Micrografting in Extensive Quantities

Please Note: *In 1995 we began using Follicular Unit Transplantation for all hair restoration procedures performed at NHI. Minigrafting/micrografting techniques were discontinued at this time. This article should be read in that context.*

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Micrografting in Extensive Quantities

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BACKGROUND

Smaller hair transplant grafts in greater quantities are becoming an unmistakable trend. As hairs grow in groups of one to four, the process is mathematically and aesthetically logical.

OBJECTIVE

To produce a natural appearing distribution of hair in the balding individual in an acceptable time frame.

METHODS

Grafts reflecting natural patterns are used. Four hundred one-hair grafts are densely packed into a frontal hairline 4-5 mm wide to create a transition zone between the forehead and a new hairline. Two-to four-hair grafts are densely packed behind the frontal zone in a graded fashion. Grafts containing no more than four hairs are used.

RESULTS

The results produce a slightly less dense but better balance that looks like the natural veneer of a normal mature male. In women or men with thinning hair, surgically increasing density satisfies many patient objectives.

CONCLUSION

Transplantation with one-to four-hair grafts in extensive quantities produces a natural "hairy" appearance with out the artificial look typical of the large traditional grafts. By using this technique, many patients can be completed in just one session. Dermatol Surg 21:306-311.

The exclusive use of very small grafts has moved from the experimental to the forefront. Dense packing of minigrafts of 1.5 mm or less in combination with one-or two-haired grafts offers the appearance of comparable density and undetectability, while using donor hair very efficiently. The use of smaller grafts in greater quantity offers many advantages normally unavailable with traditional larger hair transplantation grafts in lesser quantities.

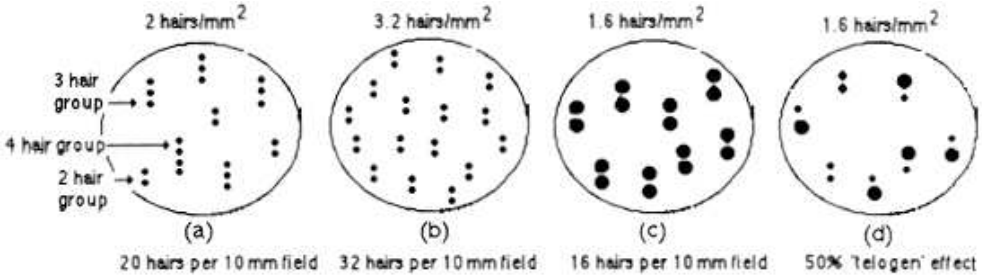
Many components of a hair transplant procedure, such as hair density, are quantifiable.1-8 Thus by identifying and assessing each component of the "building blocks" of hair transplantation, the end results of the process should be predictable. The hair transplantation physician must attempt to match the predictable end result with the patient's expectations. To address the appearance of density in the final result (with the exclusive use of micrografts), it is critical to analyze the issue of density both scientifically and logically. By counting the number of hair follicles present in the microscopic field of vision, a measurement of hair density (as the number of hairs per mm2) is easily obtained2 (Figure 1). The configuration of growing hair groups (identifying whether the hairs grow singly or in groups of two, three, four, or five), the thickness of the individual hair shafts for that individual, and the amount of miniaturization must be assessed. Assessment of the amounts of miniaturization allows anticipation of the rapidity of hair loss or the loss of hair associated with the transplantation process. The Non-mathematical Elements Contributing to the Appearance of Hair Density The three most important qualitative hair attributes that dictate the appearance of the final result of a hair transplantation procedure are as follows:

- The contrast between hair and skin color is probably the most important qualitative element in determining the appearance of hairiness. Hair that more closely matches skin color shows the result of balding less dramatically than hair color that has a high contrast with the underlying skin. Therefore, better results are easier to achieve in individuals with low contrast hair-to-skin color (HTSC).1,3
- The width of each hair shaft clearly adds value to the appearance of hair.1,3 Coarse hair may have many times more bulk than fine hair and as a result, coarse hair will carry more visual weight in creating a hairy appearance. But as the hair bulk increases, as in individuals of Japanese or Korean ancestry, the transplant surgeon needs to

adjust the technique to accommodate the increased bulk in order to avoid plugginess.

- The character and strength of each hair shaft can have a significant impact on altering the reality imposed by density. The curlier the hair, for example in individuals of African descent, the fuller the hair appears.1,3 Wavy hair offers increased coverage, while straight hair, commonly found in Asia, Japan, Korea, South America, India, the Middle East, and Mexico, allows the eye to follow the hair shaft to the scalp, thereby accentuating the contrast between the scalp and the color of the hair shaft. Straight hair "points" to the scalp and , in such individuals with thinning hair, the condition becomes evident earlier than in those with wavy or curly hair.

Figure 1. Simulated view through a hair densitometer.



- Growing hair groups of two, three, and four hairs per group and an average hair density.
- A more usual growing pattern of two hairs per growing hair group but with a high density.
- Coarse hair and a low density count.
- Coarse hair with significant miniaturization present. Note the contrast in hair bulk between hair shafts.

The Mathematical Elements Contributing to the Appearance of Hair Density

Every person is born with a particular hair population, thus the numbers of hairs per square millimeter can be ascertained scientifically.3,9,10 Hair populations vary from a low of 1.2 hairs/mm2 to a high of 4.0 hairs/mm2. The most common hair population, based on the author's direct assessment on thousands of patients, measures approximately 2 hairs/mm2 and translates into an average hair population of 100,000 hairs in an 80-in2 area of hairbearing scalp.

Transplant surgeons use the wreath of 'permanent' donor hair, which grows around the back and sides of the head. This wreath represents approximately 25% of the hair-bearing or 25% of the original hair population (20 in2). It is a generally accepted principle that the transplant surgeon can reduce the wreath of donor hair by a factor of 50% without significantly impacting the visual appearance or "fullness" of this area. Thus, in an average individual, the available, movable hair population is limited to 12,500 hairs (half of the 25,000 hairs found in the wreath of donor hair or 10 in2 of removable donor scalp). The amount of hair that can be redistributed changes if the density of the donor hair or the amount of hair bulk and curliness is greater than average.

The determination of the number of grafts that can be extracted from the donor are is based upon the direct mathematical calculation of the targeted number of hairs per graft and the area of donor skin removed. In an average person born with 100,000 hairs, the donor are can supply approximately 3125 four-hair grafts (12,500/4), 2083 six-hair grafts (12,500/6), 1041 12-hair grafts (12,500/12), 521 24-hair grafts (12,500/24), etc...These estimates are purely theoretical, however, since the density of the donor wreath decreases with each successive transplant procedure as the skin stretches to accommodate for the removed hair-baring skin. These theoretical numbers should be adjusted for the unique attributes associated with each patient's hair characteristics. The non-transplantable donor hair may be an absolute number in most individuals, making the transplantable hair disproportionally higher in high density individuals.1-6 The donor area can safely tolerate the removal, on average, of up to 10 in2 of scalp in any one procedure. Furthermore, the amount of donor hair available in any individual consequently increases proportionally as the donor density increases (Table 1).

In hair transplantation, the frontal hairline requires the highest density hair in order to make the process appear full and natural. Therefore the first transplant session, which yields the highest donor hair density, should focus on the frontal hairline, where the highest density is needed. The center of the crown represents an area that requires as much detail and consideration as the frontal hairline because of the change of hair direction and the "vortex" effect created by this swirl. Unfortunately, many hair transplant surgeons often perform scalp reductions prior to beginning the transplant process, which can dramatically reduce the density of the donor area, and hence the fullness of the hairline. The perceived value to the patient in the final end result will be significantly less than what would have been obtained had the process been done in reverse.11

Hair Growth Patterns

Hairs tend to grow in groups, most frequently in pairs, sometimes in groups of three , and more rarely in groups of four or five. These patterns are often mixed (weighted to pairs in most individuals). Understanding this architecture is critical if the incorporation of the patient's growing hair groups are to be exploited in the design of the restoration.

Table 1. Estimate of the Number of Three-Hair Grafts Available from the Donor Area Based upon Hair Density

Hair Density (Hairs/mm2)	No. of Three-Hair Grafts	No. of Hairs
1.5	1,500+	6,000
2.0	3,000+	12,000
2.5	4,500+	14,000
3.0	6,000+	18,000
3.5	8,000+	24,000
4.0	10,000+	30,000

What is Plugginess?

The appearance of 'plugginess' primarily results from the contrast between the bald skin surrounding the transplanted grafts and the hair in the grafts . Plugginess occurs when the spaces between the grafts are greater than the natural spacing between the grafts are greater than the natural spacing between the individual hairs. Therefore, in a patient with high density, the contrast between the transplanted grafts and the intervening skin is quite noticeable and cosmetically unacceptable. This contrast can be accentuated by graft contraction. In patients with low density donor sites, transplanted grafts have more space between the individual hairs, thereby reducing the high contrast problem. In these low density patients, plugginess is less of a cosmetic issue.

Healing and Scar Contraction

Assuming that all of the techniques of minigrafting are performed properly so that hair survives and growth progresses as expected, healing in the recipient site can alter the end result in distinct ways:

1. Cobblestoning occurs when the skin graft surface is elevated or depressed below the surrounding skin edge.1-3 In traditional hair transplants, where cobblestoning has been a common problem, a large number of patients experience cobblestoning as "scars" in the recipient area of the scalp. This complication is less likely to occur as the grafts become smaller.

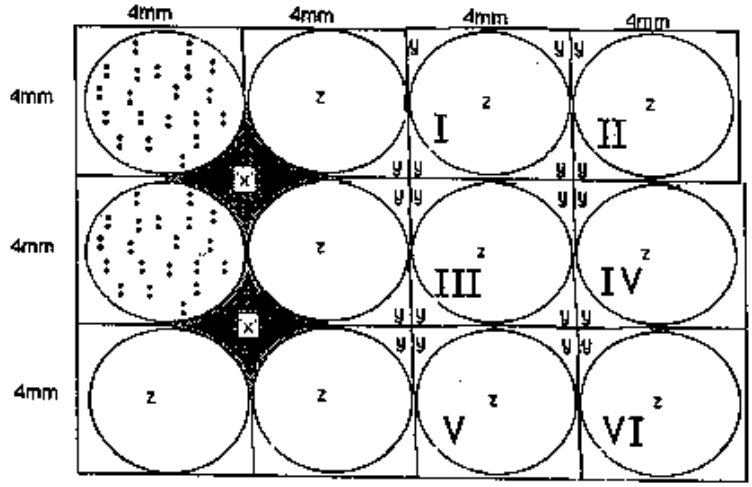


Figure 2. A schematic diagram showing the relationship in traditional large grafts between z) the dense hair grafts and x) the spaces between the grafts, which are always present under ideal conditions.

2. In the round punch hole, scar contraction is circular, thereby the mechanical effect of contraction reduces the diameter of the healing graft "ever so slightly" (worst case) and has the effect to increase the density of the hairs within the graft. Fortunately, this visual effect can be exploited to the advantage of the patient, if utilized as part of the overall design.

3. Scar contraction in slits is very common,12 causing the hairs to either line up one behind the other, or all exit from a common hole somewhere in the slit scar.

4. Significant microscopic scaring in the recipient site most likely manifests itself by reducing the malleability of the recipient skin. During transplant sessions, as fluid builds, hydrostatic pressure within the recipient area increases. The inflexible scalp cannot adjust to the pressure buildup within the recipient area, resulting, on occasion, in extrusion of the grafts. The number of procedures should be minimized so that the bulk of the work is carried out before the scar formation matures.

In the donor site, scarring occurs and becomes significantly more extensive with each surgery. The author addresses this problem as follows:

1. By repeating the surgery at exactly the same site with successive procedures, often removing the old donor scar at the time of harvesting. This produces a cosmetic end result that is much more acceptable to the patient.
2. When the donor site has been harvested previously with punches or strips in a cascading pattern, the hairs that remain between the scars can be dissected out and further utilized. The scars should be excised along with all the hair contained within.

Graft Spacing

Although the following calculations apply with a graft of any size, a 4-mm graft and the associated pattern is used (Figure 2) to demonstrate the placement of grafts in the recipient site. The area of x, equivalent to the space between the grafts under ideal conditions, is the sum total of four areas of y (y X 4 = x) and is calculated as the difference between a circular graft, z, and the area of a square encompassing the circle. Since the area of a round graft, defined here as z, measures 12.5 mm2 and the area of the square encompassing z equals 16 mm2, the area between the grafts represents 3.5 mm2 (the sum total of y X 4), or 28% of the size of the graft itself. Thus, this area becomes significant, allowing an individual to visualize the separation between the grafts. Scar contraction, which decreases graft size, enlarges the spaces between the grafts. As the surgeon makes the transplanted grafts smaller, the size of the area x approaches the distance between the growing hair groups within a graft. This means that the visibility of the space between the grafts becomes less noticeable as the graft size decreases. To illustrate this point, assume that a person has an average hair density of two hairs/mm2 and a graft size of 1.25 mm with an average of four hairs per graft in a recipient area. To accomplish this, some of the bare area between the growing hair groups may have to be excised (microscopically) when preparing the grafts. Using a regular pattern, the area of z equals 1.23 mm2, y is now 0.33 mm2, and x closely approximates the 1.23-mm2 area. The distance between the groups of hairs within the four-haired grafts will not exceed 1 mm and may often equal an area within the range calculated for x and y. The lack of uniformity in placement and smaller graft size in larger quantities maximizes undetectability. Natural hair growth is simulated as the spaces between the grafts approach the spaces between growing hair groups.

Doughnutting,2,3,13 the decrease in density within the center of the graft, increases proportionally to graft size. It often results from lack of sufficient oxygen transport to the center of the graft when grafts exceed 2 mm in size. As the graft size increases, the amount of ischemia increases. The physical laws governing oxygen diffusion in hair grafts are the same laws that physicians observe in pulmonary alveolar edema. From a practical point of view, a person with Norwood Class 7 hair loss pattern1 has lost 75% of his hair population in the front, top, and crown. Traditional hair transplantation attempts to restore hair by moving half of the donor hair (12.5% of the original hair population) to replace the 75% of the lost hair (illogical at best). If dense clustering attempts to produce a 1.2: 1 surface area between the recipient and donor area under the conditions shown in Figure 2 (ie, larger traditional transplants), then there cannot be enough donor hair to cover the bald area under any reasonable argument. This same logic applies to scalp reductions, hair flaps, and all other forms of surgical hair restoration. The ratios of bald skin and movable donor hair (using any available method of hair restoration) are critically dependent upon the geometry of the process, modified by the aesthetic skills of the surgeon an the attributes of the patient's hair. Therefore, physicians must establish realistic goals with each patient and communicate them in a manner consistent with the "informed consent" required of all physicians.

Megatransplant Sessions

Megatransplant sessions (more than 1000 grafts per session) more readily create the illusion of a fuller head of hair by redistributing the hair in smaller skin units placed in random patterns. The more densely these units are placed to each other, the better the illusion of fullness. One- or two-haired graft transplants, recommended in individuals with coarse black hair and light skin, to be effective, must be placed in massive quantities to make the impact financially and clinically practical, and aesthetically pleasing. It often takes twice the number of hairs per session to achieve the same bulk in individuals with fine hair when compared with individuals with normal hair bulk. As the hair becomes finer (and lighter in color in light skinned individuals) the number of hairs per graft can increase without producing a "picket fence" appearance. Three-hair graft transplantation is best performed in an "average" person with light brown, medium weight, wavy, soft character hair. In individuals with higher hair bulk, the number of hairs per graft should be reduced (this becomes even more important when the color between hair and skin has a high contrast). Contrary to present belief, the number of grafts transplanted in any one session is limited by the size of the donor strip and the recipient are, not by the blood supply in the recipient area. In individuals with very high density, it is possible to transplant as many as 3000+ grafts per session. Patient satisfaction, in such individuals, is extremely high. Figure 4 reflects the actual placement of grafts with a dense packing technique used routinely in my surgical practice. The graft quantities (and the very close packing of those grafts) used in the patient portrayed in Figure 3 should not routinely be used in advanced hair loss patients who will most likely not lose significant amounts of hair. This patient demonstrated that dense packing of grafts in large numbers and with small intermittent spaces is not only possible, but also does not produce a blood supply problem (as commonly thought). If dense packing of the grafts is used in the most advanced hair loss patients, one must consider that an imbalance may result as the hair loss pattern progresses.

In Figure 3, on the other hand, a brown hair color on a white skin background in a straight haired individual with a Norwood Class 6 pattern is shown 7 months after transplantation (total of 1750 grafts placed in one session). His donor density was 2.6 hairs/mm2. The first procedure used less than 30% of the donor hair, which can be safely moved and reflects only a few months growth. It is critical to note that the patient underwent a fairly radical visual transformations while leaving significant amounts of donor hair which could be used to add more density or to follow his hair loss pattern

further back. The patient elected to receive 1950 additional grafts just after these photographs were taken to fill out the crown and add further density to the front and top.

Megatransplantation allows what normally might take many years and multiple surgeries to be telescoped into one or possibly two sessions in an outpatient setting under local anesthesia. This Fast Track[SM] approach allows the required surgery to fit into an active person's lifestyle with minimal disruptions. A transition zone at the hairline is created at the same time that the bulk of the transplants are performed, so touch-ups are not required. The photographs clearly show how the illusion of fullness is created. The physician must represent that this process is nothing more hat a well-designed illusion and patient expectations should be adjusted accordingly. The hair transplantation field must reflect the science and esthetics of hair restoration and the progressive nature of the hair loss process.

Conclusion

All hair restoration procedures produce an illusion of fullness. Balancing illusion and reality requires the blending of art and science. Careful consideration of the relationships between various attributes of the patient's hair loss, hair character, hair density, hair bulk, and hair color is essential. Each and every element must be tied together after careful consideration of all of the qualitative and quantitative variables associated with each patient. Proper graft spacing with smaller grafts in substantial graft numbers avoids the appearance of plugginess. The utilization of small grafts minimizes cobblestoning and doughnutting. The process produces results that more closely approximate the "natural appearing" expectations of the patient. Ultimately, a uniform distribution of small grafts in very large quantities, where the spaces between the grafts themselves more closely approximate the spaces between growing hair groups, gives the natural appearance of normal hair. Therefore, this approach may be the ideal solution to the hair restoration process.

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