

Standardizing the Classification and Description of Follicular Unit Transplantation and Mini-Micrografting Techniques

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Previous attempts at classifying small graft transplants have focused mainly upon graft size and have not taken into consideration other technical factors involved in graft production that may influence the outcome of the surgery. The proposed classification attempts to consider these factors by including various technical aspects of harvesting, dissection, and placement, all of which impact the quality and quantity of the small grafts used in the procedure. By standardizing the nomenclature, as well as the description of the other factors involved in the surgery, communication between physicians and patients may be facilitated. In addition, different procedures may be more accurately studied and compared. © 1998 by the American Society for Dermatologic Surgery, Inc. Dermatol Surg 1998;24:957-963.

Two important articles proposing classifications of hair transplantation that reflect the recent changes in our field appeared in the September 1997 special issue of *Dermatologic Surgery* devoted to "Hair." The first, "The Knudsen Nomenclature, Standardizing Terminology of Graft Sizes," written by Drs. Dow Stough and George Bondar,¹ attempted to "allow for universal communication between hair restoration surgeons and improved surveillance of new technologies." The second article, "Accurately Communicating the Extent of a Hair Transplant Procedure," by Dr. Marc Avram,² proposed that the most accurate way to discuss the extent of a hair transplant procedure is by the number of follicles actually transplanted, rather than the number of grafts, since graft size is so variable.

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The Knudsen classification describes micrografts "without regard for shape or method of insertion" and notes that when using minigrafts "stating the number (of hairs) is not mandatory." In addition, the opinion is expressed that "the generic term follicular (unit) transplantation may become popular as a concept but it is nonspecific in relation to both amount of hair transplanted and to the precise technique used."¹ The current classification attempts to precisely define the term "follicular unit transplantation," quantify the amount of hair used in the procedure, and detail the exact techniques involved. The classification should be equally applicable to mini-micrografting; and should be structured in a way that these two techniques can be compared.

The follicular-based method proposed by Dr. Avram offers the advantage of specifically quantifying the amount of hair moved. The current classification considers additional characteristics of the grafts, as well as the technical factors that went into harvesting, dissecting, and implanting. The rationale behind this expanded classification and description is that a wide variety of factors may contribute to the absolute number of grafts that can be obtained from a given size donor strip, the quality of these grafts, and the aesthetic impact they will have.

In describing grafts, their preparation, and use, we recommend that seven main elements be included as part of the patient's permanent surgical record for all follicular unit transplantation and mini-micrografting procedures. This classification and description is not meant to be all inclusive. Other relevant aspects of the surgery should be recorded, especially those nuances unique to the individual surgeon.

The current classification and description attempts to present a balance between the quantitative and technical aspects of the procedure. It is also designed to help the physician and patient evaluate and compare different techniques. It is for use in small graft procedures and is not meant to be applicable to all forms of hair restoration surgery. The classification of procedures involving larger grafts has already been established.¹

The seven key elements in the proposed classification and description are arranged according to the sequence in which they are encountered during surgery. They are: 1) evaluation of donor site, 2) donor strip, 3) graft dissection, 4) graft yield, 5) recipient site, 6) graft insertion, and 7) distribution.

Seven Key Elements

1. Donor Area

a) Natural Hair Groupings

A preoperative evaluation should be performed and documented, preferably at the time of the consultation. METHOD: Examine clipped donor scalp with a densitometer,⁴ trichoscope (Haber RS. A new method for graft count estimation in total micrografting: introduction of the Trichoscope®. ISHRS Meeting, Toronto, Canada, September 1994), videoscanner,⁵ or similar measuring device. Divide the total number of terminal hairs seen in the field by the number of distinct natural hair groups (follicular units) to estimate the average number of hairs per follicular unit.

b) Donor Hair Density and Follicular Unit Density
Donor hair density should be expressed in hairs/cm². (Note: in Caucasians, the donor density in hairs/mm² will be approximately equal to the average size of the patient's natural hair groupings, since the follicular groupings are spaced at approximately 1 unit/mm².⁵) If the measuring device is calibrated, the donor density can be measured directly and expressed in hairs/cm². The location(s) of all measurements should be specified.

Follicular unit density should be expressed as FU/cm². This can be useful in determining the size of the donor strip required in follicular unit transplantation, since each follicular unit represents one graft. Since the follicular unit density will decrease as one moves laterally towards the ears, multiple measurements should be taken, especially in larger procedures.

At the time of consultation, at least one measurement should be taken 5 cm to the right or left of the occipital protuberance. Other areas that are often useful are the posterior midline, and 1.5 cm above the helix. Multiple, intraoperative measurements taken in the clipped donor area are also useful in estimating the size of the

donor strip, especially in a long strip where the density may vary significantly. It also may be useful to obtain photographs of, or sketch the donor area, if there is significant scarring that might affect the donor supply.

2. Donor Strip

a) Harvesting Technique

EXAMPLES: Multi-bladed knife (specify number of blades and spacing), two-bladed knife (specify width), and free-hand ellipse. Indicate the magnification used during the harvesting. Indicate the type of closure and if there was tension.

b) Location

EXAMPLES: Midline, right, left, occipital, parietal, and temporal (can be indicated in a diagram).

c) Dimensions

EXAMPLES: Length × maximum width (in cm). Specify shape (use diagram if appropriate).

3. Graft Dissection

a) Type of Grafts

Specify the percent of each type if more than one type is used (see Definitions). EXAMPLES: Minigrafts from strip cut to size, micrografts from strip cut to size, and slit-grafts from strip cut to size. Follicular units dissected from a strip.

b) Dissection Technique

Indicate which steps in the procedure were performed with each type of dissection, i.e., subdividing the strip with direct visualization and using the microscope to dissect for smaller slivers only,⁶ or complete microscopic dissection.⁷ Indicate the amount of magnification at each step. Always indicate power if any magnification is used. EXAMPLES: Unassisted direct visualization, loupe magnification (2×), loupe magnification with transillumination (Rose P. The back-light cutting table. ISHRS Meeting, Nashville, TN, September 1996), dissecting stereo-microscope (10×).⁶

c) Holding Environment for Grafts

Indicate holding solution: isotonic saline, Ringer's lactate. Indicate temperature/environment: room temperature, ice block at 59°F, refrigerator at 4°C. Indicate average duration of time in each environment.

4. Graft Yield

a) Size of Grafts: # of Grafts: # of Hairs:

1's:

2's:

3's:

- 4's:
- 5's:
- 6's:
- Total:

b) *Average Number of Hairs per Graft*
Total number of hairs/total number of grafts =

5. Recipient Site

a) Instruments

Incision: needle, scalpel blade, Beaver blade, Mini-blade.⁸ Removal: trochar, laser (indicate settings and parameters).⁹ When tissue is removed, the site may be referred to as a slot rather than a slit.

b) Size of Sites

List one dimension if incision, two dimensions if tissue is removed.

c) Graft Sizes for Each Size Site

Specify the size graft that is to be placed in each size site.

6. Graft Insertion

a) Instruments

Jeweler's forceps, dilators, Choi transplanter,¹⁰ Rapid Fire Hair Implanter Carousel.¹¹

b) Method

EXAMPLES: All sites are premade or as each dilator is removed the implant is placed.

7. Distribution

a) Regions of the Scalp

Frontal hairline, front, top, crown. Indicate the number of grafts placed in each location (see Definitions). A diagram should be included to show the distribution of the different size implants in the different regions of the scalp.

b) Dimensions

Indicate the overall dimensions of the recipient area (cm²). Use length × width if applicable.

Examples

Example 1: Follicular Unit Transplantation

1. Donor Site

- a) Average size of follicular units: 2.2 hairs (densitometer).
- b) Donor hair density = 220 hairs/cm² (5 cm to the right

of the occipital protuberance), 230 (midline), 160 (1.5 cm above right helix). Follicular unit density = 100 FU/cm² (5 cm to the right of the occipital protuberance), 80 FU/cm² (1.5 cm above right helix).

2. Donor Strip

- a) Harvesting: two parallel blades 1.2 cm apart (Rassman handle). Closure with a single running interlocking 3-0 prolene suture under no tension.
- b) Donor strip: 1.2 × 15-cm rectangle with tapered corners.
- c) Harvested symmetrically from mid-occiput and parietal areas (see diagram).

3. Graft Dissection

- a) Type of grafts: follicular units (100%).
- b) Stereo-microscopic dissection at 10× for the entire procedure (100%).
- c) Holding environment for grafts: Room temperature (3 minutes), Ringers lactate on ice block at 59°F (30 minutes), refrigerator at 4°C (1-4 hours).

4. Graft Yield

a) Size of Grafts	No. of Grafts	No. of Hairs
1's:	290	290
2's:	826	1652
3's:	361	1083
4's:	94	376
Total:	1571	3401

- b) Average hairs/graft: 2.16.

5. Recipient Sites

20-g hypodermic needle, 0.92-mm hole for one and fine two-hair follicular units; 18-g solid wire needle, 1.3-mm hole for two, three and four-hair follicular units.

6. Graft Insertion

- a) Jeweler's forceps.
- b) All sites are premade.

7. Distribution (See Figure 1 for Placement of Different Size Grafts)

- a) Regions: frontal hair line (FHL), 280; front, 390; top, 901; crown, 0.
- b) Dimensions: 8.5 cm long × 10 cm wide = 8.5 cm².

Example 2: Mini-Micrografting

1. Donor Site

Average size of follicular units: 2.2 hairs (Trichoscope). Donor hair density 220 hairs/cm² (taken 5 cm to the right of the occipital protuberance).

2. Donor Strip

- a) Harvesting: multibladed knife: seven blades, 2 mm apart. Closure with a single, simple running 3-0 nylon suture under minimal tension.
- b) Donor strip: 1.2 × 15 cm.
- c) Harvested from mid-occiput and right parietal area extending into temple region (see diagram).

3. Graft Dissection

- a) Type of grafts: mini-micrografts cut to size (50%), follicular units (50%).
- b) Loupe magnification, 2×, with transillumination (75%), dissecting microscope, 10× (25%), for single-hair micro-grafts.
- c) Holding environment for grafts: room temperature (5 minutes), isotonic saline on ice block at 59°F (1-3 hours).

4. Graft Yield

a) Size of Grafts	No. of Grafts	No. of Hairs
1's:	291	291
2's:	201	402
3's:	164	492
4's:	125	500
5's:	162	810
6's:	151	906
Total:	1094	3401

- b) Average hairs/graft: 3.11.

5. Recipient Sites

18-g Nokor needle that makes a 1.8-mm micro-slit for one- to two-hair micrografts. SP-91 mini-blade that

makes a 1.8-mm incision for two- to three-hair mini-grafts. Mini-blade that makes a 3.0-mm incision for three- to six-hair minigrafts.

6. Graft Insertion

- a) Regular needles used as dilators.
- b) Graft insertion with jeweler's forceps as each site is made.

7. Distribution (See Figure 1 for Placement of Different Size Grafts)

- a) Regions: FHL, 200; front, 300; top, 594; crown, 0.
- b) Dimensions: 8.5 cm long × 10 cm wide = 85 cm².

Discussion

This classification is the result of the combined efforts of 21 hair restoration surgeons who have experience using very small grafts exclusively in the transplant. Although the classification may appear to be complicated and somewhat cumbersome, in practice, most surgeons use only one or two basic techniques and can easily tailor their operative reports to reflect this.

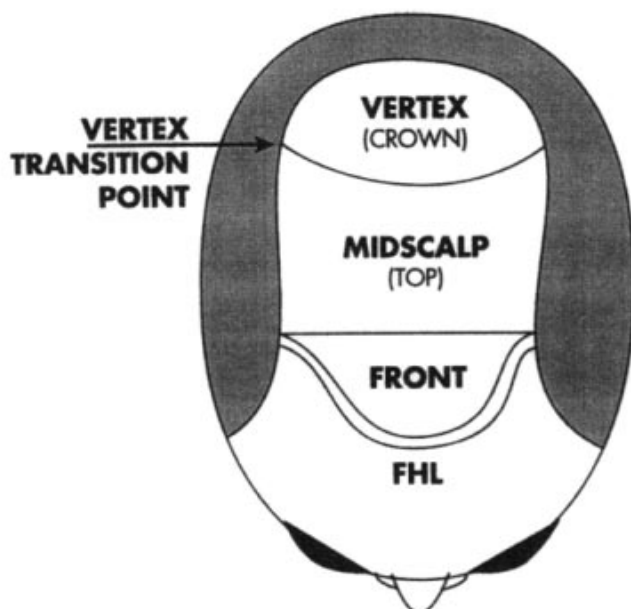
As this classification developed, it was thought that the amount of detail would be objectionable. In reality, each author further refined and expanded the original outline. This attests to the wide methodology used in hair transplantation today, even when the procedure is limited to very small grafts. This wide variation in technique underscores the importance of having a standardized way for physicians to communicate what they actually do, so that techniques can be evaluated and compared, both by their peers and their patients.

The dissection of intact follicular units is the natural outcome of using enhanced visualization, and is an integral part of both mini-micrografting and follicular unit transplantation, although the latter term should be reserved for those hair transplant procedures in which individual follicular units are used exclusively in the entire transplant. The advantage of microscopic dissection in preserving the follicular anatomy cannot be over-emphasized, as it has brought hair transplantation to a new level of refinement. We appreciate Dr. Bobby Limmer for having the great insight to introduce this important technology to our field.

It is the opinion of some of these authors that the use of large sessions should be an integral part of follicular unit transplantation. There are two main reasons for this. The first is that follicular unit dissection enables the surgeon to keep the recipient sites very small. The very small sites minimize the total recipient wounding and allows for the safe transplantation of large numbers of units in a single session. This will reduce the total number of treatment sessions needed.

A second reason is that larger sessions allow for the

Figure 1. Regions of the scalp.



generation of adequate numbers of different size follicular units. For example, with an adequate donor harvest, enough naturally occurring single-hair units will be generated so that larger groups will not have to be subdivided to produce the single-hair grafts needed for constructing a soft frontal hairline. In addition, if density permits, there will be sufficient three- and four-hair units to create greater fullness when these grafts are concentrated in select areas, such as the mid-forelock region. The absolute number of follicular units that would constitute a "large session" is, of course, dependent upon the individual patient, the judgment of the surgeon, and the capabilities of the surgical team. This discussion is beyond the scope of this paper, but is covered elsewhere.^{5,12,13}

The type of harvesting and dissection will impact the surgery, in that, besides affecting the quality of the implants, the more refined dissecting techniques will produce more hair from a given size donor strip. By employing stereo-microscopy and other devices that improve visualization of the follicular unit, accidental transection of follicles can be lessened, thus increasing the number of hairs that can be obtained from dissecting a given amount of donor tissue. In addition, a more accurate determination can be made of the true number of hairs transplanted. Unaided ("naked eye") visualization, in contrast, may significantly underestimate this number, and thus may affect the evaluation of the actual yield and the perceived number of hairs transplanted, hindering communication between surgeons trying to compare different techniques.

When performing follicular unit transplantation, the donor tissue must be taken out as a single strip in order to preserve the naturally occurring follicular units. Stereo-microscopic dissection is then required to subdivide this strip and isolate the individual units. Besides increasing the risk of transection, a multi-bladed knife (with more than two parallel blades) will unnecessarily break up follicular units at the time of harvesting. Backlighting alone is not effective in the initial dissection of donor tissue removed as a single strip since its thickness will preclude transillumination.

In follicular unit transplantation, the average number of hairs per graft (i.e., per follicular unit) should match the average size of the naturally occurring follicular units measured preoperatively. In addition, one-hair grafts should easily fit into 1-1.2-mm slits and two-, three-, and four-hair grafts should easily fit into 1.5-1.8-mm slits.

It is suggested that in the operative report the surgeon make an assessment regarding quality issues during the procedure. This may include a subjective evaluation regarding the quality of the donor tissue, transection during harvesting or dissection, problems

with graft insertion, popping, or other relevant aspects of the procedure.

This classification and description is intended for grafts containing up to six hairs. For procedures involving larger graft sizes, the standard Knudsen classification would be appropriate. Grafts containing more than six hairs should not be termed minigrafts. This upper limit had been suggested in a 1994 letter to the Forum by Dr. Walter Unger¹⁴ and has been adopted by this group. Although somewhat arbitrary, it has a practical advantage in that it is difficult to perform hair counts of grafts containing more than six hairs. A disadvantage is that in patients with different hair characteristics, grafts of similar numbers may vary greatly in their clinical impact.

Some of these authors anticipate that as follicular unit transplantation gains wider acceptance, all hair transplant procedures will eventually be characterized by simply describing the number and complexion of the individual follicular units, and many of the currently used descriptive terms will be abandoned.

The purpose of this classification and description is to provide hair restoration surgeons with guidelines regarding information that should be documented when performing hair transplantation procedures using small grafts. It is hoped that this will facilitate communication among physicians, stimulate research, increase the accuracy by which hair transplant procedures can be represented to our patients, and, ultimately, improve the quality of the care that we offer them.

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References

1. Stough DB, Bondar GL. The Knudsen nomenclature: standardizing terminology of graft sizes. *Dermatol Surg* 1997;23:763-5.
2. Avram MR. Accurately communicating the extent of a hair transplant procedure: a proposal of a follicular-based classification scheme. *Dermatol Surg* 1997;23:817-8.
3. Headington JT. Transverse microscopic anatomy of the human scalp. *Arch Dermatol* 1984;120:449-56.
4. Rassman WR, Pomerantz MA. The art and science of minigrafting. *Int J Aesthet Restor Surg* 1993;1:28-9.
5. Bernstein RM, Rassman WR, Szaniawski W, Halperin A. Follicular transplantation. *Int J Aesthet Restor Surg* 1995;3:119-32.
6. Bernstein RM, Rassman WR. Dissecting microscope versus magnifying loupes with transillumination in the preparation of follicular unit grafts: a bilateral control study. *Dermatol Surg* 1998;24:875-80.
7. Limmer B. Elliptical donor stereoscopically assisted micrografting as an approach to further refinement in hair transplantation. *J Dermatol Surg Oncol* 1994;20:789-93.
8. Arnold J. Mini-blades and a mini-blade handle for hair transplantation. *Am J Cosmet Surg* 1997;14:195-200.

9. Unger WP. Laser hair transplanting. *Int J Aesthet Restor Surg* 1995;3:137-42.
10. Choi YC, Kim JC. Single hair transplanting using the Choi hair transplanter. *J Dermatol Surg Oncol* 1992;18:945-8.
11. Rassman WR, Bernstein RM. Rapid Fire Hair Implanter Carousel: a new surgical instrument for the automation of hair transplantation. *Dermatol Surg* 1998;24:623-7.
12. Bernstein RM, Rassman WR. Follicular transplantation: patient evaluation and surgical planning. *Dermatol Surg* 1997;23:771-84.
13. Bernstein RM, Rassman WR. The aesthetics of follicular transplantation. *Dermatol Surg* 1997;23:785-99.
14. Unger W. Nomenclature of minis & micros. *Hair Transplant Forum Int* 1992;3(1):11.
15. Beehner M. Where is thy crown, your majesty? *Hair Transplant Forum Int* 1998;8(1):18-9.

Appendix: Definitions

Follicular Unit

The follicular unit of the adult human scalp is a naturally occurring entity that consists of one to four, and occasionally five, terminal hair follicles, one, or rarely two, vellus follicles, the associated sebaceous lobules, the insertions of the arrector pili muscles, its neural and vascular plexuses, and the fine adventitial collagen, which surrounds and defines the unit (the perifolliculum)³ (Figure 2).

Follicular Unit Graft

A graft that is obtained by dissecting out the individual, naturally occurring follicular unit. This is also referred to as a "follicular unit implant," a term that implies (unlike most grafts) the ratio of hair/skin is greater in the follicular unit implant than in the original donor area, since some of the non-hair-bearing tissue has been trimmed away in the dissection⁵ (Figure 3).

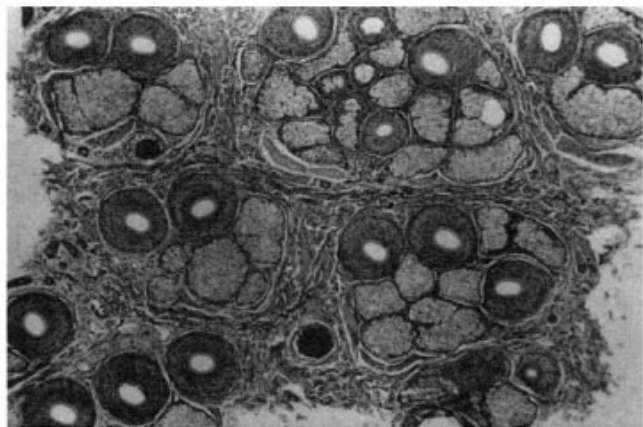
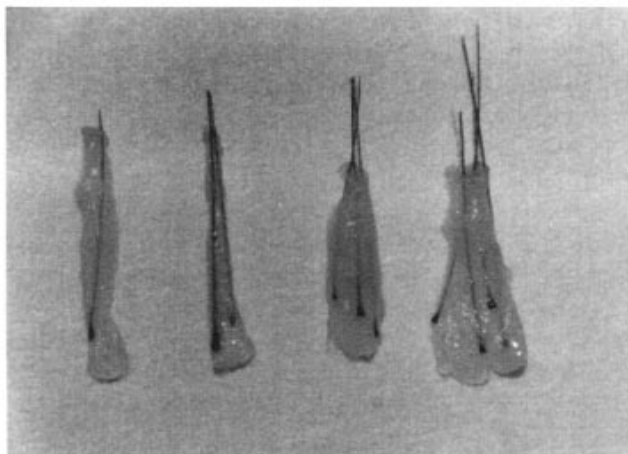


Figure 2. Transverse section of a normal adult male scalp at the level of sebaceous glands showing multiple distinct follicular units (H&E, $\times 40$).

Figure 3. One-, two-, three- and four-hair follicular units as seen through a dissecting stereo-microscope ($\times 10$).



Micrograft

A one- to two-hair graft. It may consist of naturally occurring one- and two-hair follicular units or be derived from larger units which are subdivided.

Minigraft

A three- to six-hair graft derived from either a single follicular unit, multiple follicular units, or multiple, partial follicular units. As suggested by Walter Unger, this may be further classified into small minigrafts of three to four hairs, and large minigrafts of five to six hairs.¹⁴

Slit-graft

A three- to six-hair graft derived from either multiple follicular units, or multiple, partial follicular units where the dissection technique specifically attempts to produce a linear arrangement of follicles, or follicular units. This may be further classified into small slit-grafts of three to four hairs, and large slit-grafts of five to six hairs.

Follicular Unit Dissection

A technique in which naturally occurring, individual follicular units are dissected from donor tissue that has been removed as a single strip (rather than with a multi-bladed knife of more than two blades) in order to keep the follicular units intact. Some non-hair-bearing tissue is removed to decrease the overall bulk of the implant. Stereo-microscopic dissection is required.

Mini-Micrografts or Slit-grafts Cut to Size

A dissection technique whereby the donor strip is subdivided to produce grafts of specific sizes as defined by the number of hairs they contain and/or the size of

tissue that will fit into a specific recipient site. The removal of excess skin is not required. The dissection can be performed with or without magnification and the donor tissue may be removed as a single strip or with a multi-bladed knife (Shapiro R. The yield in megasection. ISHRS Meeting, Nashville, TN, September 1996).

Follicular Unit Transplantation

A method of hair restoration surgery where hair is transplanted exclusively in its naturally occurring, individual follicular units. Single strip harvesting and stereo-microscopic dissection are required. The grafts must be placed into small recipient incisions. (This procedure has also been referred to in the literature as "Follicular Transplantation,"^{5,12,13} but the more descriptive term "Follicular Unit Transplantation" is recommended.)

Mini-Micrografting

A method of hair transplantation that uses grafts containing one to six hairs, in groups that do not necessarily correspond to the naturally occurring follicular units. The recipient sites may be either incisions, excisions (tissue removed), or both.

Front

The frontal portion of the scalp comprises the frontal hairline, a zone of transitional density, and the area immediately behind it, which generally has the greatest

Commentary

This proposal of classification and description of current techniques in hair grafting has attracted an impressive array of authors. The stated goal of clarifying terminology deserves support because, as techniques continue to evolve, so will terminology. That said, the all-encompassing, encyclopedic approach suggested might not attract universal support. "The devil is in the detail" indeed.

The article concedes that the proposal may seem cumbersome and gives a telling comment that various additions were suggested by authors in the committee process used to workshop the paper. This emphasizes the varying importance individual surgeons attach to the recording of various operative details. As a blueprint for recording information for research purposes, there is much to recommend. I am less enthused about it as a proposal for an adequate medical record.

In these litigious times accuracy is important, but so is

density in the transplant. It is bounded posteriorly by a line drawn from one fronto-temporal corner to another. The frontal area often represents, on the average, approximately 50 cm².¹³

Midscalp (Top)

Lies immediately posterior to the front and extends to the vertex (crown). It is bounded laterally by the temporal/parietal fringes. The hair on the top portion of the scalp points in a predominantly anterior or anterior/diagonally inferior direction.

Vertex Transition Point

The description of this point has been recently defined by Michael Beehner,¹⁵ as the point in the posterior aspect of the scalp where the horizontal starts to become vertical. It is the most posterior point of the top or midscalp and generally lies just behind the highest part of the skull. It is the approximate point where the hair changes direction from a predominantly anterior, or radially anterior direction, to a whorl. This point is important in that it represents a natural stopping point for the transplant when the reserves are limited and/or the planning conservative.

Vertex (Crown)

The region of the scalp posterior to the vertex transition point where the hair takes on a whorl pattern.

discretion. Do we really want to exactly quantify the number of hairs grafted? A criticism that we are likely to underestimate the number of hairs grafted (by naked eye visualization) may in fact be a benefit in the medical record. The exact dimensions of the donor strip, combined with a densitometer count, gives a hair-count number we have to "live up to" in all our procedures. Likewise, the suggestion that we report, in the medical record, any incidence of "transection during harvesting or dissection" indicates the difference between theory and reality. Perhaps an attempt to provide a framework for the minimum reporting requirements of a medical record would have been more useful.

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