additional time required for this technique is warranted in his opinion because it maximizes the reduction of follicle trans-section as the ellipse is excised, and minimizes injury to neurovascular bundles.*40 (Pathomvanich, D., Dematol Surg 2000; 26:345-348).

Dow Stough and Parsley observed this technique at the 2001 Live Surgery Workshop in Orlando, Florida and found that the field of vision was substantially impaired by bleeding but felt that the trans-section rate was less than with other techniques. The procedure took approximately 30 minutes, rather than 10 to 15 minutes to accomplish, but most of us work better in our own offices so this was probably not representative of the time he usually needs. Stough feels that individuals with dark hair are the best candidates and excellent tumescence and vasoconstriction are more necessary than with faster techniques for obvious reasons.47 Parsley has questioned an increased risk of desiccation because the procedure is so time consuming.48

Because there is little margin of error for the cutting angle with a horizontal incision of the donor area with a multi-bladed knife, Blugerman proposed what he called the "vertical strip harvest".*34 In this technique, he uses a non-angled multi-bladed knife with #15 blades to initially incise the donor area vertically. The blades in this knife are 1.5 to 2.0 mm apart. He limits the depth of incision to 7 or 8 mm in order to minimize nerve and vascular damage. He then removes an ellipse with a #10 blade (Fig. #). The thin strips are separated by the assistants and further dissected. (Jul-Aug 1996 Hair Transplant Forum International, pg.10). Alkek has described a similar harvesting technique* as have Al-Ghamdi and Kohn.* (Al-Ghamdi W., Kohn T., Vertical Harvesting in Hair Transplantation, Dermatol Surg. 2001; 27: 597-600). We have found that these approaches are considerably more time-consuming and in our hands produce more follicle transection than is seen with our usual method of strip harvesting. Nevertheless, the above noted authors claim lower rates of follicle trans-section.

» How Wide Should Donor Strips Be?

Both the length and width of donor strips are decided upon on the basis of multiple factors that are discussed elsewhere in this chapter. The number of FU desired and scalp laxity, however, are two of the most important ones. Bernstein, Rassman, and Seager frequently excise strips that extend from ear-to-ear, or sometimes further interiorly, and are 12-15 mm wide at their widest points. In the post-auricular areas, however, where the scalp is tighter than elsewhere, the strip may be made considerably narrower.

Seager, for example, when trying to obtain 2,500 to 3,000 or more FU, commonly removes a strip that is 8 mm wide superior to the auricle, but is usually 1.2 to 1.5 cm wide, and occasionally even wider, in the mid-occipital region, yet only approximately 7 mm wide in the post-auricular area.* In trying to produce such large numbers of FU in a single session, he generally will excise the maximum width of tissue that allows for closure with reasonable tension in each area. The effect of the preceding is that the shape of the donor strip is often "wave-like" rather than a long rectangle or ellipse, and is usually no more than 1.2 cm wide at its widest point.

This wave pattern is most frequently achieved by scoring the skin with double-bladed knives of various widths, at various points along the proposed strips – but joining the scored lines with a single blade as the strip is excised. In subsequent sessions, the initial widths may be decreased because of scarring from previous harvests that have decreased scalp laxity. Alternately, he may increase these widths to compensate for the presence of the hairless scar line within the donor strip and decreased hair density on either side of the scar, if scalp laxity allows for this. Towel clamps are used in most patients to assist in donor area closure during each session, and staples are preferred to sutures.

As implied by the foregoing, in most instances he includes previous donor scars in new harvests from the same general area and rarely leaves more than two scars in the donor area regardless of the number of sessions undertaken. Extra separate and smaller excisions may sometimes be later taken from the least lax but still usable portions of the parietal areas, during the course of any patient's series of treatments.52 These are the areas in which the previous strips were narrowest because of low scalp laxity but the safe donor area was wider than in the temporal or occipital areas.

Most practitioners use shorter and/or narrower donor strips. Avram, Shiell, Stough, and Beehner, and Shapiro, for example, usually limit their strips to a width of 8-10 mm and Mangubat to 8-12 mm. Bernstein and Rassman generally range between 1.2 and 1.5 mm in strip width. Unger's and Cole's approaches are described in detail at the end of this chapter.

Should One Excise Old Scars Within New Donor Strips?

Should scars from previous donor strips be included in subsequent harvests, or should strips always include only unscarred tissue? Unger and Cole prefer the former. Bernstein and Cole discussed multiple potential problems that may result from a donor excision that includes previous scars.* They are summarized below along with additional comments by Cole:

When the donor area is excised, the defect is closed by stretching the edges of the wound and suturing them together. This skin stretch decreases the follicular density of the skin adjacent to the scar.

Scar formation distorts hair growth direction immediately adjacent to it. Cole and Bernstein have noticed that this directional distortion tends to be greater on the inferior side of the scar than the superior side, and creates a potential problem in future donor area excisions, which incorporate the pre-existing scar. The bulbar region of hairs, inferior to the scar, generally appear to be pulled more inferiorly than the infundibular segment of the same hair shaft, resulting in a somewhat curved hair. Because the hair exists in a parabolic fashion, it is impossible to excise the curved hair with a straight scalpel blade without transecting it. Hairs superior to the scar are generally distorted only marginally, if at all, most likely because the preponderance of stretch comes from the neck. In brief, hair transection is more likely when excising a scar, especially on the inferior side of the scar.

The scar is significantly harder than the non-traumatized adjacent skin, so greater force is required to dissect through the tougher scar tissue when grafts are being created from it. Greater force requires more manual dexterity during the dissection process, in order to minimize damage to the hair follicles. In other words, the margin for error is reduced.

Scar tissue is less translucent than non-scar tissue and thus, increases the technical difficulty of preparing un-transected hairs.

Skin stretch also reduces donor area compliance around the scar. This means that the maximum width of donor area excision will be reduced in subsequent procedures that incorporate the scar and the new scar will likely be somewhat wider.

Scar, of course, contains no hair. If a scar is 1 mm wide, future harvests that include it may result in a reduction of potentially 10 FU/cm2 due to the presence of the scar alone. Because the scar width varies significantly along its path, FU estimation is also made more complex. Moreover, when scars form in the donor region, they may be larger deep to the hair papillae than they are on the surface of the skin. This can result from leaving a space below the hair papillae that heals by secondary intention.

In reply to the preceding arguments, it should be pointed out that:

a) Both decreased hair density and follicle angle distortion are significantly affected by the closing tension of the donor site. Minimal tension will produce minimal change in each. The routine excision of wider strips, such as the 12 to 15 mm wide ones that Bernstein prefers, will no doubt often result in greater wound closing tension, that will have a far greater effect on adjacent hair density and angle, for example, than that seen with the 8-10 mm wide strips that Avram, Shiell, Beehner and others typically use. Moreover, once wound tension starts to increase, it does so exponentially in Unger’s experience. A mere I mm increase in donor strip width, often is the difference between no tension on closing and substantial tension that is disproportionate to the small increase in strip width.

b) If previous donor scars are not excised as part of the donor strip(s) in subsequent sessions, each session will add an extra scar to the donor area. Six sessions will, for example, leave six scars instead of one or two scars, and can result in an unnatural zebra-like pattern of scarring in the patient’s donor area.

c) Multiple scars may well reduce scalp mobility and the width of future harvests more than one or two scars do.

d) Each scar interrupts, to some extent, the blood supply superior to it. This is true whether the scar is wide or fine. Taking a strip from an area superior to a previous scar, results in a reduced blood supply to the inferior flap of the new wound. It also results in the area between the old and new donor area having its blood supply cut-off inferiorly as well as superiorly, and increases the risk of telogen effluvium or necrosis in that section of the donor area. Each additional donor strip, superior to the preceding ones, increases the risk to good healing of the new wound and the donor area tissue between all old and new harvests and scars. If instead, subsequent donor strips are taken inferior to each prior one, the inferior flap of the new donor wound will always have an intact blood supply. But, the superior wound flap blood supply will be more profoundly affected than was the inferior wound flap in the first example. This is because, with a scar superior to the wound, the blood supply will come to the superior flap area primarily from an inferior location, and the new incision interdicts this source. Thus, the superior wound flap has its blood supply reduced superiorly (by the old scar) and completely cut-off from the more important inferior source of blood supply by the new incision.

Unger minimizes follicle damage, wound tension, and other potentially negative sequelae about which Cole and Bernstein have been concerned (1) by keeping old scars well away from the blades, and never using more than two-bladed scalpels when he sees significant hair angle differences, inferior and/or superior to an old scar, (2) by harvesting narrower strips in those few instances when he anticipates more than average donor wound tension. The instances are "few" because he only uncommonly tries to transplant more than 1500 to 1750 FU (or its equivalent in other types of grafting) per session and usually uses two contralateral donor strips instead of one. He therefore, generally harvests significantly narrower strips than most of those who, like Cole, Seager, and Bernstein, use a single donor area per session and (3) by beginning with narrower donor strips and taking slightly wider donor strips, if necessary, in subsequent sessions. This approach increases the likelihood that wound tension will be acceptable even after multiple sessions in the same area. It can also compensate for any decreased hair density adjacent to old scars as well as for the absence of hair in the scar which is usually very fine because of low closing tension. If one is anticipating only carrying out two or three sessions in an individual, Seager's and Bernstein's approach is not that problematic, but Unger prefers a more measured utilization of donor tissue in four to six, or even more sessions, for reasons explained in Chapter 6, and later in this one. Cole is able to obtain five or more large sessions with his technique averaging 1500 grafts each and over 2000 grafts in some individual sessions. Cole believes the average donor region contains at least 7000 movable follicular units.

IF VIRGIN MIDLINE ELLIPTICAL DONOR AREAS ARE HARVESTED WITH EACH SESSION, SHOULD THEY BE INFERIOR OR SUPERIOR TO PREVIOUS HARVESTS?

Midline elliptical donor harvests may begin (a) at the superior most aspect of what you judge to be the "safe" donor area, with new strips taken more inferiorly with each subsequent session (b) in the middle of the safe donor area, with subsequent harvests taken superior or inferior to previous ones or (c) at the inferior most aspect of the "safe" donor area, with subsequent sessions taken more superiorly. The blood supply consequences of these options have already been dealt with but others are discussed below:

Working from the inferior aspect toward the superior aspect has certain advantages. (a) As noted earlier, hair-angle on the inferior side of the scar is distorted to a variable degree, while that superior to the scar maintains a more natural angle. There is, therefore, less risk of follicle trans-section when a strip is removed from the superior side of the scar. (b) Working from inferior toward superior may also improve the patient's ability to conceal the scar. Should MPB progress inferiorly with the passage of time, there is less likelihood that it will impair camouflage of the donor site scar or advance into previously harvested areas. (c) Going from inferior to superior, results in the mobile neck-skin being pulled progressively into the donor region, rather than the alopecic or future alopecic crown being pulled into the donor region, if one instead harvests from superior to inferior - thereby, possibly enlarging the alopecic crown. On the other hand, superior donor strips can be considerably longer than the most inferior ones, enabling the production of more grafts than the latter. Superior strips can also be wider and result in lower wound tension, as Seery pointed out earlier in this chapter. Of course lower incisions can be angled superiorly rather than stopping posterior to the auricles. In this instance, the inferior incision might be longer.

Harvests extending from supra-auricular region to supra-auricular region require a turn over the occipital protuberance. This is not problematic with a single blade. When more than one blade is used the inferior blade must travel faster than the superior blade at this turn. For this reason Cole terms this movement the critical turn of the occipital protuberance. This turn is similar to running around a track 440 meters long. As the racer approaches each turn, the outside lane has a greater distance to travel around the turn. Therefore, he must run faster or be given a head start so that all runners race equal distances. The speed of the inferior blades must increase as the distance between the blades increases. It is almost impossible for three or more blades to each engage this turn at their respective ideal speeds. Hence, the risk of follicle damage is greater at the critical turn and increases significantly as the number of blades increases.

Harvests beginning in the middle of the donor area offer an important advantage that the other two options don't: Hair becomes progressively finer and sparser in the most inferior and superior aspects of the donor area, as the patient ages. Every effort should, of course, be made to not harvest from areas in which future thinning can be anticipated to be cosmetically significant. Harvests beginning in the middle of the donor area, offer the advantage of removing donor strips from the inferior side of the scar in the next procedure and on the superior side of the scar in a subsequent procedure, thus minimizing the chance that one will encroach on areas that are ultimately destined to lose their hair or become excessively sparse. Of course, the safest approach is not only to begin with a single donor strip in the middle of the donor area, where the hair is the safest long-term and most dense, but to excise the scar from any preceding session in the center of the new strip. This is the approach that Unger recommends whenever one is concerned about the patient developing type VI or VII MPB. Cole recognizes the rationale for this approach, but points out that the follicular density will always be lowest on both sides of the scar, particularly the inferior side. Therefore, excising the strip with the scar in its center might lead to a reduction in follicular yield.

» Should One Include Temporal Hair In Donor Strips?

Some practitioners excise a relatively wide donor strip that extends through the left and right occipital and parietal areas but avoids the region superior to the auricles. The primary advantages of such a harvest are an increased hair yield and a higher proportion of pigmented hairs. If your patient prefers a short hairstyle in the temporal areas, this may also be the most appropriate pattern, in order to conceal the donor scar. However, while FUD and hair density are greatest in the mid-occipital region and superior to the mastoids, decreasing superior to the auricles, the highest preponderance of natural single hairs is superior to the auricles. (Table 8.)
This midline excision pattern is also potentially the most inefficient means of donor harvesting when multiple procedures are carried out. Scars inevitably decrease the ultimate donor yield, and this technique has the greatest potential for the most and/or widest scars, because the length of the strips is shorter than those that extend into the temporal areas. Therefore the width or number of excisions must be increased to produce the same number of hairs. In addition, the tapered ends of the donor strip(s) often contain the most follicular trans-section and this occurs in an area with high FUD and hair density if the donor strip stops before entering the less dense supra-auricular regions. Furthermore, the "virgin" supra-auricular area has a far lower hair yield capacity when treated as a separate entity, as its length relative to the length of its tapered ends, is less advantageous.

This pattern also fails to take advantage of the temporal hairs' natural tendency to lose pigmentation first. As noted earlier, hairs chronologically programmed to maintain pigmentation longer may, in later life, lead to a cosmetically noticeable disparity between the hair color of the grafted region and the adjacent temporal areas, which have a more "salt and pepper" appearance. It has been noted that non-pigmented hair is much more difficult to dissect into FU. Even with microscopes it can be very difficult to maintain a high hair yield from non-pigmented donor regions. Therefore, a harvest limited to occipital and parietal areas has the capacity to improve FU yield if one is operating on someone whose temporal hair is already less pigmented. As has already been noted, in such cases, obtaining grafts that contain more than one FU may be advantageous.

HARVESTING CURLY HAIR

Markedly curled hair, such as Negroid hair, presents a different problem. (See also Chapter 15). The incision must follow the curvature of the hair shaft to avoid its trans-section. Arnold has described a technique of incising the donor area with a hand-made curved scalpel blade. Cole prefers Arnold's technique with the Negroid hair. The resulting strip may also be "pre-slivered" in the donor area with incisions made perpendicular to the long axis of the strip as described earlier in this chapter and by Blugerman, Alkek, Al Ghamdi, and Kohn.** Unfortunately, in these authors' admittedly limited experiences, this latter type of dissection is likely to produce more trans-section than if there is direct visualization of the donor tissue during its dissection into grafts. Using a multi-bladed knife in individuals with tightly curled hair will almost certainly result in a higher follicle trans-section rate than if a single strip or elliptical harvest is employed, and a multi-bladed knife is therefore contraindicated. On the other hand, harvesting of Negroid hair is one of the few times when the use of the "old" power punch may be advantageous. Power punches can be moved in a gentle arc that follows the curvature of the follicle as the individual grafts are being drilled out. Round grafts that are 4 to 5 mm in diameter can be removed and divided into whatever size grafts are required. Cole also sometimes uses a power punch at the end of a case of FUT in which 20 or more empty FU size recipient sites remain after all the FU have been used. He is better able to get control close to the number of FU he wants by calculating how many of these grafts will be necessary to produce them.

» Donor Harvesting And The Direct Follicular Extraction Technique

Regardless of the number of blades in the scalpel, the objective of incision harvesting is to remove donor area with a minimum of follicle wastage. Such wastage results from transection of hair shafts during scalpel incision or damage to hair bulbs as the strip is being excised from its bed. Inserting the blade(s) parallel to the hair shafts minimizes the former, while careful separation of the strip from its bed, just deep to the bulbs, will minimize the latter. A deeper excision leaves more adipose tissue on the strip and increases the amount of work your surgical staff will have at the time of graft preparation, but also is more likely to avoid accidental damage to the bulbs. Deeper excision also results in trans-section of the larger and deeper vessels and nerves. Cole prefers a scalpel with a #10 Persona blade, to separate the strip from its bed. He excises the strip up to and touching the dermal papillae but is very careful to avoid trauma to the papillae and matrices. He performs this process slowly with 5x magnification, removing only as much adipose tissue on the underside of the strip as is necessary to safeguard the dermal papillae.

Unger, on the other hand, prefers a deeper separation of the strip because he is more fearful of accidental bulb injury and feels that the time added to the technician’s work, to remove the excess subcutaneous tissue, is relatively small. Trimming of the fat away from the bulbs can also be done more accurately by technician’s working on their tables than during the process of strip separation when less magnification is employed, the tissue is often farther from the physician’s eyes and varying amounts of bleeding may also be present. He is less concerned with the severing of the occasional deeper vessel than Cole and others who use shorter, wider excision patterns than he does, because his generally narrower excision patterns are closed with essentially no tension, which eliminates the most important cause of wide donor area scars and other potentially negative sequelae. Unger excises the incised strip with a small curved iris scissors held with its concave side adjacent to the donor area bed. Multiple strips can be removed collectively or, less often, separately. The tissue is lifted externally with forceps or a tissue hook allowing for direct visualization of the hair bulbs.

Because the tapered ends of ellipses often have the highest incidence of follicle trans-section, Seery has described trapezoid tapered ends to minimize the problem (Figure #)Fig. 16). This method does appear to decrease trans-section but may result in "dog-ears" if not done perfectly and a potentially less than ideal scar because it "violates" Langer's Lines.

The Direct Follicular Extraction Technique

Recently a new technique of donor harvesting has gain popularity primarily among the lay population, who have promulgated this approach through the Internet. The first to describe this approach was the Australian, Woods, who has marketed his approach himself through the internet. Woods claims he is able to harvest individual follicular units with a cylinder. He tumecese the tissue to a firm state then removes individual follicular units. Cole has attempted this technique previously without success. Cole firmly believes the approach is more harmful to follicular survival than any other method of donor extraction. Woods has never reported his results at any scientific meeting and has avoided interaction with the Australian Society of Hair Transplantation. Therefore, one should view his reports as suspect. In addition, this method of harvesting has the greatest potential to increase the technical difficulty associated with any future harvests. As the scar forms in the resulting defect, the scar changes the growth angle of the adjacent hairs. This makes the probability of removing subsequent distorted follicular units more difficult with any method of direct follicular extraction. Should the surgeon elect to alter methods to the more conventional strip harvest in subsequent sessions, these distorted hair follicles adjacent to rock hard scar will be far more difficult to dissect regardless of technique. Therefore, the risk of follicular injury is increased. Each 1mm hole will expand in size upon incision of the plug. While the size of the resulting scar will be slightly less due to wound contraction as it heals, the result will be thousands of small scars in the donor region. These multiple scars have the potential to become far more visible and unnatural in appearance as the donor reserves are depleted. More recently Rassman has described a new technique for direct follicular extraction. He recommends a FOXX text prior to undergoing this procedure. The FOXX test determines the sutibility of each candidate for this procedure. IN Cole's opinion the potential pitfalls of subsequent procedures out weigh the benefits of this technique. The results of such techniques have not been disclosed to the scientific community at this time.

» Closing The Donor Area During The Hair Transplant Surgery

Prior to donor wound closure, some physicians cauterize vessels, which bleed excessively. The so-called "end vessel of Arsenault" is particularly vexing. This vessel can be defined as the arteriole that nearly always gets severed, and bleeds excessively, at one or both ends of your incision, no matter how long or short it is or where it's located. (It was named after the surgical resident who first pointed it out to Unger and his colleagues as they were enjoying a coffee in the surgeon's lounge between cases). Unger uses a hyfrecator set at unipolar delivery and 80 for any vessel that bleeds more than most, and that fails to stop bleeding within approximately five minutes. He notes that the plumes should be removed with an efficient smoke evacuator system, since they contain benzenes, aldehydes, hydrocarbons, carcinogenic carbonized particles, virus, and even bacteria. * Unger also points out that the interdiction of blood supply and post-operative pain are greater with cauterization, so it should be kept to a minimum. (Unger WP, What's New In Hair Replacement Surgery, Dermatologic Clinics, 14:October 1996, pp783-802.) For these reasons, Cole prefers to place a small hemostat on vessels experiencing significant bleeding or a temporary skin staple, and prefers to avoid all cautery in almost all cases. Beehner prefers an infrared coagulator that Unger tried and discarded as inconsistently effective in his hands.

Many surgeons, including Dow Stough, Griffin, Arnold, Mangubat, and Seager prefer staples for skin closure. Most practitioners, however, continue to prefer sutures. There is no doubt that staple closure is faster, that staples cause very little tissue reaction and in most instances result in comparable scars to that produced by suturing, but the degree of patient discomfort continues to be debated. In our experience, sutures are less uncomfortable post-operatively, and at the time of suture or staple removal. Mangubat has studied staples vs. sutures on contralateral sides of the donor area and had no complaints regarding discomfort from the staples on a post-operative questionnaire he had his patients complete at their follow-up visits. Interestingly, his patients did say the staples were more uncomfortable, but they "accepted" them because he believes, and tells them that "the results are worth it". (He also does not undermine his wound edges; instead placing towel clamps on the edges to produce mechanical creep, and removes them as he comes to them with the advancing staples). The staples are removed in 10 to 14 days. Cole and Unger have both tried similar studies but discontinued them because there was so much patient complaint about the stapled side. Shiell has twice performed a 10-patient study comparing 4-0 Nylon to staples in closing 8 mm wide donor wounds on contralateral sides. He found no difference in the cosmetic results between staples and sutures, but almost all his patients claimed the staples were much more painful to remove at seven days. Bernstein performed a 22 patient study where he compared staples to Monocryl.80 Bernstein's study found that 14 of 22 patients preferred the Monocryl side, 1 patient preferred the staple side, and 7 of 22 had no preference. The most common complaints with the staples were inconvience, postoperative discomfort, and occasional pain associated with their removal. The average scar width on the staples side measured 1.78 mm compared to 1.42 mm on the suture side. It is hard to explain this difference in patient acceptance of staples except in the context of the power of suggestion by the surgeon.

The need for galeal, subcutaneous, or dermal sutures in donor wound closure is another area of controversy. Dow Stough, Shiell, Bernstein, Unger, and most hair restoration surgeons, in general, find no benefit from using double layer closures., Bernstein believes that in situations where there is no undue tension there is no need for buried sutures.80 Scars that are wider than 1 mm wide occur, for example, in less than 2% of Unger's patients; the majority has scars that are 0.2 – 0.5 mm wide or less and are difficult to find unless one knows where to look. Thus, two-layered closures, at least in wounds that close with minimal or no tension, appears to be superfluous unless there is prior history of unexpectedly wide scars without tension. In addition, buried sutures may cause a tissue reaction resembling an infection, that frightens patients, is annoying to treat and usually produces worse scars than normal. Such suture reactions are uncommon, and generally occur only at the point of a buried knot, but if they are unnecessary in the first place, it seems unwise to add another possible complication to the surgery. At three months post-operative check-ups, Shiell found there was rarely any difference between the patients who were closed in two-layers and those who were closed in one-layer. He does, however, employ a two-layer closure if closing tension is greater than average and for patients with existing wide scars. He believes that wide donor scars are more a result of "genetic predispositions" than tight closures and occur more frequently in individuals of Mediterranean and African origin. Cole agrees there is a genetic predisposition to wide donor scars. He finds they are more common in individuals with dark pigmented, coarse, often wavy hair. He also generally finds that wide scars in those genetically predisposed to them tend to recur, regardless of the method of closure (staples, two-layer, one-layer, or alteration in suture material), and are widest when incisions are made in the inferior occipital area and, least common, superior to the ears. Unger and Cole find that wide scars, paradoxically, are most likely to occur in those individuals with extremely lax scalps. Cole recommends that you consider evaluating the patient for hyper-extensibility of the joints, when the scalp is significantly looser than average and the patient has dark, coarse hair. Unger postulates that maturation of the scar is somehow delayed in such individuals and, therefore, leaves his sutures in place for a minimum of 14 days instead of his usual 7 to 10 days. This frequently, but not always, leads to more usual scar widths. In addition, he sometimes employs galeal sutures as well as superficial ones in these patients.

Beehner, Limmer, and Parsley use interrupted deep Vicryl sutures in their two- layer closure of the donor area. Beehner’s technique for inserting deep sutures is to place interrupted 3-0 Vicryl sutures in the tough fibrous portion of the dermis, rather than the galea.78 For his longer incisions he uses five to six sutures, and for the shorter ones (7-9 cm) he employs three sutures. He found that 2-0 Vicryl resulted in a considerably greater frequency of suture reactions than 3-0. He also decreased the number of knots from three to two for each interrupted suture. He inserts the needle in the subcutaneous fat just below the bulbs. The needle is passed to the upper dermis and exits just below the epidermis. He then enters the opposite margin just below the epidermis and passes the needle into the subcutaneous fat. The knot is tied in the superficial subcutaneous fat. He cuts the suture flush with the skin, and closes with a simple running 3-0 Prolene suture that is removed six to seven days later. The resulting donor scar is rarely greater than 1–1.5 mm and he says he rarely excises the old scars in subsequent procedures because of this.

Limmer and Parsley have a different method of using interrupted 3-0 Vicryl sutures. 76,77 They first place 4-0 catgut vertical mattress sutures every 3 cm while using a towel clamp to approximate the skin edges. Between each of these sutures they tie a 3-0 Vicryl suture similar to Beehner, with the knot in the subcutaneous tissue or deep dermis.(Fig. 16) Parsley also does not feel the subcutaneous tissue is of value for placing donor area sutures. He, too, prefers the holding strength of the deep reticular dermis. Moreover, he is careful to keep the Vicryl at 1 to 2 mm below the epidermis to minimize the possibility that the suture will "spit". He closes the epidermis with a 4-0 plain catgut suture in a running lock stitch.76* The suture dissolves within 10 to 14 days.

Cole also believes that subcutaneous sutures help to improve the width of the donor scar. His two-layer technique is completely different than those of Beehner, Limmer, and Parsley. Cole uses either 0 Vicryl or 4.0 monocryl in the subcutaneous plane just deep to the papillae.(Fig. 17) Cole believes that some patients will produce wider scars regardless of technique and even his two-layer closure is minimally effective. To eliminate the suture reaction, the initial knot is tied on the surface 1 cm lateral to the incision margin. The needle is then passed into the subcutaneous tissue from the surface of the skin, where it remains until he reaches the other end of the wound ;margin or another desired point along the suture line. He has never seen "spitting" when this technique is employed. Cole prefers to bury the first knot of his two layer closure, however due to the amount of tension is greater on it. (Fig. 18) The second knot is buried or passed outside the wound. Cole feels that "spitting" occurs in the minority of patients and he has not observed "spitting" with monocyrl suture.

As for what type of suture is best, Cole generally closes his wounds that are 6 mm or less in width with a running 4-0 Supramid suture. He leaves these sutures in place for seven days. With wider wounds he uses a 3-0 Nylon or Supramid suture, or 2-0 chromic suture. He may leave these sutures in place for 12 to 14 days. Placing the suture superficially in the upper dermis least impairs blood supply to the wound, but may result in a greater incidence of post-operative bleeding and wider scars in the subcutaneous fat because of the open space that must fill with scar tissue. Cole, therefore, runs his sutures into the subcutaneous fat deep to the bulbs. Unger, after trying numerous types of suturing techniques and sutures, has also settled on a deep but single-layer closure and usually uses 2-0 Supramid on a CL-20 reverse cutting needle. He would use a 3-0 or 4-0 Supramid suture, similar to Cole, but the length of the suture and size needle he prefers is only available with 2-0 Supramid.

Despite the foregoing, because a significant number of Cole's patients come from a long distance, he often closes with an absorbable suture, 2-0 Chromic, 4-0 Monocryl or a combination of 4-0 Chromic with a buried suture. This has the benefit of insuring the suture will not require removal. Many times, a local physician, friend, family member, or spouse removes the sutures of the visiting patient. Even local physicians are prone to miss a running suture within the long hair of the donor region. Using an absorbable suture insures the missed suture will eventually dissolve without consequence. One must choose a suture that will last long enough to insure healing without lasting so long that it is annoying to the patient. The disadvantages of most absorbable sutures are the length of time it takes for them to dissolve and their greater irritability or tissue reactivity. Patients look forward to the day their sutures are removed. After the seventh day, the donor region becomes increasingly pruritic, yet absorbable sutures are often still present for 21 days. This results in an extra 11 to 14 days (or more) of discomfort, over that experienced with non-absorbable sutures that are usually removed at 7 to 10 days. Despite this, Cole cannot think of a single patient who did not want the absorbable sutures for subsequent procedures. Table #9 -- lists a variety of absorbable sutures and the time required for them to dissolve.

Shiell routinely closes with a 4-0 monofilament nylon using a continuous interlocking "blanket" stitch for the donor site.* He removes the sutures in 7 to 10 days.* His loops are 8 mm apart and 4 mm deep. For those patients who come from other cities, he prefers 3-0 plain catgut.79*

Bernstein uses 4-0 and 5-0 Monocryl sutures. He states that Monocryl Monocryl is stronger and produces less tissue reaction than chromic or Vicryl sutures. He also advocates a simple running stitch, keeping the sutures a maximum of 1.5 mm from the wound edge with approximately 0.5 cm between each loop. He advances the suture on the surface rather than below the skin* (Fig.#). Email 6/13/00. Cole warns that the knot unravels more easily with Monocryl so the surgeon must insure a proper, firm tie. In addition, since Monocryl maintains only 20 to 30% of its tensile strength at two weeks, Monocryl may not be the ideal buried absorbable suture.

As can be seen from the preceding, different practitioners have found different techniques for donor wound closure to be optimal in their hands. The novice may be left confused but should in some respects be reassured by these differences in opinion. As is commonly the case, there is no single "best way". There are many factors that must be considered when one is deciding on how to "best" close a wound. These include how wide a strip is typically being taken, where its greatest width is, if there are other scars present inferior and/or superior to the current donor site and whether the tumescent fluid - if any - contains epinephrine or not. Each of these factors, and probably others, will have an effect on the optimal method of closure. For example, with multiple donor area scars, and wider typical strips and therefore greater wound closing tensions, it may be more advantageous to use a double-layer closure and/or superficial interrupted sutures or staples. Unger’s usual two relatively narrow, usually contralateral donor sites (see below), are easily closed with single-layer sutures. In addition, there is, at most, only one scar superior or inferior to any donor area no matter how many sessions have been carried out. The result is the routine production of excellent scars and minimal discomfort. He has learned to take less, rather than more, from any area, and to close with minimal tension. Over the years his patients’ problems have only rarely been in the recipient area – most commonly they have occurred in the donor area when he attempted to take just "a little more" tissue in order to produce more grafts for an anxious patient. For out-of-town patients, he may sometimes use 2-0 to 4-0 Vicryl rapide instead of Supramid, but generally prefers not to do that because, as noted earlier, all "dissolving" sutures cause more irritation than non-dissolving ones. Frequently, either he or the patient knows someone competent to remove them, who practices within a reasonable distance from where they live. These sutures are also used for the galea, on those rare occasions when double-layer closure is deemed advantageous because of unexpected closing tension, or a past history of wider than usual scars, despite no closing tension.

»Wide Or Noticeable Hair Transplant Scars

Since most donor area harvests are horizontal, the length of the donor excision controls the length of the scar. The width of the scar is more variable. As has already been discussed, it is likely that if one does not close a donor wound with significant tension, the primary factor in determining the width of a scar is dependent entirely upon individual patient characteristics. Some patients tend to form finer scars and some seem to form wider scars. Many years ago, Patrick Frechet noted that with scalp reduction surgery, tighter scalps tend to form finer scars. This basic tenet seems to hold true in the donor region as well. Parsley lists four reasons for wider scars: greater tension, more inferior occipital donor sites, excision of pre-existing donor scars, and excessive follicle trans-section. The first of these has been previously discussed, at length, and is the easiest to understand. It is widely believed that donor strips taken from inferior to the occipital notch are more prone to result in much wider than usual scars. Unger feels that the occipital notch is too high a defining point if there is no wound tension, but agrees with the generalization that the more inferior the donor area, the greater the likelihood that wider than usual scars will be produced. As indicated earlier, many practitioners find that wide scars are relatively resistant to improvement with scar revision surgery, even with two-layer closures, but excising normal donor area scars as part of new donor strips does not tend to produce wider scars in the authors"Unger’s experience. Cole believes that removing even a fine existing donor scar predisposes the donor area to a wider subsequent scar. He often closes in two layers when excising a pre-existing scar and believes this improves the resulting scar. Finally, trans-section of hairs superior and inferior to a donor strip may also result in wider than average lines of alopecia, but this is not due to scar formation. True scar contains no hair or pigment. Normal skin should retain its normal pigmentation and is of course histologically different from scar tissue. The tendency to a wider than usual scar over the mastoid area, may be due to another factor; the incision frequently violates Langer’s lines to some extent. Brandy has noted that vertical incisions, which do not follow Langer’s lines, result in wider scars than vertical incisions that do. If a donor incision begins at or near the occipital protuberance and moves to a more superior plane, superior to the auricle, there must be some vertical component to the incision line. As this incision crosses the vertical against Langer’s lines, it can therefore result in a wider scar.

As more and more hair is removed from the donor area with multiple procedures, the ability of the patient to conceal the donor area scarring may become more difficult. This is especially true if the number of scars increases – that is, previous scars are not excised as part of new harvests. The problem is frequently may be worse for patients with fine hair, a short hairstyle, and significant color contrast between the hair and skin and a preference for short hairstyles. Sheill notes that the angle and type of hair growth in the donor area is also important for cosmesis. Some donor regions contain hair that curls up so that a natural part is formed around the scar making it more easily noticeable.* After several procedures, it is wise to take additional time in the assessment of the donor region in order to ascertain the effect additional harvesting will have on the patient’s ability to camouflage their scars. If you are not certain of the effect, trimming some of the hair from a specific region will allow you to better anticipate any potential negative effects. If scars become more noticeable, especially when the hair superior to it is moved slightly to the left or right, it would be wise to avoid the removal of more hair from this region. The area that most often develops problems with coverage following multiple donor harvests is the mastoid region. In addition, as indicated, it is prudent to study the patient's hairstyle. Short hairstyles make scar concealment more difficult. Often the hair is cut much shorter over the auricles. Should your patient prefer this style, you may want to avoid harvesting from the supra-auricular region, unless the patient is willing to change his/her preference.

Unger recommends two "pearls" for donor area closure:

- tie the knots at either end of a donor wound 5-10 mm beyond the end of the donor site. Any exudate from the end of the wound is likely to gather around the knot and make its removal more difficult and painful when the sutures are being removed.
- take time to "flip" hair from underneath the sutures so that it lies more normally, covers the donor site better, and is less likely to get caught during combing. The latter results in a pulling on the sutures, pain and possibly wider scars.

»Complications With Hair Transplant Donor Areas

Minimal or no closing tension is the ideal situation, but if the margins of the wound do not approximate with little tension, there are a number of options for dealing with this situation:

"Beehner has found that waiting for 45 to 60 minutes, prior to closure, decreases the degree of wound tension. This interval provides additional time for the large volume of tumescent fluid to be reabsorbed, resulting in more skin laxity prior to closure. It is important to keep the wound moist during the delayed closure.

Cole has suggested the use of skin staples prior to suturing a wound under tension. The staples are removed just ahead of the advancing running suture closure, and have the benefit of controlling excessive bleeding as well as inducing mechanical creep.*

Arnold has described the use of modified towel clamps to assist the surgeon increase the width of excision from a scalp reduction. He later modified their use to include assistance with closing of a tight donor area wound. Raposio has found that exerting mechanical forces on the scalp resulted in no additional scalp removal in alopecia reduction surgery than from undermining alone. * He theorized that the inelastic nature of the galea prohibited any benefit from mechanical creep. This suggests that much of the benefits of mechanical creep with temporary skin staples or tension clamps may result strictly from dissipation of the tumescent infiltrate. There might also be some benefit from stretching of the skin on the neck, where there is no galea.*

A fourth solution for tight closure is to undermine one or both margins of the donor wound, but no farther than 5.0 cmmm from the edge(s). This act decreases tension, but *creates the greatest risk to the donor area vascular bed. Though there are few reported cases of donor area necrosis, undermining or closing a wound under tension creates a greater potential risk for this complication.*

Galeal or dermal sutures, usually 3-0 Vicryl, 2-0 to 4-0 Vicryl Rapide, 4-0 Monocryl or Chromic catgut, can be employed to take the tension off the superficial skin sutures.

Deep plane fixation sutures, as described below by Seery, can be tried. Recently, Unger used Seery's technique on an individual in whom previous attempts at scar reduction resulted in no improvement, despite the employment of galeal sutures and and minimal closing tension. The results from this last attempt, as per Seery, were far better.

Rather than creating a locus of great tension that is likely to break down, Rassman, Marzola, and Seager prefer to leave a small gap between the wound margins at areas of great tension, and to close the rest of the wound, where there is little or no tension. This is the most conservative option but will, of course, result in slower than usual healing by secondary intention at that site, a wider than usual scar - at least initially – and greater exudation from the open defect. Seager has claimed that the width of the resulting scar is often little or no greater where the wound was left open to heal by secondary intention, than in the area in which the donor region was approximated, because the scar contracts with the passage of time. (Conversely, JamesJaime Reyes believes that leaving a small gap with wound closure leaves aresults in a slightly wider scar than closing under even slight tension). The patient will perhaps also have the least risk of serious post-operative complications such as donor area necrosis and "railroad track scars", with this approach."

All hair restoration surgeons will, at some point, be presented with a complicated donor area, a donor area with wide scars, "shotgun" punch graft scars, multiple linear scars, or a donor area near depletion. Such a donor area will present more challenges than a "virgin" one and will raise your appreciation for a well thought out long-term plan for harvesting in a virgin donor area. Various techniques exist for handling complicated donor areas. Some surgeons advocate avoiding scars while others recommend removal of some of the scarring in sessions devoted entirely to scar removal or as part of a procedure that includes harvesting new hair for transplantation. Nordstrom has used his silicone suture for treatment of wide donor scars.* He has seen scars as wide as 20 mm at their widest parts, reduced by 50% or more when this suture is employed.

With shotgun scars, alterations of hair angles occur wherever there is scar tissue. Therefore, excising an ellipse is nearly always the best way to obtain more donor material. Epstein, (Monday, Sept. 25/00 email) advocates the use of a power punch to excise round grafts between scars from round grafts, and then later excising the original scars with the same punch or – a method we prefer - excising the entire area with a scalpel, prior to closure of the wound.

As your experience grows, you will gain knowledge and techniques to manage complicated donor sites. Whatever you do, you should avoid further complicating the donor area. Therefore, consider referring a patient whose donor area challenges your level of expertise to a more experienced practitioner. If your patient presents with low donor area hair density or a severely depleted donor area, it may be wise to avoid further surgery. If the patient has little hair to move, you may also, for example, have a reduced capacity to meet his expectations. In addition, whatever you do, take narrow enough a donor area to close with absolutely no tension. The blood supply in the region is already severely depleted by scar tissue. Also, post-operative edema over the first two to three days will increase wound tension to a surprising extent.

Unger recommends that everyone should evaluate the donor area in a patient, daily, at least once. You will probably be shocked at the effect of post-operative edema on wounds originally closed without tension. He also recommends that:

- you try to remove strips that contain more scar than hair, so the appearance of the donor area afterwards will be better than before,
- at least one donor wound edge should pass through intact (non-scarred) tissue so the blood supply in at least one edge will be more normal than that present in scar tissue,
- a 3% - 4% minoxidil solution be applied twice or three times daily to the wound area to possibly increase vasodilation in the area, d) bacitracin ointment should be applied two or three times per day (after the minoxidil is applied) to minimize the possibility of infection in this area with reduced blood supply and,
- sutures should be left in place for 10 days rather than the usual seven days as healing in areas with extensive scarring is usually somewhat delayed.

»The Seery Approach To Donor Site Closure Under Tension

The following donor area closure protocol is recommended by Gerard Seery.* This method is based on the principle of "deep plane fixation" and is believed to be particularly useful in secondary or tertiary harvesting in a fibrotic donor area or when a notably wide strip e.g. 2 cm is being taken.
The donor area strip is removed and hemostasis secured

A sewing edge is obtained with a sweeping movement of a #10 blade through the subcutaneous tissue on both sides of the wound. This is rarely accompanied by significant bleeding. In first time harvesting, or even in secondary harvesting when the tissues are mobile and well vascularized, this step alone usually allows for a simple one or two layer closure as preferred. If, however, the wound remains refractory to closure, proceed to step 3.

Further undermine the wound edges, but not for more than another 1 cm or so than detailed in Step 2. Evert the superior wound edge and place a PDS 2/0 suture in the deep dermis as far away as possible from the wound margin, for example, 6-7 mm from the wound margin. Suture this as inferiorly as possible to the deep fascia (not to the deep dermis) in the bed of the most inferior part of the wound. Use moderate tension only (Fig. #19).

It is stressed that sutures are placed from deep dermis to deep fascia and not from dermis to dermis. Several sutures may be necessary depending on the length of the wound and degree of difficulty in closing. Alternate each suture placement, that is, from as superior as possible in the dermis of the superior flap to as inferior as possible in the deep fascia in the inferior-most reaches of the wound and the adjacent suture from as inferior as possible in the dermis of the inferior flap to as superior as possible in deep fascia in the superior part of the wound (Fig. # -20). Alternate from superior to inferior and from inferior to superior until the wound edges are approximated. All knots are should be buried. The skin is closed with 3/0 or 4/0 nylon placed either as running or interrupted sutures.

The above is not a simple technique and requires practice to perfect. Because of its complexity, it is an excellent five-finger exercise for improving surgical skills. Its main benefit, however, is to facilitate low-tension closures in fibrotic donor areas or when a wide strip is being taken and in situations in which the surgeon is experiencing difficulty closing the wound for whatever reasons. Its rationale is based on surgically minimizing wound tension and thereby obviating embarking on tension-inducing methodologies in order to effect closure.

Seery has also provided a biomechanical rationale for deep plane fixation closure,* and it is quoted here:

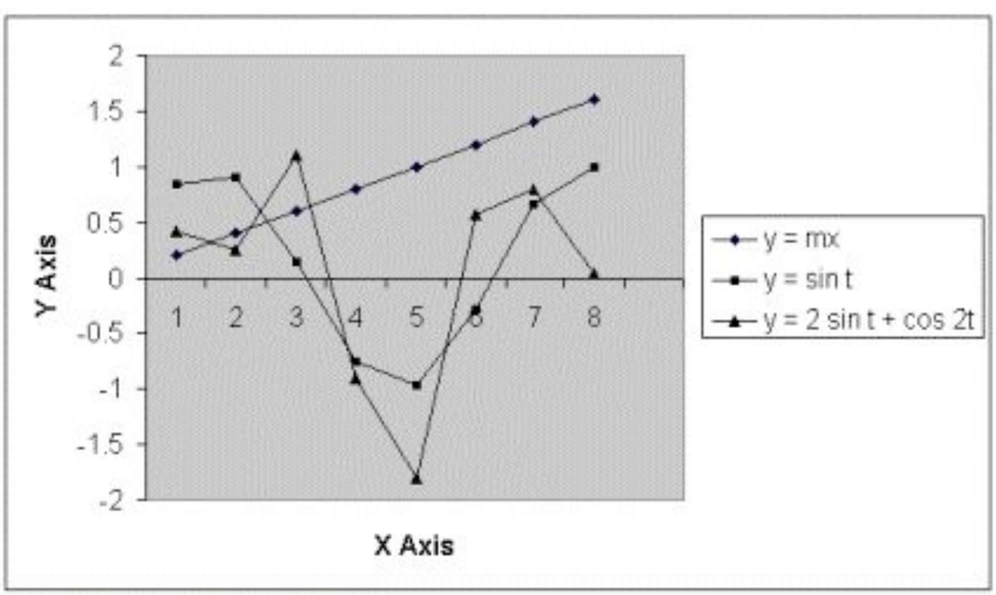
"Tension created at the wound on closure is responsible for multiple adverse sequelae (see below). The standard method of combating tension is to attempt to overcome it with a combination of extensive undermining and traction with tension clamps, big needles, heavy suture and muscular force. The methodology of donor site closure, detailed above, is a modification of deep plan fixation. This eschews extensive undermining and traction closure. The rationale for its use depends on two tenets of surgical practice:

- Channeling tension forces through non-undermined tissues notably limits their adverse effects as compared with tension transmitted in extensively undermined tissues * and
- tension vector forces channeled away from superficial "at-risk" tissue into deep plane tissues allows the adverse effects of tension to be dissipated in tissues other than the wound.*
-

The most important criterion in deciding the width of the strip that may be successfully harvested, without creating undue tension at closure, is the laxity of the tissues.* Donor area tissues may be either naturally tight or tight as a result of prior harvesting. A combination of each is the worst possible scenario. The belief that closure problems posed by tight scalps can be solved by extensive undermining and stretching is in serious need of review. The scalp is made up of collagen, elastic fibers, blood and lymphatic vessels, and nerve fibers with mucopolysaccharide ground substance and tissue fluid. All of these elements are adversely affected by extensive undermining and stretching. The ability of skin to recover from stretch resides in its elastic component.

When skin stretches, the elastic fibers elongate in the direction of the stretching force, allowing the convolutions in collagen to straighten out. The resultant elongation is a function of progressive displacement of ground substance and tissue fluid, which accompanies collagen realignment.* This continues until there is a structure of parallel collagen fibers that resists further extension. This complies with a principle of Physics that states that stress (stretch) is directly proportional to strain (elongation) provided the elastic limit is not exceeded. The elastic limit of skin (or any substance) is that point at which the components commence to rupture and the stress/strain ratios no longer apply. It is accompanied by adverse tissue changes. The elastic limit for skin elastin is about 100% and that for collagen 10%. When skin elongates more than 100% of its resting length, the elastic fibers rupture.* The impaired elastic is now no longer able to return the collagen to its normal resting state even when stress is removed. This results in permanent, irremediable adverse consequences for the tissues called plasticization, better known to surgeons as stretch-atrophy. (thin, dry, brittle, poorly vascularized skin) commonly seen following donor area traction closures and after overly ambitious alopecia reductions.* Stretch-atrophied tissues are relatively unsatisfactory for subsequent harvesting or hair transplantation.* Skin stretching also attenuates blood vessels decreasing tissue perfusion which, if allowed to continue unchecked, will ultimately exceed the critical closing pressure and perfusion stops. Lesser degrees of stretch will reduce circulation. Elongation of nerves and reduced lymphatic drainage causes pain and edema, respectively.*

Non-undermined skin is better able to withstand the ill effects of tension stretching than undermined skin. Extensive undermining is also ineffectual. In a clinical research study by Seery, * two groupings of mid-line alopecia reductions were described, the only difference being that one had undermining of 15 cm bilaterally and the other only 5 cm of undermining bilaterally. The excision widths in each group were identical at 39 mm. There was no significant difference in stretch-back. The suggested the extra undermining of 10 cm bilaterally contributed nothing in terms of increased tissue excision. This conclusion is scientifically supported by Raposio * who, in an excellent paper on tensiometric measurements in serial scalp reduction, reported "the benefits of an extensive (15 cm) undermining were minimal as compared with those obtained with 5 cm undermining." As a practical matter, it is unlikely that undermining of much more than 2.5 cm from the donor wound edge is worthwhile."



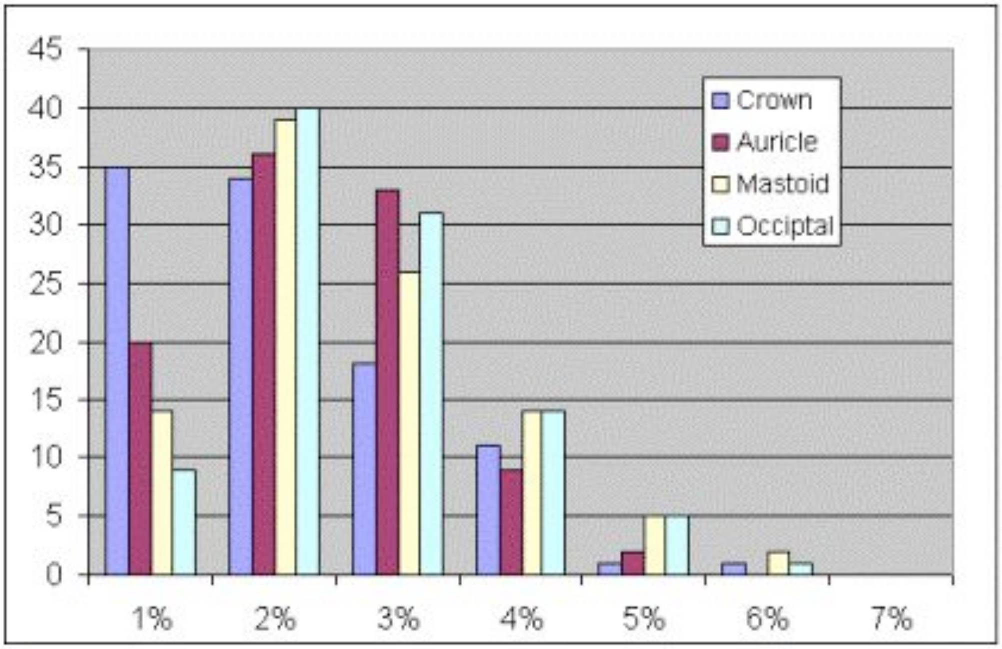


Table 8. Percentage of naturally occurring surface hair groups per follicular cluster based on regional location in the individuals, who are a Norwood Class III-VI.60