

Contemporary Hair Transplantation

MARC AVRAM, MD,* AND NICOLE ROGERS, MD†

BACKGROUND The field of hair transplantation has evolved considerably over the last quarter century. Performed correctly, the cosmetic results of contemporary hair transplantation are virtually undetectable in women and men. Large, pluggy “punch grafts” have been replaced with natural-appearing follicular unit grafts, which maintain their existing anatomy and with proper technique can match the orientation of surrounding hair follicles.

OBJECTIVE To review all of the steps involved in hair transplantation surgery and to provide an overview of medications used in conjunction with transplantation to help prevent hair loss.

MATERIALS, METHODS, AND RESULTS The authors review key aspects of the consultation, physical examination, selection of appropriate candidates, excision of donor area, hairline design, graft creation and placement, and postoperative instructions. The role of medications such as minoxidil and finasteride in preventing ongoing hair loss is an essential part of the treatment plan. For nonsurgical candidates, other treatments such as wigs, hairpieces, and camouflages are reviewed. Future trends may involve the use of low-level laser light therapy, dutasteride, and cloning of follicles.

CONCLUSION Patients and physicians alike are pleased with the results of contemporary hair transplantation, and physicians can now recommend the procedure without reservation.

The authors have indicated no significant interest with commercial supporters.

Hair transplantation has been performed for decades. It is based on the theory of donor dominance.¹ This theory correctly postulates that hair removed from the posterior scalp and transplanted into the thinning frontal scalp will continue to grow, without suffering from the effects of male or female pattern hair loss. Unfortunately, for decades the procedure was a scientific success but a cosmetic disappointment. Visible “plugs,” which became apparent as surrounding hair was lost, frustrated patients and physicians. Over time, fewer dermatologists felt comfortable performing hair transplantation themselves or referring patients to have the procedure done.

During the past decade, the field of hair transplantation has undergone a cosmetic revolution. The era of unnatural appearing “pluggy” transplants is over. Major advances include a reduction in graft size and the use of microscopes for graft creation, with pro-

duction of follicular unit (FU) grafts. Other changes include improved methods for donor harvesting, hairline design, anesthesia, and staff training. In the 21st century, men and women can expect consistently natural-appearing transplanted hair (Figures 1 and 2). This article is an overview of the contemporary surgical technique and how it affects candidate selection and the use of medication for hair loss. It is a safe procedure, with high patient and physician satisfaction. Through greater awareness, more physicians will be satisfied performing the procedure and feel confident referring patients. Ultimately, our patients suffering from hair loss, whether genetic or from other etiologies, will be the beneficiaries.

The Consultation

The consultation is the key to the success of the procedure. It is the opportunity for the physician and patient to establish realistic expectations

*Department of Dermatology, Weill Cornell Medical College/NY Presbyterian Hospital, New York, New York;

†Department of Dermatology, College of Medicine, Tulane University, Metairie, Louisiana

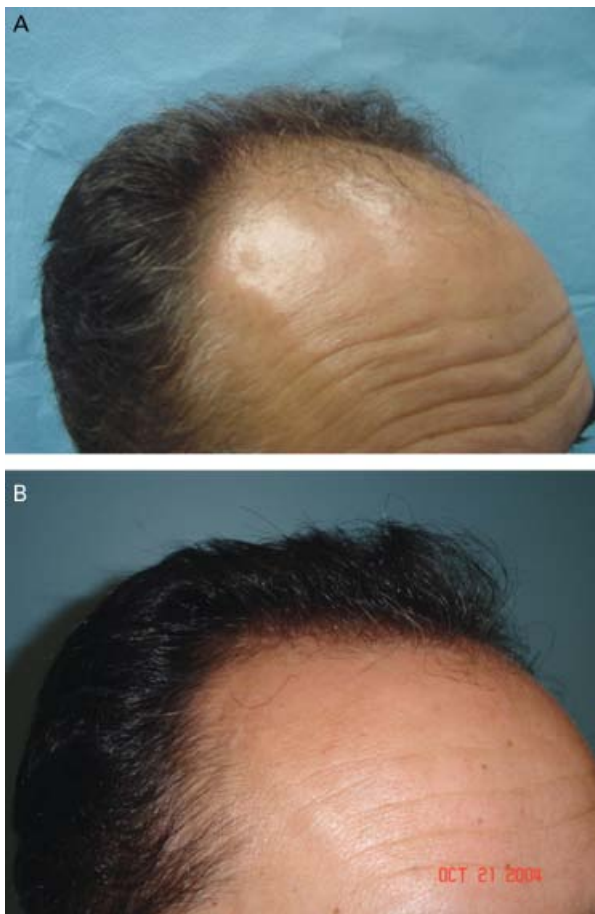


Figure 1. (A) Before and (B) after hair transplantation in a man (1,430 follicular units, 1 session).

regarding what a transplant can and cannot accomplish. Hair naturally grows in 1- to 4-hair follicular groupings on the scalp. We explain how in the past, physicians harvested 10- to 20-hair groupings as 3- to 4-mm punch grafts and then placed them in the frontal scalp. Nowadays, graft size has been reduced to more natural 1- to 4-hair follicular groupings, which explains why surgery looked artificial in the past and why modern techniques using 1- to 4-hair grafts consistently achieve natural-looking results.²

Key points to include in every consultation are the patient's goals, history of hair loss, the patient's physical examination, the use of medications to treat



Figure 2. (A) Before and (B) after hair transplantation in a woman (1,800 follicular units, 2 sessions).

their hair loss, and where to and where not to transplant. It is essential to provide an overview of the procedure and discuss how it will affect the patient's daily life (Table 1).

Physical Examination

Men and women of all skin types and hair color are candidates for the procedure. The key physical characteristics are the caliber of the patient's hair, the donor density (hair follicles per cm²), and the extent of hair loss. For men, this is commonly done using the Norwood scale (Figure 3) and women the Ludwig stage (Figure 4).

Coarse, wavy hair will create far greater perceived density than the same number of fine straight hairs.

TABLE 1. Key Concepts in Hair Transplant Consultation

- Address the patient's stated goals
- Presence of a permanent donor scar. This is of no practical significance unless the patient wears his or her hair very short or shaved. If a patient likes to wear their hair closely cropped, review follicular unit extraction.
- Net perceived density from a hair transplant is equal to the number of follicles transplanted minus the rate of ongoing hair loss.
- Review a hairline design for men that will look natural in the short and long term.
- Coarse, thick hair will create the perception of greater density than an equal number of fine, straight hairs.
- Risks, benefits, and side effects of medications approved by the Food and Drug Administration. Medications should not change candidate selection, hairline design, or placement of grafts for short- and long-term cosmetic results.
- Explain why transplanting the vertex in younger patients has long-term cosmetic risk and should be avoided.
- Limited donor area.

As a result, patients who are transplanted with coarse, wavy hair may appear to have more hair than a patient transplanted with an equal number of fine straight hairs (Figure 5A–D). The density of hair follicles in the donor region will determine how many follicles are available to transplant. The majority of Caucasian patients have 60 to 100 FUs per cm^2 .³ Those with poor donor density, measuring less than 40 FUs/ cm^2 , are poor candidates for the procedure. The lack of available hair will not allow enough hair to be transplanted to have a significant cosmetic effect. Conversely, those with average or above-average donor density have ample resources to have a significant cosmetic effect. They may also be able to undergo several future surgeries, if deemed appropriate and necessary.

Hair Loss History

The length of time and rate of hair loss are important to establish and to gauge the ultimate extent of expected hair loss. Given the polygenic nature of hair

loss, there is currently no single diagnostic test to determine the rate and extent of hair loss. As a general rule, patients who present with thinning hair in their late teens or 20s are more likely to lose all of their hair than those who have gradual thinning that is not cosmetically apparent until their 30s or 40s. The net perceived density from a transplant is equal to the number of hair follicles transplanted minus the rate of ongoing hair loss. As an example, if a patient loses a thousand follicles over a year and receives a transplant of two thousand hairs, the net density from the procedure will be one thousand, not two thousand, hairs. Over the next 3 to 5 years, as they continue to lose their hair, the patient may appear to have less hair than before the initial procedure, although they will have more hair than they would have had without undergoing transplantation. Conveying these key principles to patients is essential to establish and manage their short- and long-term expectations. The majority of our patients meet their cosmetic goals with one to two procedures.

Medications and Hair Transplantation

The role of medications with hair transplantation should be discussed during the consultation. To maximize density from a procedure, it is vital to maintain existing hair. Starting patients on medications like finasteride and minoxidil can slow the ongoing rate of hair loss. The Food and Drug Administration (FDA) has approved both for male pattern hair loss and minoxidil for female pattern hair loss. The risks and benefits of each medication are discussed and reviewed. By maintaining existing hair through medication, the relative perceived density from transplantation will be much greater. Most with remaining pigmented terminal hair opt to take one of the medications in conjunction with surgery. Others choose not to take the medications and proceed only with transplantation.

All surgeons must distribute the transplanted hair assuming that the patient may eventually wish to

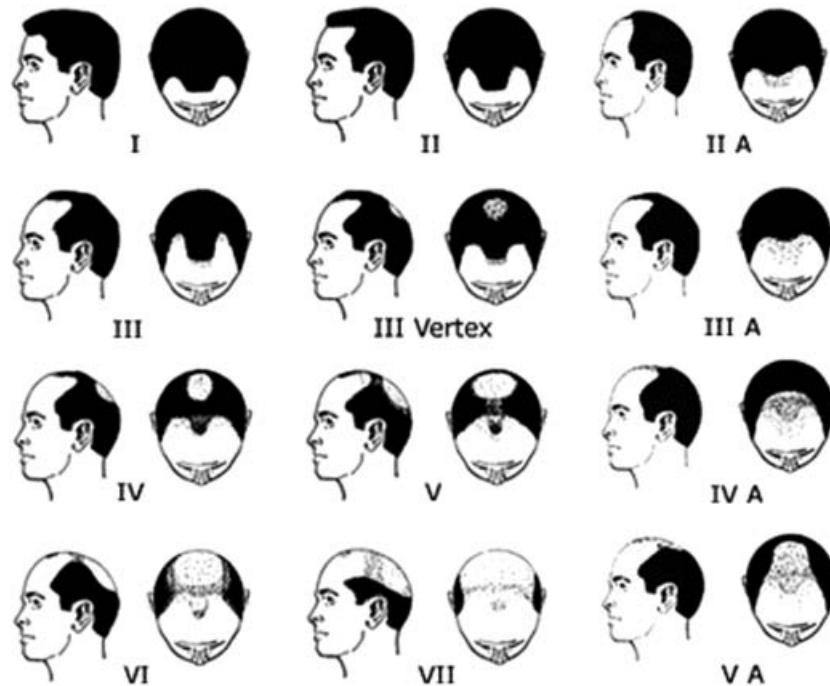


Figure 3. Norwood scale for male pattern hair loss. From Norwood OT, Hair transplant Surgery, 2nd edition, 1984. Courtesy of Charles C. Thomas Publisher, Ltd., Springfield, Illinois.

stop their medication altogether. Finasteride and minoxidil are elective medications. Patients may, for a variety of reasons, decide to discontinue their medication. They should be aware that their resulting hair loss will affect overall density. Nonetheless, it should not affect the natural distribution and appearance of the transplanted hairs.

Which Areas of the Scalp Should Be Transplanted?

Transplanted hair should appear natural 1 and 20 years after the procedure. Male and female pattern hair loss are progressive conditions. During a consultation, patients must be made to understand the ongoing nature of their hair loss and how that affects where the hair should be placed. Fortunately, the

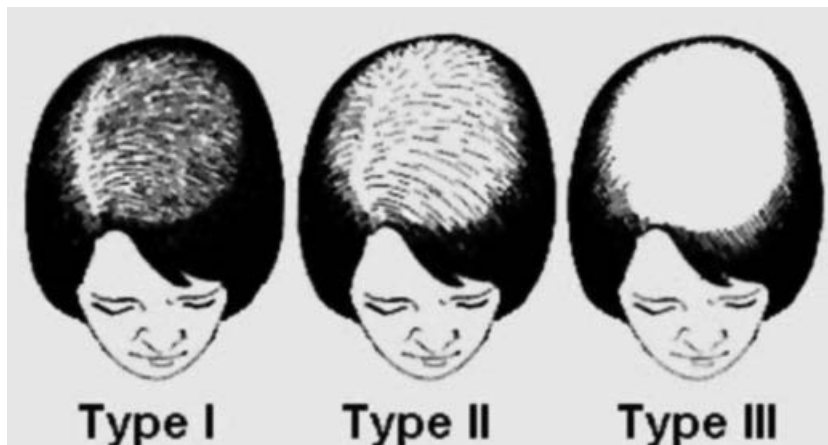


Figure 4. Ludwig scale for female pattern hair loss.



Figure 5. (A) Before and (B) after transplanting coarse, thick hair. (C) Before and (D) after transplanting thin, fine hair.

front half of the scalp is the safest and cosmetically most important region to transplant for women and men. The vertex of the scalp in men is more cosmetically risky to transplant. If one transplants this vertex, and the patient's bald spot continues to enlarge, it will result in a "doughnut" of unnatural-appearing hair (Figure 6). This, coupled with a limited donor region, is a good reason to avoid transplanting the vertex in younger patients.

After the Consultation

A complete medical history is obtained. After the consultation, all patients are encouraged to contact the office with any questions regarding the procedure. Any relevant medical condition or medication that might affect the safety of the procedure is discussed and cleared by the primary physician treating the patient. Once a patient schedules the procedure, preoperative and postoperative instructions and a consent form are sent to the patient for their review.

The Procedure—An Overview

All procedures are performed in the outpatient setting. The vast majority are done under local anesthesia. A few patients who are anxious about the anticipated pain may undergo monitored sedation in our accredited facility. All patients are told that an elliptical donor strip, obtained from the posterior scalp, will leave a permanent scar. They are told that the scar is of no cosmetic significance unless they decide to shave their hair or wear it very short. For patients who like to wear their hair short, FU extraction is another option, as discussed below.

In our office, the average procedure takes 3 to 4 hours. Other hair transplant surgeons may have longer operating times, depending on the number of grafts being transplanted. Very large cases, involving 2,000 to 3,000 grafts, may vary in time between 6 and 12 hours. During the procedure, patients should feel completely comfortable. They are encouraged to watch a movie, listen to music, or simply relax. All are instructed to let us know if they are feeling any



Figure 6. Example of enlarging bald spot around a vertex transplanted with large plugs.

discomfort, so that we may inject more anesthesia. Once the last graft is placed, an overnight dressing is applied, and patients go home. Some physicians allow their patients to go without dressing. Either way, they must be cautious not to traumatize the newly placed grafts. Detailed pre and postoperative instructions (Tables 2 and 3) and the timeline for expected hair growth are reviewed (Table 4).

Medications

Often, dermatologists are the first doctors seen for evaluation of hair loss, but if these physicians do not specialize or have an interest in hair loss, they may provide their patients with inaccurate or misleading information. In this section, we will attempt to dispel some of these myths and discuss how and when to incorporate medications into the treatment of male or female pattern hair loss.

TABLE 2. Preoperative Instructions

<i>Days Before</i>	<i>Instructions</i>
10 days or more	Stop all elective blood thinners, including aspirin, vitamin E, and supplements such as ginseng, ginkgo, and garlic. Must obtain medical clearance from the prescribing physician to stop any nonelective anticoagulants, such as warfarin (Coumadin) or clopidogrel bisulfate (Plavix). If the medication cannot be safely stopped, the surgery is not performed. Call the office with any questions regarding any aspect of the procedure or consent sent at the time of scheduling.
Morning of surgery	Eat breakfast and take prophylactic antibiotics.

For many young patients, it is difficult to predict future hair loss. Some unlucky men may progress to a Norwood VI by the time they are 30 years old, whereas others may have only barely perceptible thinning. In such situations, hair surgery alone may be an imprudent move. The first case may have insufficient donor area to treat or keep up with the degree of hair loss, and the second case may successfully regrow just with the medication. Second, it is often possible to stave off the need for hair transplant surgery for many years. Young male patients started on oral finasteride, minoxidil, or both and women started on minoxidil can hold onto their hair for a longer time and ultimately even regrow a good amount of hair.

Either way, this starting point helps develop trust between the patient and the physician, creating a partnership with the goal of helping the patient keep his or her hair. Nonetheless, patients may feel comfortable knowing that hair transplantation is a long-term option. For some patients, we have been able to defer their surgery for many years. When they eventually have hair transplant surgery, they are motivated to continue with the medicine as part of a synergistic approach. Nonetheless, surgical hair

TABLE 3. Postoperative Instructions

<i>Postoperative Day #</i>	<i>Instructions</i>
0	<p>Prednisone 40 mg orally daily for 3 days to reduce frontal edema; not mandatory, but the majority of patients take it to reduce frontal edema.</p> <p>Finish prophylactic antibiotics—1 day total. There is no standard for antibiotic use with hair transplantation. Some physicians give no antibiotic; others give longer courses.</p> <p>Acetaminophin with codeine, with food, as needed. Patients are told they should not require any after the day of the procedure and should inform the doctor if it is needed.</p> <p>No heavy lifting or leaning head down.</p> <p>Light activity only: reading, TV, computer, walking.</p>
1	<p>May gently remove dressing.</p> <p>May gently run water over scalp while in shower. Do not rub or scrub grafts.</p> <p>Apply antibiotic ointment or emollient to donor site until staples or sutures are removed 7 to 10 days post operatively.</p>
2–6	<p>May gently wash with baby shampoo over scalp while in shower.</p> <p>Use pads of fingers, not fingernails, to loosen any scabs around the grafts.</p>
7–10	<p>Sutures or staples removed. Resume full sports and regular hair care.</p>

TABLE 4. Timeline for Expected Hair Growth

1–3 months	Low risk of telogen effluvium of untransplanted hair from wound healing. Most likely to occur in patients with diffuse thinning. If from surgery, the lost hair will regrow with transplanted hair. Minoxidil may reduce this risk.
3–6 months	Beginning of growth of transplanted hair.
8–14 months	Full growth of transplanted hair.

restoration must be planned with the possibility that, one day, they will go off the medicine. This way, patients' results will appear natural no matter what.

Finasteride, known commercially as Propecia (1 mg), is an oral medication that blocks the conversion of testosterone to dihydrotestosterone (DHT) by the enzyme 5-alpha-reductase. Five-year results have shown that hair growth peaks at 1 to 2 years but stays above baseline for 90% of patients.⁴

Men find it easy to take orally, with no known risk of drug interactions or need for laboratory monitoring.⁵ We discuss with them the need to inform their primary care physicians, because it can lower the prostate specific antigen value by a factor of two.⁶

Several studies from the urology literature have investigated what role, if any, finasteride plays in the development of prostate cancer. Although some studies show that it decreases the rate of prostate cancer,⁷ others suggest that it increases the severity of cancer in those who develop it.⁸ However, these results have been questioned with respect to sampling bias.⁹ More compact prostate tissue, caused by the finasteride, may appear to be a higher grade of malignancy when detected. The consensus among most physicians is that it is neither a preventer nor a promoter of prostate cancer. Because finasteride is absorbed in the bloodstream, it can have some effects on sexual drive or function. Approximately 2% of men, or one in 50 studied, reported some sexual side effects.¹⁰ If these occur, the patient can simply discontinue the medication, and the effects will resolve within 1 to 2 days, based on its short half-life of 6 to 8 hours. Other rarer side effects that have been reported are gynecomastia and depression.¹¹

Finasteride is not FDA approved to treat female pattern hair loss, and efficacy studies do not support an off-label usage.¹² There is evidence that it may be

helpful to women who have high androgen levels.¹³ In any situation, it is crucial that women not consume or handle crushed tablets while they are pregnant. This can result in a specific type of birth defect, wherein there is feminization of a male fetus. Men whose partners are trying to have a baby may take the medicine with no risk of adverse effects.¹⁴

Minoxidil began as an oral medication for the treatment of recalcitrant high blood pressure.¹⁵ When it was found also to grow hair, dermatologists applied it topically for the treatment of hair loss.^{16,17} For many years it was available only as a 2% or 5% solution, but a 5% foam has recently become available.¹⁸ The foam does not contain propylene glycol, which was found to cause irritation and allergy for some users of the solution.¹⁹ We discuss with our female patients that they may develop unwanted hair growth, in places like the side of the face and the forearms,^{20,21} but if this occurs they may simply switch back to the 2% solution or use laser hair removal. There have been some reports of birth defects in the early literature, although they were mostly related to women taking the oral form of the medication.^{22,23} More recent reports of women using minoxidil during pregnancy have described hypertrichosis of the fetus, which resolved shortly after birth.²⁴ We recommend that women actively trying to get pregnant or who are pregnant not use minoxidil.

As with all modes of treatment for hair loss, including hair transplantation, patients must allow a full 6 to 9 months for the medication effects to be apparent because this is the time needed for the medication to affect the new hair cycle. We also have found that finasteride²⁵ and minoxidil work well in the front of the scalp as well as the vertex. The instructions on the labeling indicate efficacy only in the vertex. We explain to patients that the vertex was the part of the scalp that was tested in clinical trials and that other studies and our own experience have shown that the frontal areas respond in a similar manner. Also, patients should be prepared to use both of these medications in an

open-ended manner. Discontinuation may result in the loss of hair that was retained or regrown while on the medicine.

Donor Area

For reasons not understood, hair in the posterior scalp is relatively spared from male and female pattern hair loss. It provides a perfect physical match of hair to be harvested and placed into the thinning frontal scalp. During the consultation, we review how the donor ellipse is removed. Key points to emphasize include that, after the hair is harvested, there should be no change in the perceived density of a patient's hair in the donor region; a permanent scar will be visible if the hair in the posterior scalp is shaved or closely cut; there is a limited amount of donor area; and transplanted hair from the donor region will grow for as long as it was genetically programmed to grow. For most patients, that is effectively lifelong. If a man's or woman's posterior scalp is genetically determined to thin over time, it will thin whether in the posterior scalp or transplanted into the frontal scalp. For patients who like to wear their hair short and want no visible donor scar, FU extraction (FUE) is discussed.^{26,27} FUE is the harvesting of individual FUs with 1-mm punches (Figure 7). It has some advantages and some disadvantages (Table 5). It is particularly helpful in patients who like to wear their hair short (and cannot



Figure 7. Follicular unit extraction of 1-mm grafts.

TABLE 5. Advantages and Disadvantages of Donor Harvesting Techniques

<i>Advantages/Disadvantages</i>	<i>Ellipse</i>	<i>Follicular Unit Extraction</i>
Minimal transection of donor hair	Yes	No
Maximum number of 1–4 grafts safely harvested per procedure	2,000–2,500	≤ 1,000
Time to harvest donor hair	600–2,000 grafts in 15–30 minutes	100–200 grafts per hour
Visible donor scar with hair length > 1 cm long	No	No
Visible donor scar with hair < 0.5 cm long	Yes	Likely not
Overall percentage of cases used	> 95%	< 5%

have a linear and visible scar), who have small areas of alopecia, and who require transplantation when no further donor is present for a strip excision. Nonetheless, it is time consuming, and many surgeons report a higher rate of transection. Elliptical harvesting of the donor strip provides more hair with less transection per procedure and remains the standard method of donor harvesting.

The optimal donor region is determined before the procedure begins. The region between the occipital protuberance and 1 cm above the top of the ears is the safest place to harvest hair. The area higher above the ear and below the occipital protuberance may thin over time and should be avoided (Figure 8). The length and width of the strip will reflect the number of hair follicles needed to achieve the cosmetic goal of the procedure. Currently, there is no instrument to precisely measure how many hair follicles will be obtained from an ellipse. Density can be estimated using a variety of different instruments. Over time, with the examination of many donor regions, visual estimation of donor density is often as

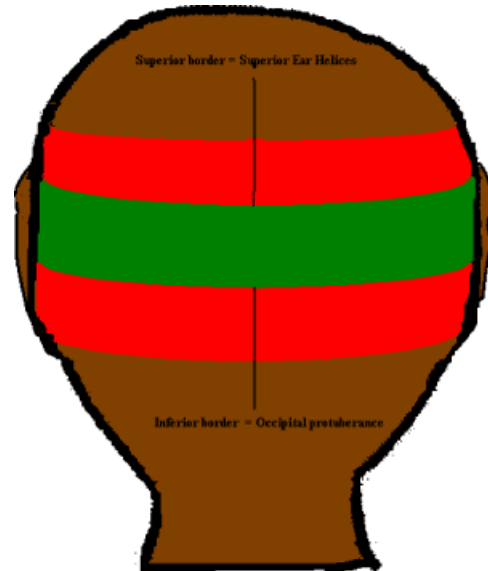


Figure 8. Green indicates “safe area” for harvesting donor ellipse. It is bordered inferiorly by the occipital protuberance and superiorly by a line drawn from the tops of the ears.

accurate as current instruments. The average density in the posterior scalp is 65 to 85 FUs per cm².²⁸ This average will help determine the width and length of the ellipse (Table 6). As with any cutaneous procedure, the greater the width of the ellipse, the greater the risk of a hypertrophic or stretched scar. To minimize this risk, we harvest strips no wider than 1 cm. We prefer greater length than width in a donor ellipse to achieve the desired number of follicular groupings.

We encourage all patients to wear their hair at least 2 to 3 cm long the day of the procedure in the posterior scalp. This is so their own hair will camouflage the sutures or staples immediately after the procedure. The donor region is trimmed with a moustache

TABLE 6. Predicting Donor Strip Size Based on Available Donor Density

<i>Follicular Units per cm²</i>	<i>Strip Size Required to Harvest 1,000 Follicular Units</i>
Above average > 85	12 × 0.8 cm
Average 65–85	15 × 0.8 cm
Below average < 50	22 × 0.8 cm

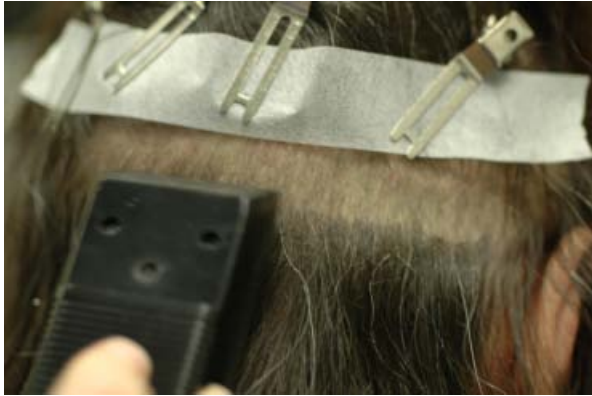


Figure 9. Trimming of donor area.

trimmer to a length of 2 to 3 mm (Figure 9). Some physicians harvest the donor region with patients sitting with their chin to the chest. We strongly prefer harvesting with patients in the prone position. The prone position allows better visibility and stability for donor harvesting. It also dramatically reduces the incidence of vasovagal episodes during donor harvesting.

The donor region is anesthetized with 1% lidocaine with epinephrine 1:100,000. In addition, 10 to 30 mL of saline is added to produce turgor in the donor ellipse. The turgor helps with anesthesia, provides hemostasis, and reduces transection of hair follicles. The ellipse can be removed using a scalpel or a double-bladed handle with spacers in between (Figure 10). The incision should be below the bulbs of the follicles in the subcutaneous tissue, so there will be minimal transection of hair follicles. For optimal visibility, skin hooks on both sides of the ellipse are used to retract. The ellipse can be removed with scissors or scalpel. Usually, hemostasis is excellent, and there is no need for electrocautery. The donor region can be repaired with staples or sutures. A two-layered closure is not needed, but many physicians perform them when encountering excess tension.

Many hair transplant surgeons implement a “trichophytic” closure technique, which involves excising a narrow rim of epidermis along the inferior border so that the underlying hairs grow directly into

(and better conceal) the resulting donor scar. There is evidence that this technique may improve the scar’s appearance, but patients may also experience a slightly higher incidence of cyst or ingrown hair formation.

While the donor site is being repaired, the donor ellipse is handed to a surgical assistant and the meticulous separation of follicular groupings is begun. First, the strip is divided in slivers, much like slicing a loaf of bread. Then, each sliver is divided into individual FUs of 1-, 2-, 3-, or 4-hair grafts depending on how they exist in the scalp. Microscopes are frequently used for this meticulous and detailed process. Once the last suture or staple is placed to close the donor site, a temporary dressing is applied, and the patient turns over onto his or her back. The sutures are removed in 7 to 10 days.

Hairline Design

There are several ways to design a natural-appearing hairline.²⁹ Some hair transplant surgeons recommend using fixed distances or relationships with various anatomical landmarks. One general rule of thumb is that the most anterior aspect of the frontal hairline should be at least 8 to 9 cm above the glabella. Despite this rule, there is no fixed mathematical formula for designing a hairline. The shape of



Figure 10. Surgical excision of an ellipse (slightly smaller for eyebrow transplantation).

each patient's head is slightly different. Creating a natural hairline is a combination of technical skill and artistic abilities. Good technical skill involves appropriate site angling and hairline design. The artistry is choosing a hairline that fits with the patient's overall features.

Perhaps the most important goal of hairline design is to anticipate the areas where patients may have future thinning. A few simple rules can keep the beginner hair surgeon out of trouble. Try to avoid bringing the hairline any farther forward than it already is (or was, before hair loss). We often start slightly above the existing hairline, to anticipate future thinning. As the frontal hairline recedes, so too does the temporal hairline. Second, do not bring the hairline too straight across on either side. The patient's natural temporal recession should be preserved. A hairline should be in an irregularly regular pattern or "feathered" (Figure 11).³⁰ Third, avoid transplanting the vertex in young patients, which can leave an unnatural island of hair as the surrounding "bald spot" enlarges.

Part of hairline design also involves prioritizing the placement of hair to the most aesthetically useful areas, within each surgery. In the initial surgery, we usually focus on framing the face. By placing the hair in the frontal one-third to half of the scalp between



Figure 11. Normal hairline with feathering of individual hairs.

thinning hair follicles, we create a natural appearance around the face. How much hair we can move in that first surgery depends on the density we find in the donor area and the amount of existing hair in the recipient region. In an era of highly effective medications, it is vital not to destroy existing pigmented terminal hair to place a predetermined number of hair follicles. For many cases, we use polarized magnification to reduce glare and minimize transection of existing terminal hair.³¹ Patients with wide skulls will need more hair to cover the same area, and patients with narrower heads need less. Either way, the amount of density in the donor area will affect how much hair is available. With additional surgeries, one can further increase the density of the transplanted areas and then move slightly back to increase the coverage of the posterior scalp. Although it is not usually wise to transplant the vertex, it is often possible to achieve a good amount of coverage simply by transplanting posterior aspects of the crown area. A safe long-term hairline design is to keep the transplanted hair anterior to the vertex transition point (Figure 12).

Before each surgery, we meet with the patient once more, in front of a mirror, to review and draw in the area of planned hair placement, using a grease pencil or marker. When we have agreed on a realistic place for hair placement, the patient comes to the procedure room. We locate the donor area, trim it, and excise this strip from the posterior scalp as described



Figure 12. Avoid placing transplanted hair where the posterior scalp angles downward.

above. Then, while the technicians are separating the grafts, we locally anesthetize the anterior scalp to start making sites. We use mostly 0.5%, and 1% lidocaine with epinephrine 1:100,000 and with 0.25% bupivacaine in longer cases, measured out in 3-mL syringes to minimize the hydrostatic pressure of injecting superficially in the dermis. The most effective way to numb the anterior scalp is with a ring block around the front. Supraorbital and supra-trochlear nerve blocks can be done as well.

Graft Site Creation

Graft sites can be created using a variety of different instruments. Perhaps the most common, and readily available, are 19- and 20-gauge needles. These measure 1.09 mm and 0.90 mm wide, respectively. Our office uses SP88s and SP89s, which are 1.00 and 1.25 mm wide (Medical Sterile Products, Puerto Rico). Several other chisel and custom-made blades can be used to make sites as small as 0.6 and 0.7 mm in diameter. Care should be taken to be sure that the nicks are made at an acute angle of 30° to 60° and at a depth of 4 to 6 mm, facing forward and toward the center of the scalp, to mimic the natural growth of hair follicles on the scalp. The sites should be made with a light touch and fairly quickly, although not so close together as to decrease the survival of any individual grafts. The target density for transplantation is 20 to 35 sites per cm², which is approximately 30% to 50% of original FU density. In patients with excellent donor supply and healthy (nonscarred) recipient tissue, the density may reach 40 to 50/cm².

The graft placement process involves a team of specialized technicians. Two to four team members work together closely to move the hair efficiently into the graft sites. Specialized instruments, such as forceps with curved tips or straight tips, can be used to help plant the grafts. Assistants must take special care to grasp the perifollicular tissue above the base of the follicle so that the architecture of the follicle is not destroyed. Other tools such as the Choi implanter, used in Asia, can be helpful in the graft

placement process. One can use a cotton-tipped applicator to help keep the graft in place and handle any bleeding. The application of pressure is also helpful in dealing with “popping,” where grafts come back out of their sites. This can occur as a result of high blood pressure, excess fluid from the anesthesia, larger-than-needed recipient sites, and in longer cases, edema from the surgery. Individual collagen characteristics can also affect whether the scalp feels firm or “squishy,” and this may affect how well the grafts stay in place.

In all stages of hair transplantation, it is crucial to have good ergonomics and lighting. The process of dividing the grafts can be especially cumbersome. We have raised the level of the counters in the operating room so that the assistants can lean directly forward and square their shoulders while cutting individual grafts. Other setups include tilting the cutting board toward the assistant, using microscopes, or using light-emitting diode backlighting for the cutting boards. While placing the grafts, assistants may choose to stand or sit, again depending on their comfort and convenience. Either way, frequent rotation is helpful so that no one gets sore muscles or becomes uncomfortable.

Corrective Surgery

Some patients who underwent surgery in the 1980s or early 1990s still have large, pluggy grafts. For these patients, correcting unnatural transplants is not elective but is a mandatory step to regaining their self-esteem. All patients can be improved. To correct these transplants, it is often necessary to remove the uniform, artificial-looking transplanted hair and replace it with hair in a more natural-looking pattern. We can use steel punch trephines to remove them and redistribute them as smaller hair groupings (Figure 13A and B). In patients who want a return to the status quo ante, we can use laser hair removal to eliminate the grafts altogether. This can require five to seven sessions and does not always eliminate surface irregularities such as cobblestoning (Figure 14). Corrective hair surgery is a lengthy



Figure 13. (A) Before and (B) after corrective surgery.

subject that is addressed more completely in other settings.

Hairpieces, Wigs, and Camouflage

For some patients, the degree of hair loss is so significant that they cannot benefit from hair transplantation. Likewise, their expectations for fullness may not be achievable given the limitations of their donor area. For these patients, cosmetic hairpieces and wigs can work well to camouflage their hair loss. Extensions are another option, wherein artificial but matching strands of hair are blended in with and attached to existing hair. These can provide fullness, but should be used with caution because they may result in further pulling and traction on existing follicles. Patients like one product called

Toppik (Spencer Forrest, Westport, CT) for its ability to camouflage open spaces on the scalp. It is composed of keratin fibers that adhere to the hair and scalp. A similar product, available in Europe as well as the United States, is sold under the trade name Nanogen (Alkam Corporation, Pasadena, CA).

Scalp Reductions

Scalp reductions are the surgical removal of bald skin from the vertex of the scalp. There is no role for scalp reductions in the frontal scalp. A variety of techniques may be used to remove unwanted bald skin from the vertex, primarily or with the assistance of scalp expanders.^{32,33} Unlike transplanting hair, which takes 8 to 12 months to achieve coverage, a scalp reduction results in an immediate reduction in bald skin. A reduction may result in long-term cosmetic consequences such as visible scarring or an unnatural angle of hair growth as the anatomic vectors change. These risks, coupled with the consistently excellent results from contemporary hair transplantation, have resulted in a substantial decline in the number of reductions performed.

Future Trends

The field of hair transplantation has changed a great deal in the last 15 years. Despite the many advances, challenges remain. The most significant of these



Figure 14. Cobblestoning may result even after removal of large plugs.

include developing new medications, staff training, the length of time of the procedure, and limited donor supply. Finasteride and minoxidil are already important in our armamentarium of tools. Still, there is room for more: better medications and devices.

Dutasteride is a relative of finasteride that blocks the type 1 and type 2 versions of the 5-alpha-reductase enzyme. Because of its dual action, it may have even more effect than finasteride in maintaining and regrowing hair.³⁴ Concerns about potentially deleterious effects on sperm, especially given its long half-life, have limited its implementation.³⁵ If more studies can demonstrate greater efficacy and safety and FDA approval is given, the drug will gain a role in hair transplantation.

Another technology being investigated for hair growth is the use of low-level laser light therapy (LLLT), which involves shining light in the 650- to 800-nm spectrum, at low powers of 5 mW, to stimulate hair growth.³⁶ No independently funded, peer-reviewed, published clinical trials have confirmed its direct efficacy in this role. Many companies have developed technology to deliver the light through a brush or with a hood directly onto the scalp. One company has achieved FDA 510k approval to market the technology as a device. Although these products are marketed heavily, our own experience has shown equivocal evidence that they change a patients' global appearance. Thus, LLLT is far from replacing finasteride or minoxidil as a first-line treatment for hair loss. Future trials will determine the role of LLLT for hair loss.

To address the need for staff training and time to cut and place grafts, it would be helpful somehow to automate this process. The current technique of manual graft site creation and placement is time consuming. Devices that create multiple sites at a time can speed the process but create a uniform appearance, with hairs maybe too perfectly oriented in relation to each other. Others have proposed using ablative carbon dioxide and erbium-doped yttrium

aluminum garnet lasers to create sites.^{37,38} These have had limited usefulness because of their potential to cause thermal damage to surrounding tissues,³⁹ but if we can develop a laser or robotic instrument that can sense the presence of existing hair, and create sites that are at a safe but random distance from them and from each other, this will be a major achievement.

The most exciting future achievement will be the ability to clone hair, thereby creating limitless donor region. Hair could be cultured from a single punch biopsy of the scalp, and patients would not have a single linear scar, as they do now. There would be no need to "ration" hair, as we do now. The vertex could be transplanted without future concerns of donor area depletion. Several private companies are working on this technology, but it appears to still be at least 5 to 10 years away from implementation.

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Address correspondence and reprint requests to:
 Marc Avram, MD, Weill Cornell Department of
 Dermatology, 905 Fifth Ave., New York, NY 10021, or
 e-mail: dochair@aol.com