Hair Transplantation

Hair Transplantation is a fully illustrated reference book that provides a state-of-the-art overview of all aspects of hair transplantation. Using a combination of written text, color photographs, and tables, eleven leading physicians and practitioners in the field discuss the latest surgical procedures to restore a natural-looking frame of hair to the face.

This volume is an indispensable reference for both experienced and novice dermatologists, plastic surgeons, and physicians interested in hair transplant surgery.

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HAIR TRANSPLANTATION

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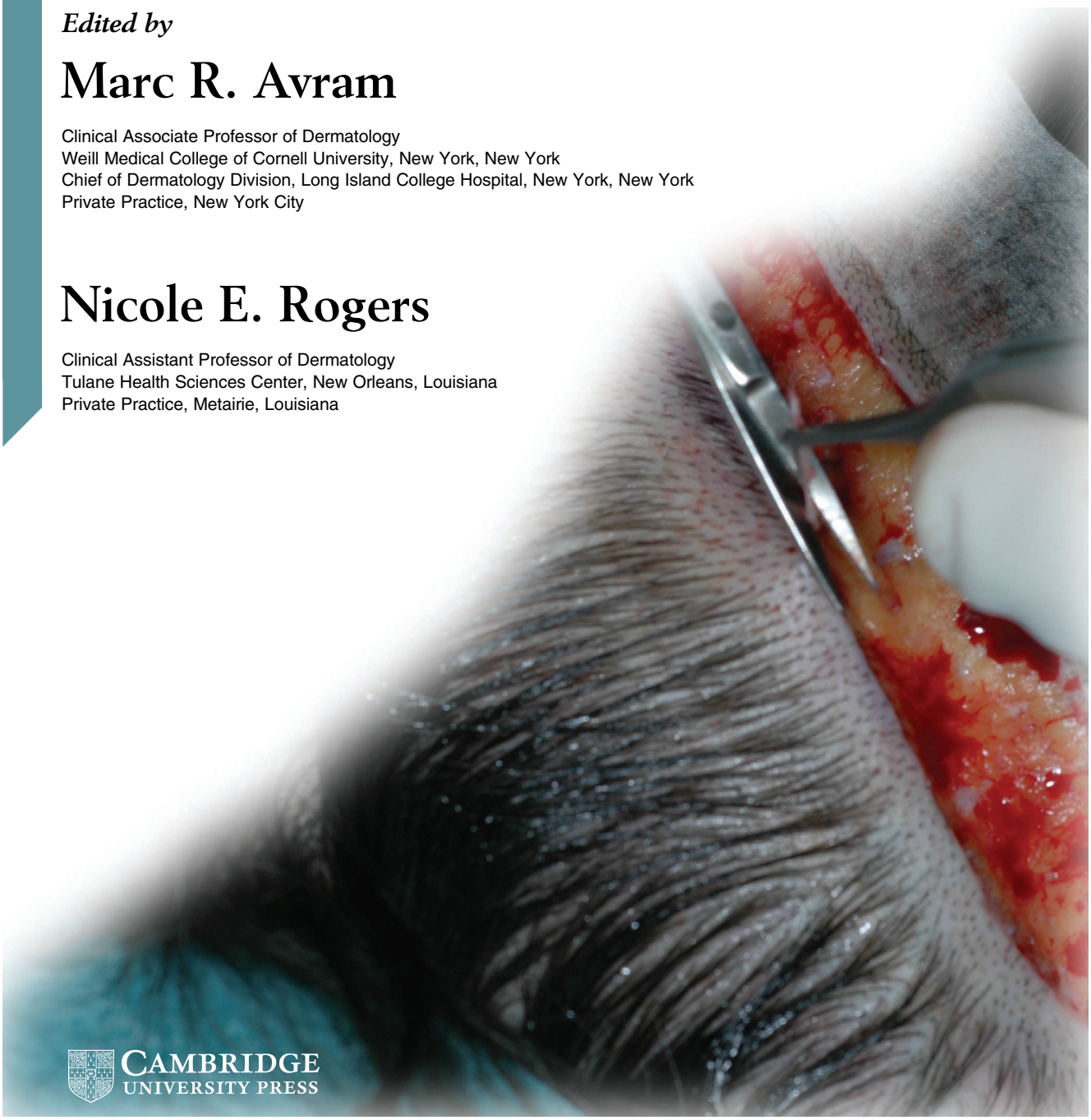

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Chapter 1

THE CONSULT, PREOPERATIVE PERIOD, INSTRUMENTATION AND ANESTHESIA SETUP, AND POSTOPERATIVE PERIOD

by

Marc R. Avram, MD and Nicole E. Rogers, MD

THE CONSULT

Any successful hair transplant begins with a patient's first interaction with the physician's office. Whether via phone or e-mail, a well-informed, timely response to a patient's question is the first step in establishing a good doctor–patient relationship. If a patient requests information before the consult, he or she should be directed to a website or published literature that reflects the philosophy of the office.

The consult establishes candidate selection and realistic expectations. All patients should expect natural undetectable transplanted hair. No patient should EVER have a straight "pluggy" hairline. This is because over the last decade, physicians have transitioned from larger ten to twenty hair grafts to natural one- to four-hair follicular groupings. With the appropriate technique, *all* patients will have natural-appearing transplanted hair. Therefore, in the early twenty-first century, the key to success is to establish realistic expectations regarding the *perceived density* from a hair transplant. To establish this, a hair loss history must be obtained by the physician during the consult. This includes how long the hair loss has been going on, the rate of hair loss, treatments to date, and physical characteristics of the hair, including the caliber, wave, and donor density (Table 1.1). The net density from a procedure is equal to the total number of hair follicles transplanted minus the ongoing loss of existing hair. It will be more difficult to create the perception of a net increase for patients with rapidly ongoing hair loss than for patients whose hair loss has slowed, either naturally or from medications. Patients who have an equal number of thick, wavy hair follicles versus fine, straight follicles will have equal growth of transplanted hair but a very different perception of density. Those with thicker caliber follicles may appear to have 50–100% more hair than those with thin, straight hair (Table 1.2).

Another important issue to discuss is where to transplant hair and how many procedures will be

TABLE 1.1. The Consult

Physical Exam	Questions
Caliber of hair: coarse vs. fine	How long have you been losing your hair?
Donor density: hair/cm^2	What have you done to try to treat the hair loss?
Wavy vs. straight	What about your hair loss bothers you?
	Medical history
	What are your expectations from a hair transplant?

needed over time to achieve the patient's goals. The physician should ask whether the patient's chief cosmetic concern is the frontal scalp, the vertex, or both. It is important to review the ongoing nature of hair loss in men and the natural recession of temporal and posterior hairlines in the vertex. Transplanted hair must appear natural one year – and twenty years – after the procedure. The frontal two-thirds of the scalp is a long-term, cosmetically "safe" region for transplant. The vertex of the scalp has more long-term cosmetic risk for male patients. The ongoing nature of hair loss can create an unnatural "doughnut" of bald skin surrounding transplanted hair. The number of surgeries needed will reflect the rate and extent of future hair loss. The majority of patients can achieve their cosmetic goals with two procedures.

All patients should have a comprehensive medical history taken and documented. Any active medical conditions or medications that may interfere with a safe transplant procedure should be discussed with other specialists or the primary physician treating the patient. When necessary, medical clearance should be obtained prior to the procedure.

TABLE 1.2. Key Concepts

- Ongoing hair loss affects the density and cosmetic appearance of the procedure
  - Net density = HT − ongoing hair loss
- Caliber of hair follicles will help determine the perceived density of the procedure. An equal number of thick and thin hair follicles will not create the same perceived density
- Donor density
- Visible scar if the donor region is shaved
- Limited donor

TABLE 1.3. Preoperative Course

- No specific preoperative bloodwork is required
- Review consent form and written pre/postsurgery instructions at least 24 hours before surgery. All questions should be answered before surgery
- All women in child-bearing years, check B-HCG
- Prophylactic antibiotic as indicated
- Avoid aspirin or alcohol for at least one week prior to surgery
- If needed, medical clearance from primary physician

Patients should be encouraged to contact the office with any questions they have before undergoing the procedure. Once scheduled, all patients are sent a packet containing detailed preoperative instructions and a detailed consent form (Table 1.3). We encourage all patients to contact us with any questions or concerns they have before the procedure.

THE DAY OF THE PROCEDURE

On the day of the procedure, we encourage all patients to have breakfast before coming into our office. The patient is brought into a room, the preoperative and postoperative instructions are reviewed, and any questions are answered. The consent form is reviewed and signed. The physician comes into the room and answers any questions. The physician reviews the procedure once again, detailing where the hair will be transplanted. Patients are encouraged to let the physician or anyone on the staff know if

TABLE 1.4. Postoperative Course

- Resume normal activities immediately, but avoid heavy exercise for 1 week
- Overnight dressing removed on post-op day 1
- Prednisone 40 mg once daily for 3-5 days, given to help reduce frontal edema from local anesthesia
- Tylenol #3 1–2 tabs every 4–6 hours as needed for pain; if needed beyond first night, then call doctor
- The recipient and donor sites are cleaned with diluted hydrogen peroxide solution for 1 day postop only
- Advised to shower on day 1 but do not pick/scratch at hemorrhagic perifollicular scabbing
- Emollient applied to recipient sites for 1 day and donor region 1 week
- Majority of patients return to work 2–3 days postop and feel cosmetically comfortable
- Staples removed 7–10 days after surgery
- First follow-up 6 months after surgery
- Final density 12 months after surgery

TABLE 1.5. Items to Be Autoclaved Together

Steri-wrap autoclavable sheets ×5
Steel instrument container
Multi-blade handle
2.0-mm spacer ×4
1.5-mm spacer ×1
1.0-mm spacer ×1
0.5-mm spacer ×1
Scalpel handle
Multi-tooth forceps (for grasping donor ellipse during harvest)
Scissors (optional, for undermining donor region)
Hemostat (in event of bleeding)
Staple remover
Follicular forceps ×6 (curved or straight, designed for cutting and planting grafts)
Skin hooks ×2
Steel comb
Tongue depressor ×5
Petri dish ×3
3 × 3 gauze (full pack)
Cotton tip applicator ×100

they need to go to the bathroom during the procedure, want something to drink or eat, or need more anesthesia.

Patients are brought to a changing room where they can leave their belongings and put on a gown. They are then escorted into the procedure room. Here, the staff is introduced and the donor region is marked and trimmed. The procedure is about to begin!

After the procedure is completed, a dressing is applied that should be kept on overnight. The dressing, which is nonadherent to any part of the scalp, is to protect the grafts while they heal. It consists of Telfa

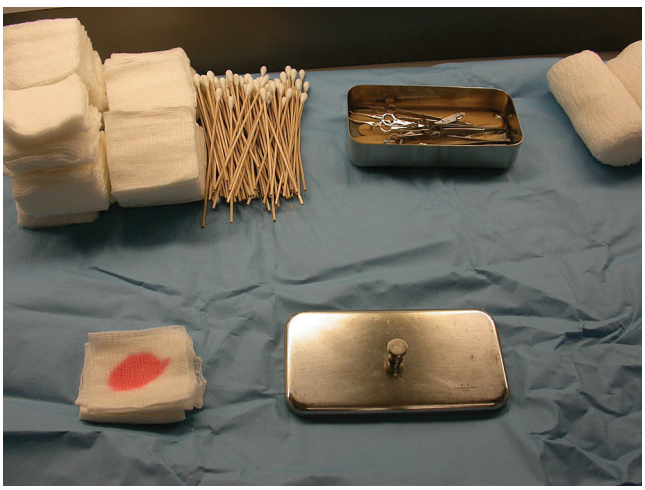

FIG. 1.1. Central work area.

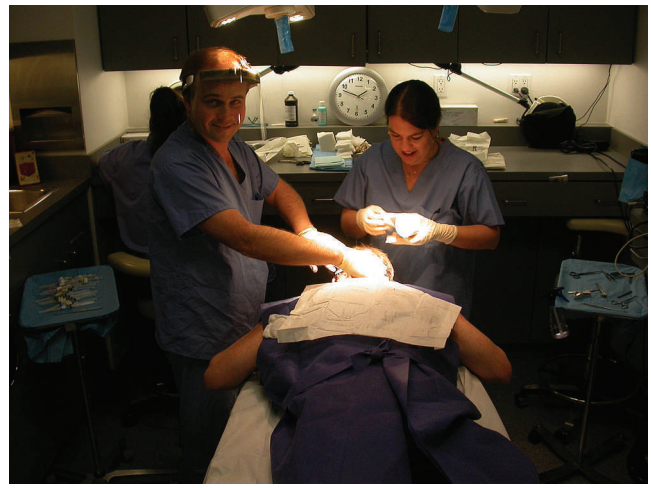

FIG. 1.2. Sterile, blue sheets are used to cover two Mayo stands placed on either side of the operating table.

pads with ointment applied over the scalp and donor region held in place with gauze and a Kerlix. A cap is placed over the dressing for cosmetic camouflage. The dressing is left in place overnight and removed the next day. The patient is instructed to call the office with any questions or concerns (Table 1.4).

INSTRUMENT AND ANESTHESIA SETUP

The day of the procedure can proceed smoothly with proper preparation and setup. The hair transplant

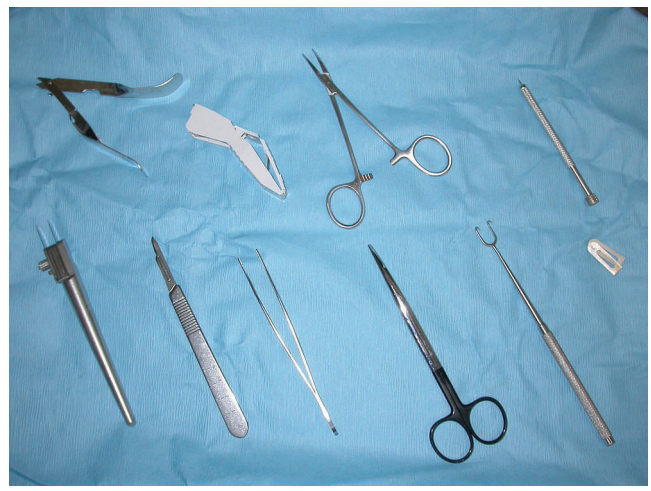

FIG. 1.3. On one Mayo stand, we place the forceps, multi-blade scalpel with appropriate spacers, single-blade scalpel, multi-tooth forceps, scissors, hemostat, staple remover, skin hooks (from packet), and a disposable sterile stapler.

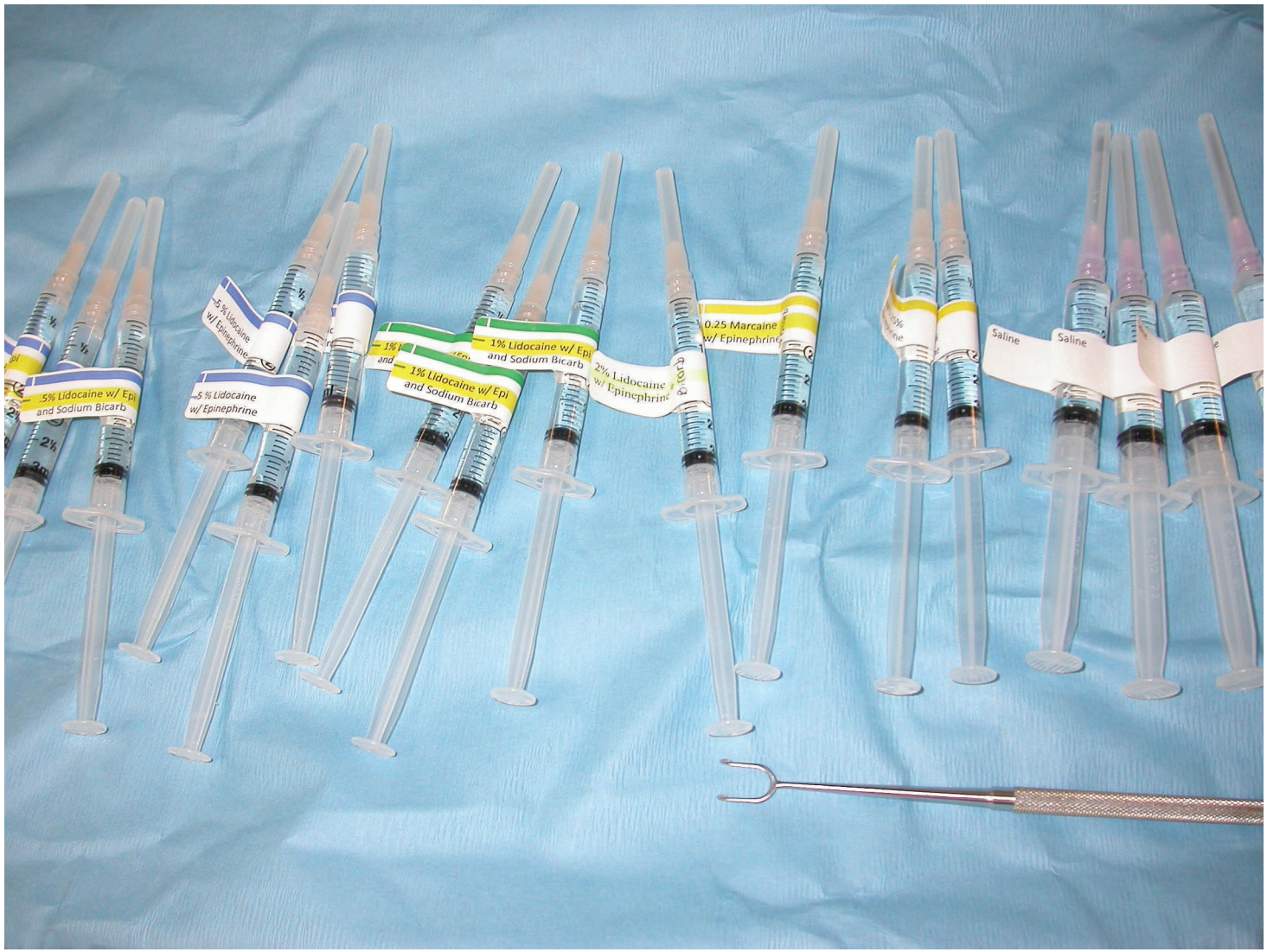

FIG. 1.4. On the other Mayo stand, we place the local anesthesia syringes.

TABLE 1.6. Anesthesia for Donor and Recipient Sites

Anesthesia	Number of Syringes
Lidocaine HCl 0.5% with epinephrine 1:200,000	3 @ 3 cc each
Lidocaine HCl 0.5% with epinephrine 1:200,000 with sodium bicarb	3 @ 3 cc each
Lidocaine HCl 1.0% with epinephrine 1:100,000 with sodium bicarb	2 @ 3 cc each
Lidocaine HCl 1.0% with epinephrine 1:100,000	1 @ 3 cc
Saline	4 @ 5 cc each
Lidocaine HCl 2.0% with epinephrine 1:100,000 with sodium bicarb	1 @ 3 cc
Marcaine 0.25% with epinephrine 1:200,000	3 @ 3 cc

team should prepare for the surgery by creating a number of packets that are organized, sterilized, and ready for surgery. We outline what instruments are needed and how best to place them in the operating suite. Of course, everyone develops his or her own way, but we have found success with this arrangement. Table 1.5 lists items that can be autoclaved together and then set up in the central work area (Figure 1.1).

Sterile, blue sheets are used to cover two Mayo stands placed on either side of the operating table (Figure 1.2). On one Mayo stand, we place the forceps, multi-blade with appropriate spacers, scalpel,

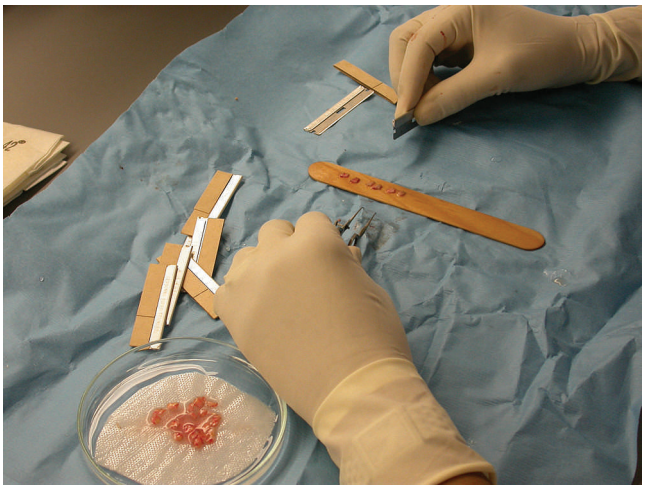

FIG. 1.5. The follicular forceps, petri dishes, tongue depressors, and five razor blades are placed on a half-sheet of Steri-wrap and used by the technicians to cut the grafts.

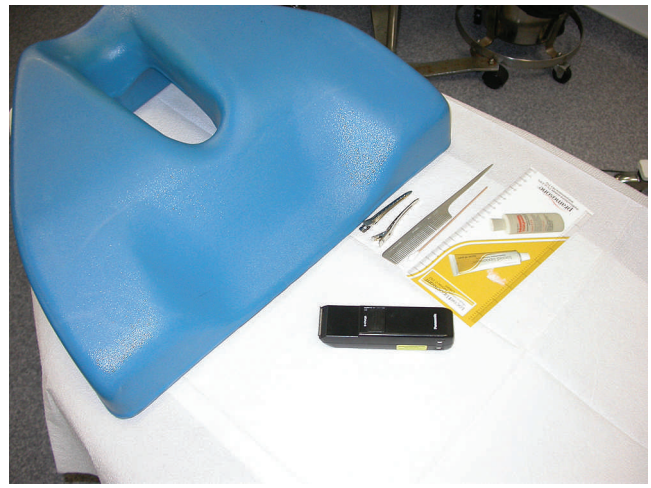

FIG. 1.6. A comb, paper tape, and hairclips are kept ready for marking the donor area surgical site.

multi-tooth forceps, scissors, hemostat, staple remover, skin hooks (from the packet), and a disposable sterile stapler (Figure 1.3). We then add whatever needle will be used to create recipient sites.

On the other Mayo stand, we place the local anesthesia syringes (Figure 1.4). Again, the syringes are drawn up in advance and labeled appropriately (Table 1.6). All syringes containing anesthesia are 3 cc in size. This is to reduce the hydrostatic pressure needed to inject intradermally, which is more difficult than injecting in the subcutis. Saline is also drawn up, but in larger, 5-cc syringes. Saline is

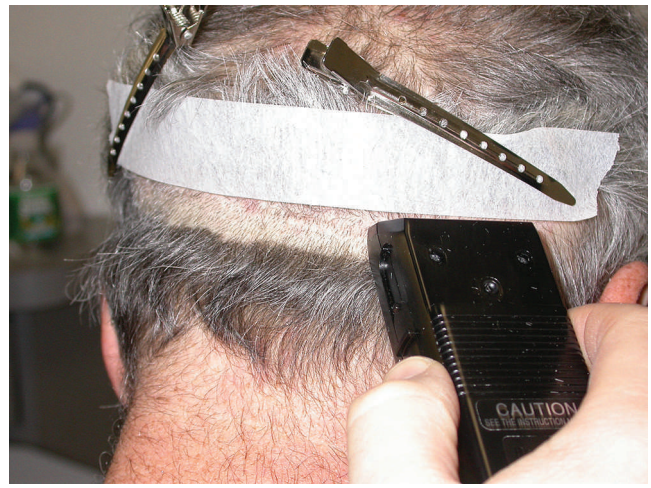

FIG. 1.7. We trim the hair to a length of 2–3 mm.

injected directly into the subcutis of the donor area for hemostasis, anesthesia, and to create turgor to help straighten the follicles. Table 1.2 provides a description of the different types of anesthesia used.

The follicular forceps, petri dishes, tongue depressors, and five razor blades are placed on a half-sheet of Steri-wrap and used by the technicians to cut the grafts (Figure 1.5). Tongue depressors are folded lengthwise and used as cutting boards, with the convex side up. Multiple razor blades are placed at each cutting station because they can dull quickly depending on the tissue. Patients with a history of previous transplantation, resulting in scar tissue, can have tissue that is especially difficult to divide.

Before the patient enters the room, the operating table is draped with a clean paper. We provide an ergonomic headrest for the patient to lie in a prone position during the harvest process. A comb, paper tape, and hairclips are ready for marking the donor area surgical site (Figure 1.6). A ruler is available to measure the planned donor area, as well as an electric razor to gently trim it prior to excision. As shown in Figure 1.7, we trim the hair to a length of 2–3 mm.

TABLE 1.7. Miscellaneous Equipment

Item	Purpose
Spray bottle with 75% saline, 25% H_2O_2	To keep scalp clean and moist while planting grafts
Antibiotic ointment	To spread on Telfa pads
Telfa pads	To cover the donor and recipient sites postoperatively
Kerlix gauze	To wrap the scalp postoperatively
Bandana or cap	To cover the bandages postoperatively

Other miscellaneous items needed for the procedure are listed in Table 1.7.

Many of the instruments mentioned in this chapter are available on the internet or through suppliers, such as A to Z Surgical/George Tiemann Instruments and Ellis Instruments.

Chapter 2

MEDICATIONS AND HAIR TRANSPLANTATION

by

Dow Stough, MD and Brent Moody, MD

INTRODUCTION

Patients with hair loss will often present to a hair transplant surgeon for a consultation. As a result, hair transplant surgeons must be aware of both surgical and medical options to treat male and female pattern hair loss. Their knowledge must include not only an understanding of medical causes for hair loss but also medical management options. The ideal medical or surgical solution for the treatment of hair loss would be simple to use, without side effects and complications, and would be universally effective and affordable. To date, such an agent has not been discovered. It is because of these shortcomings that medical agents are frequently used in combination with one another and as adjuvant therapy to surgical hair restoration. As the commonly available and promoted treatments for hair restoration are intended for the management of pattern hair loss or androgenic alopecia, the prescribing physician must be able to recognize all other forms of alopecia as well.

CURRENTLY AVAILABLE AGENTS

Minoxidil

The most commonly utilized topical therapy is minoxidil. This medicine was originally developed as an oral antihypertensive agent. When given for treatment of refractory hypertension in renal transplant patients, it was found to cause a secondary hypertrichosis. Soon, studies demonstrated that the topical version of this agent resulted in increased hair counts. A 2% minoxidil solution received FDA approval in 1988 for male pattern hair loss. Later, the FDA approved both a 2% and a 5% solution formulation for over-the-counter distribution. A 5% minoxidil foam vehicle delivery system was recently introduced. The foam product is easier to use than the solution, which appears to increase compliance. Figure 2.1 illustrates the Rogaine Foam (McNeil-PPC, Inc. Morris Planes, NJ) product.

Topical minoxidil is effective in both male and female pattern hair loss. The exact mechanism of action in promoting hair growth is unknown. Studies have demonstrated the superiority of minoxidil over other vehicles in both men and women. The treated patients experienced increases in both number and weight of their hair. The 5% formulation has also been shown to be superior to the 2% formulation in men. In a randomized trial of 5% and 2% minoxidil in females, the patients perceived a greater benefit from the 5% formulation. However, the investigators did not detect a significant difference between the

FIG. 2.1. Rogaine foam. This form of topical minoxidil is easier to use than solution and may increase compliance.

two formulations. Additionally, the 5% formulation resulted in a greater incidence of side effects, including unwanted hypertrichosis in women.

In addition to its role in the medical management of pattern hair loss, minoxidil serves as a useful adjuvant therapy in the surgery patient. Small studies, as well as observations from experienced hair restoration surgeons, have led to the use of minoxidil in the preoperative and postoperative phases. It can help decrease post-transplant effluvium and hasten the growth of transplanted hair follicles.

Strategies for optimizing minoxidil use:

1. Men should use the 5% solution once daily. Although the product insert recommends twice-daily application, simple daily application, in addition to using the foam, can dramatically enhance compliance.
2. Women should begin with the 2% formulation. If they are not satisfied with the response, they can step up to the 5% formulation. Although the 5% solution is not approved for use in women, this off-label usage is commonly recommended by many hair transplant surgeons. As above, use of the foam may increase compliance because it is easier to apply than the solution. It may also result in less hypertrichosis because it is less messy and does not drip down the sides of the face and neck.
3. Despite the product label indicating that minoxidil is for the vertex only, it may be applied to all thinning areas.
4. Apply the solution directly to the scalp with a dropper. The foam should be gently rubbed into the scalp using one's fingertips. Be sure to wash hands afterward.
5. Some patients have reported scalp irritation after using the solution. This can result from propylene glycol in the solution. If severe, the patient should discontinue or switch to the foam, which does not contain propylene glycol.
6. Best results are seen when used perioperatively in surgery patients.

Antiandrogens

It is widely accepted that androgens play a pivotal role in mediating male pattern hair loss. The contribution of androgen excess in causing female pattern hair loss is speculated but less certain. A number of oral antiandrogens have been proposed for the management of pattern hair loss. Figure 2.2 illustrates the key androgen pathways involved in androgenic alopecia.

In the male patient, dihydrotestosterone (DHT) plays a key role in pattern hair loss. Circulating testosterone, derived from the testes and the adrenal gland, enters the intracellular space and exerts a

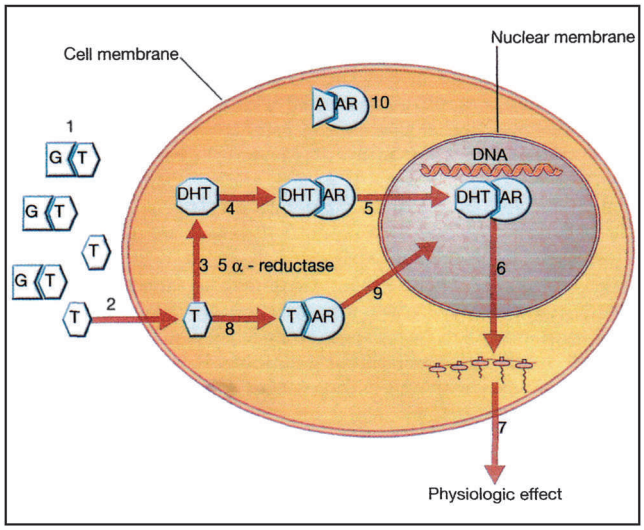

FIG. 2.2. ***Key androgen pathway: 1. Testosterone (T) bound to circulating binding globulins (G). 2. T enters target cell. 3. Conversion of T to dihydrotestosterone (DHT) by 5α reductase. 4. DHT binds to cytosol androgen receptor (AR). 5. DHT–AR complex enters cell nucleus. 6. DHT–AR complex binds to DNA, producing cell-specific mRNA. 7. Protein synthesis produces physiologic effect. 8. Direct binding of T to alternate cytosol AR. 9. T–AR complex enters cell nucleus. 10. Antiandrogen (A) binds to cytosol AR.***

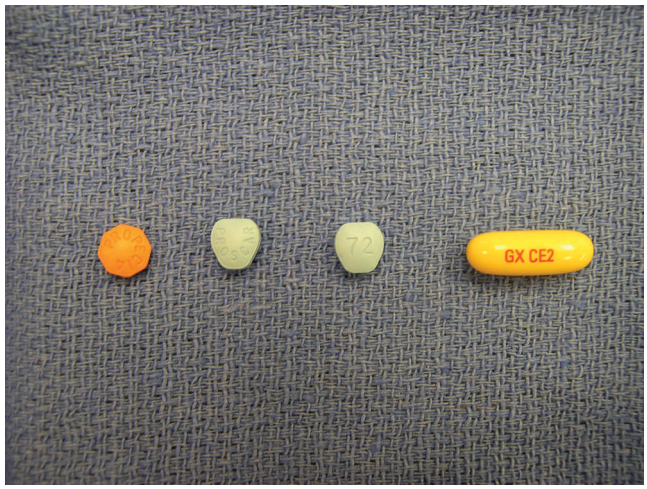

FIG. 2.3. ***Oral agents for male pattern hair loss – left to right: Propecia (1 mg finasteride, Merck & Co., Inc. Whitehouse Station, NJ), Proscar (5 mg finasteride, Merck & Co., Inc. Whitehouse Station, NJ), Finasteride 5 mg (generic), and Avodart (0.5 mg dutasteride, GlaxoSmithKline).***

physiologic effect. Five-alpha reductase is the enzyme responsible for the conversion of testosterone to DHT. The net result is that DHT leads to progressive hair miniaturization. In the female patient, the pathways and activities of androgens in hair loss are not fully elucidated. Some women with pattern hair loss benefit from antiandrogen therapy, suggesting androgens play a role in this condition.

Figure 2.3 depicts currently utilized oral agents: finasteride in three forms and dutasteride.

Finasteride

Finasteride competitively inhibits type II 5α reductase. This enzyme has two isotypes: type I is constitutively expressed throughout the body, while type II is isolated to the scalp hair follicles, prostate, and liver. Finasteride was first approved in a 5 mg dosage, as Proscar®, for the management of benign prostatic hypertrophy. Later, a 1 mg dose was introduced for the treatment of male pattern hair loss. Large clinical trials have confirmed the beneficial effects of finasteride in reversing or arresting the progression of male pattern hair loss. In the postpubertal male, DHT exerts no necessary physiologic effect; thus, its inhibition is possible without significant side effects. The chief adverse effects of the oral administration of finasteride are a decreased libido and erectile dysfunction.

Finasteride is available in 1-mg tablets as the branded drug Propecia® (Merck). The manufacturer offers a ninety-day supply under the branded name Propecia® ProPak®. Finasteride 5-mg tablets were introduced as the branded drug Proscar® (Merck). Finasteride 5 mg is no longer patent protected and is available as a generic medication. As a cost-saving measure, some patients have utilized 5 mg generic finasteride and quartered the pills to deliver a daily dose of approximately 1.25 mg (Figures 2.4 and 2.5).

The enzyme 5α reductase is critical for male fetal development. Females of childbearing potential should never ingest this drug. They also should also not handle broken or crushed tablets.

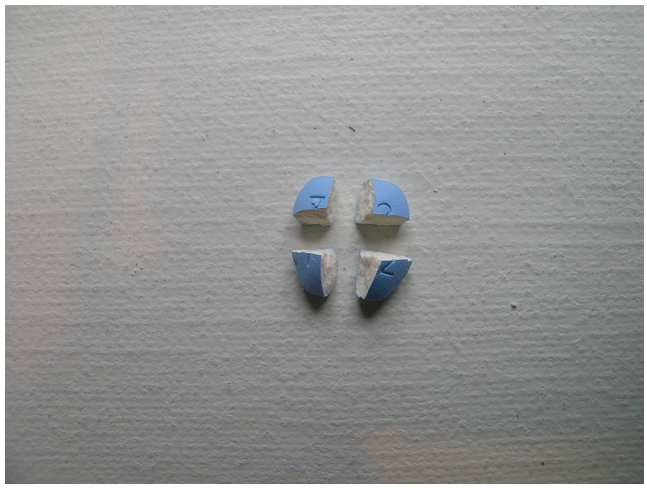

FIG. 2.4. Generic finasteride 5 mg quartered. Note that females of childbearing potential should avoid handling or using broken or crushed pills.

FIG. 2.5. Inexpensive, simple to use commercially available pill splitter used to section 5 mg finasteride in Figure 2.4.

The utility of finasteride in female pattern hair loss is less certain. Although it should not be used in women of childbearing age, it has been tested in postmenopausal women. A multicenter trial of postmenopausal females with pattern hair loss failed to show benefit from finasteride 1 mg. Smaller studies utilizing higher doses of finasteride (2.5 or 5 mg) in normoandrogenic females have shown some benefit. Other small studies have shown some benefit of finasteride in hyperandrogenic females with pattern hair loss. When weighted, the best conclusion regarding the utility of finasteride in female pattern hair loss is one of uncertainty.

Strategies for optimizing the use of finasteride:

1. Start medication at the earliest sign of hair loss.
2. Women of childbearing potential should not use or handle crushed or broken tablets.
3. The medication must be continued indefinitely and should not be discontinued if the patient undergoes hair restoration surgery.
4. Efficacy in postmenopausal women is uncertain.

Dutasteride

Dutasteride inhibits both type I and type II 5α reductase. Dutasteride 0.5 mg, branded as Avodart® (Glaxo Smith Kline), is indicated for the treatment of benign prostatic hypertrophy. The use of this medication in treating hair loss is considered off label. Dutasteride is a more potent inhibitor of 5α reductase than is finasteride. As both isoenzymes are present in the human scalp, it is theorized that dual inhibition may provide an enhanced response in pattern hair loss compared with inhibition of type II 5α reductase alone. A controlled trial comparing dutasteride and finasteride demonstrated a faster onset of the dual 5α reductase inhibition over inhibition of type II isoenzyme alone in the treatment of male pattern hair loss. A placebo-controlled study of identical twin males demonstrated that dutasteride was effective in treating pattern hair loss. Similar to finasteride, the most common side effect was

decreased libido, yet the incidence appears to be rare. The ultimate utility of dutasteride in pattern hair loss remains to be fully elucidated.

OTHER AGENTS

Although minoxidil and 5α reductase inhibitors are the most commonly utilized agents for pattern hair loss, the hair loss expert should be familiar with other novel agents.

TOPICAL ANTIANDROGENS

Fluridil

The idea of delivering antiandrogenic agents locally to the target tissue (scalp hair follicle) has significant promise in the treatment of pattern hair loss. Fluridil is a topical antiandrogen agent that was recently developed. It has shown promise in treating male and female pattern hair loss and appears to have minimal systemic absorption. A 2% fluridil preparation is available in a number of European countries (Eucapil-Interpharma Praha); however, the product is not available in North America and has not been universally accepted among hair loss experts in the European communities.

Ketoconazole

Some evidence suggests that topical ketoconazole, an imidazole antifungal that interferes with steroid biosynthesis, may be beneficial in treating pattern baldness. A recent study showed that three of six test subjects achieved some hair regrowth from the application of 2% ketoconazole lotion. The investigators also studied the effect of ketoconazole on androgen receptors. They concluded that ketoconazole suppressed activity at the androgen receptor, suggesting this may account for its action in pattern hair loss. Some hair loss experts prescribe 2% ketoconazole shampoo for routine usage in their patients with male pattern hair loss.

SYSTEMIC ANTIANDROGENS

Given the critical role that androgens play in normal male physiology, the use of systemic antiandrogens is not viable in male pattern hair loss. However, a variety of such medications have been employed for female pattern hair loss. Studies have investigated antiandrogen therapy in women with hyper and normo-androgen states. Women who have clinical and/or biochemical evidence of hyperandrogenism are especially good candidates for systemic therapy. Normoandrogenic females may benefit by having an increased sensitivity to androgens in the scalp.

All women of childbearing potential taking antiandrogens should avoid pregnancy. The reason for this is that ingestion of such medicines during pregnancy may result in the feminization of a male fetus. Concomitant use of oral contraceptives is helpful, not only in ensuring birth control but also in additionally lowering circulating androgens.

Cyproterone Acetate

Cyproterone acetate is a competitive inhibitor of DHT at the androgen receptor. It has been used for female pattern hair loss with benefit, particularly in women with hyperandrogenism. Moreover, some benefit has been reported in normoandrogenic females as well. The dosing regimen depends upon the patient's menstrual status. Postmenopausal women can be treated with 50 mg daily. Premenopausal women are treated in a cyclical manner, taking 100 mg for ten days of each menstrual cycle combined with an oral contraceptive.

Spironolactone

Spironolactone is an aldosterone inhibitor used as a diuretic and antihypertensive agent. It has antiandrogenic properties and has been used in women with pattern hair loss. Daily doses range from 100 to 200 mg. Because spirolactone is a potassium-sparing

diuretic, laboratory evaluation of potassium levels is warranted. The ideal candidate is a woman already on birth control medication, who has other signs of hirsutism as well. This agent tends to stabilize hair density rather than to promote regrowth.

Flutimide

Flutimide is a competitive inhibitor of the androgen receptor. Studies have shown benefit in female pattern hair loss. Daily dosage is 250 mg. The clinician must be aware that flutimide has been associated with hepatic injury, and judicious laboratory monitoring is recommended.

MEDICAL THERAPY IN THE SURGICAL PRACTICE

As stated earlier, the hair restoration surgeon is likely to be the first physician consulted regarding hair loss. Thus, the surgeon must be familiar with all available options for the hair loss patient. If the surgeon does not actively manage the medical aspects of hair loss, he or she must at least recognize when medical therapy is appropriate and refer the patient to the appropriate specialist. Additionally, most hair restoration surgeons now recognize the value of adjuvant medical therapy in the surgical patient. Oral therapy is usually instituted first because of higher compliance with a once-daily pill than with a topical medication applied twice daily. In the sufficiently motivated patient, combination therapy with minoxidil and finasteride is recommended.

The surgeon is cautioned not to rely upon continued medical therapy as a safety net against poor surgical planning. Patients may decide to stop using their medications anytime. Thus, the results of hair surgery should be aesthetically pleasing, regardless of ongoing hair loss or discontinuation of drugs. The proper use of medical and surgical modalities makes the treatment of patients with pattern hair loss both challenging and rewarding at the same time.

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Chapter 3

THE DONOR AREA

by

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INTRODUCTION

Hair transplantation is currently performed by the majority of surgeons using a large number of naturally occurring individual follicular units (Follicular Unit Transplantation). There are two different techniques to harvest follicular units from the donor region: 1) the classical technique known as *strip harvesting*, which is followed by stereomicroscopic dissection of the follicular units, and 2) *follicular unit extraction* (FUE) in which individual follicular units are removed directly from the donor region through very small (≤1.00-mm) punches. In this chapter, the author will mainly review the strip harvesting technique, which is currently used by the majority of surgeons worldwide. FUE is a relatively recent technique whose main advantages over strip harvesting are that it does not leave a linear scar and the wound healing is more rapid. However, the biggest problem encountered while using FUE is follicular transection, which occurs very commonly when inexperienced surgeons operate, but can be reduced to acceptable limits by using specific surgical tools, and with specific surgical training. FUE will be discussed in more detail in another chapter of the present textbook.

SAFE DONOR AREA

The donor area refers to the zone where the hair follicles are obtained for the transplant process. In androgenetic alopecia, a horseshoe-shaped area of the occipital scalp is consistently spared, and this zone is considered the main source of hair follicles available for transplantation. Most of these hair follicles do not suffer, or suffer to a much lesser degree, from the androgen-dependent involution that occurs in androgenetic alopecia.

The most common donor zone lies in the occipital scalp, extending as a horizontal band of approximately 5–6 cm width (Figure 3.1). However, the boundaries of the safe donor area should be individualized for each patient. Wetting the hair, examining the scalp, and carefully reviewing the history may reveal changes in these boundaries. In the occipital area, the occipital notch or the nuchal ridge is regarded as the inferior harvesting limit. Strip excisions performed below the nuchal ridge appear to have a higher chance of

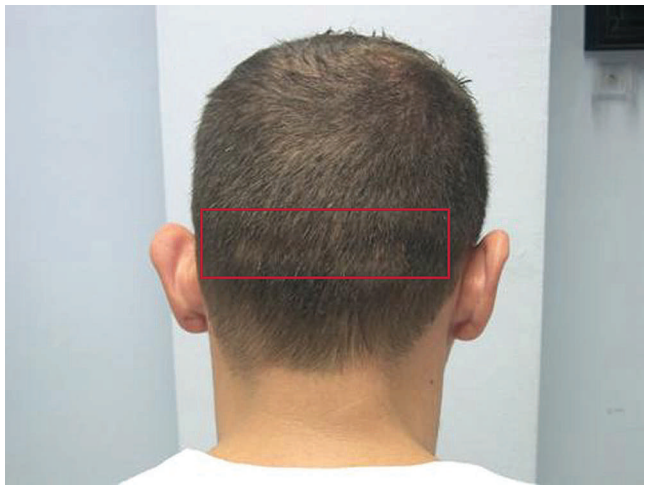

FIG. 3.1. The donor area normally extends along the occipital and temporal scalp. The safe zone is in the middle of the occipital and temporal scalp.

developing a wider scar. The lateral harvesting limit should ideally extend no further forward than a vertical line extended upward in the immediate preauricular area. It is important to bear in mind that androgenetic alopecia is a progressive process and that, as the aging process takes place, hair follicles can be lost from the superior and inferior aspects of the occipital region. Therefore, harvesting too high above or too low below the safe zone can lead to a visible donor area scar in the future. A safe recommendation would be to harvest 2–2.5 cm below the superior limits so that the resulting scar is covered by hair.

CANDIDATE SELECTION BASED ON THE DONOR ZONE

Based on the donor region, not all patients are good candidates for hair transplantation. Before committing to any hair transplant procedure, every surgeon should evaluate the caliber of the hair shaft and the hair density of the donor region.

The caliber of the hair will give us an idea of the degree of hair miniaturization and will directly influence the outcome of transplantation. Those with large-caliber hair shafts (greater than 80 microns) are excellent candidates; in contrast, patients possessing fine, silky hair (<50 microns) cannot expect significant density. If we were to transplant the same number of follicular unit grafts in two patients with different hair caliber, the patient with larger hair shaft diameter would always achieve a fuller coverage than the patient with fine, thin hair. These fine hair patients may have "see-through" hair, even with recipient site densities of 30 follicular units per cm^2. In addition, early detection of miniaturization in the donor area is a warning sign that the donor area may not be stable. It is important to discuss this issue with the patient at the time of consultation in order to avoid unrealistic expectations.

Another characteristic to evaluate in the donor region is the density. It is important to differentiate between follicular unit (FU) density (number of follicular units per cm^2) and hair density (number of hairs per cm^2). The average FU density in the donor occipital scalp of Caucasians ranges from 70 to 100 FU/cm^2, and the average hair density is around 260 ± 30 hairs/cm^2 (as a rule of thumb, the hair density is about 2.5–3 times the FU density). Surgeons consider that patients require a density count of at least 40 FU/cm^2 in their donor area to be regarded as candidates for hair transplantation. However, more important than the follicular unit density is the distribution of natural hair groupings in each FU (follicular unit composition) because this will determine the patient's hair density. For example, a patient with a large number of three and four hair grafts will have a fuller hair transplant than a person with the same FU density but with predominantly one- and two-hair follicular units. We have to take into account that there are significant differences in the FU count among different ethnic groups. In general, Asians and Blacks have a lower donor density than Caucasians. Density studies have shown that the majority of follicular units in Caucasian donor scalps contain two- and three-hair follicles.

A variety of instruments are available to measure donor hair density. In 1993, Rassman introduced a small handheld instrument, the "Hair Densitometer,"

which consists of a magnifying lens and an opening of a predetermined size. More recently, video microscopes have been developed that can project high-resolution images of the scalp onto a computer screen and provide a permanent digital record. To measure the hair density, the hair is clipped short (1 mm) and the instrument is placed directly on the scalp. The image can be overlapped with a 1-mm grid using imaging software (Photoshop), which facilitates the quantification of follicular units and hairs per surface area.

HOW TO CALCULATE THE SIZE OF THE DONOR STRIP THAT NEEDS TO BE EXCISED

It is very simple to calculate the area of the donor strip to be excised (Table 3.1). First, we have to measure the follicular unit density of the occipital scalp. The greater the donor density, the shorter the donor strip required. Then, according to the number of follicular units desired to transplant, we apply the following formula:

$$\text{Number of follicular units desired to harvest} = \text{Follicular unit density} \times \text{area of donor strip}\,(\text{cm}^2).$$

EXAMPLE: We want to transplant 1,500 follicular units in a patient with a follicular unit density of 96 FU/cm^2. What size of donor strip do we need to excise?

$$1{,}500 \text{ follicular units required} = 96 \text{ FU/cm}^2 \times \text{area of donor strip},$$
$$\text{Area of donor strip: } 1{,}500/96 = 16\,\text{cm}^2.$$

Once the area that needs to be excised is known, the length and the width of the strip can be modified according to the formula: area = length × width.

In this patient, if we want to limit the width of the strip to 0.8 cm, the length of the strip will then be 20 cm (16 cm^2/0.8 cm).

TABLE 3.1. Length of the Donor Strip According to the Number of Follicular Units Desired to Harvest (Considering an Average FU Density of 85 FU/cm^2)

# FU	Length of Strip (cm) N.B. The strip width is fixed at 1 cm
500	6
700	8
900	10.6
1,000	12
1,200	14
1,400	16.5
1,600	19
1,800	21
2,000	23.5

SCALP ELASTICITY

Before excising the donor strip, it is also important to determine the elasticity of the scalp in order to predict the difficulty in closing the donor area. This is especially important in patients with a tight scalp or in megasessions when the surgeon wants to excise donor strips wider than 1.2 cm. The greater the laxity of the scalp, the wider the donor strip that can be harvested. A useful method to evaluate scalp elasticity is the Mayer–Pauls formula, which defines scalp elasticity as the percentage of the original length that vertical lines or dots placed 5 cm apart move toward each other when compressed maximally by the examiner's thumb (Table 3.2). The formula is as follows:

$$\frac{50\,\text{mm} - D}{50\,\text{mm}} \times 100 = \text{Percent scalp elasticity},$$

where D = the new compressed distance between the vertical marks after maximal thumb compression.

TABLE 3.2. Maximum Donor Width That Can Be Excised According to the Measured Scalp Elasticity

Scalp Elasticity (%)	Maximum Donor Width (cm)
10	1
15	1.5
20	2
25	2.2

POSITION OF THE PATIENT FOR STRIP REMOVAL

There are three different positions in which the patient can be placed for the strip excision: prone (face down), lateral (right and/or left), and seated. When using the prone position, there is a special pillow (i.e., prone pillow) designed for this purpose.

The author prefers to place the patient in a lateral position, since it is the most comfortable position for both the patient and the surgeon. When the strip size is from ear to ear, one side is excised first and sutured, and then the patient is turned over, and excision and suturing of the other side is completed.

DONOR-SITE ANESTHESIA

The donor area is prepared by clipping the donor-site hair to approximately 2–5 mm in length. The contour of the strip can be drawn with a surgical marking pen.

The great local anesthetic workhorse in hair transplantation surgery is 1% lidocaine with 1:100,000 epinephrine. More dilute solutions such as 0.5% lidocaine to 1:200,000 epinephrine are also adequate. Bupivacaine (0.25% with 1:200,000 epinephrine) can also be used in conjunction with lidocaine to produce longer lasting anesthesia.

Pain experienced on infiltration is due to a combination of factors, including the needle stick, the physical distension of tissues with fluid, and the low pH of the local anesthetic solution. We can minimize the pain of the infiltration very significantly by simple maneuvers such as injecting the anesthetic very slowly, using 1-cc Luer lock syringes with 30-gauge needles, and simultaneously applying vibration anesthesia. This type of anesthesia employs commercially available, inexpensive massagers to reduce discomfort (Figure 3.2). The mechanism of action is based on the "gate control" theory of pain. The ascending pain impulses can be modified

FIG. 3.2. Personal massager used in our clinic for vibrational anesthesia. The massager is applied close to the syringe to reduce pain associated with the infiltration of anesthetic.

or "gated" at the spinal level by "fast" fibers activated by vibration emanating from the same dermatome. The use of these massagers for analgesia requires an assistant, who firmly applies the massager within a few centimeters of the area that is being infiltrated.

TUMESCENCE

Tumescence involves the infiltration of saline solution at the level of subcutaneous fat of the donor area to produce the tissue turgor necessary to facilitate excision of optimal donor strip. The tissue should be anesthetized prior to tumescing. Larger 3- to 5-cc syringes are best suited to deliver rapid infusion. The author normally uses 20–50 cc of saline, enough to produce tissue turgor. The saline also assists in hemostasis through tamponade, and the donor follicles are also lifted away from the underlying occipital arteries, reducing the probability of artery transection.

STRIP EXCISION

The distance from ear to ear is generally 25–30 cm, depending on the size of the cranium. The author generally likes to obtain as much donor area from one side of the scalp as possible from the auricle to

the mid-occiput. This results in one surgical scar on one side of the head. It has the advantage of leaving the other side free for the second surgery. The next surgical procedure involves the other side of the head and still results in only one scar from ear to ear. On repeat excisions, the new strip can be taken from a new virgin area or from the same area, so that the old scar is in the center or in the superior or inferior border of the strip.

Most surgeons favor taking a single elliptical donor strip from the occipital scalp that ranges from 8 to 12 mm in width. Single-blade harvesting is usually done with a No. 10 blade (#10 Persona plus blades). As mentioned earlier, each case must be individualized based on donor tissue laxity, donor tissue density, and previous scars. From the epidermis to the base of the hair follicle, the tissue usually extends to a depth of 4–6 mm. A few years back, the skin used to be cut through with a scalpel to a depth of 6–7 mm. However, a significant advance in the last few years has been the concept of "tension donor dissection," proposed by Dr. Pathomvanich and Dr. Stough. This concept involves superficially scoring the edges of the strip, only 1–2 mm deep. Two skin hooks are then applied at the edges of the incision in order to produce a tension vector that travels away from the wound (i.e., perpendicular to the wound incision). The surgeon is then able to gently press and "separate" the hair follicles with very minimal cutting of tissue. The scalpel is used to push the hair follicles apart. As a result, we stretch the tissue between the follicular units and dissect it through these minimal tension structures (Figure 3.3). Using this tension dissection technique, transection of hair follicles at the edges of the incision is significantly reduced. Alternatively, other surgeons use hemostats to mechanically separate the tissue or a recently developed instrument, the so-called "Haber Spreader," that uses the same principle of tissue separation.

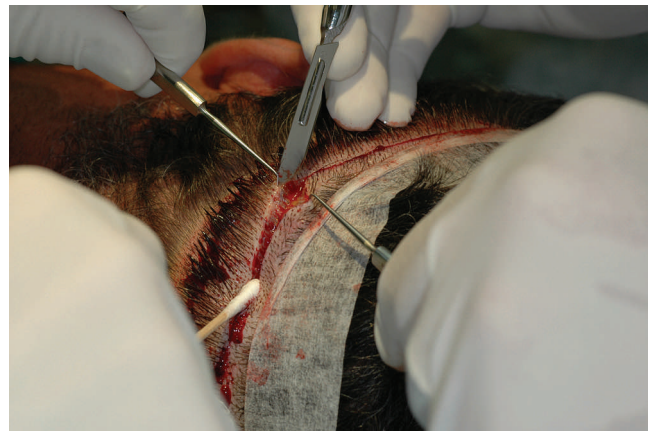

FIG. 3.3. Tension donor dissection. The borders of the strip are first cored with the scalpel, and then an assistant provides upward and outward traction with skin hooks.

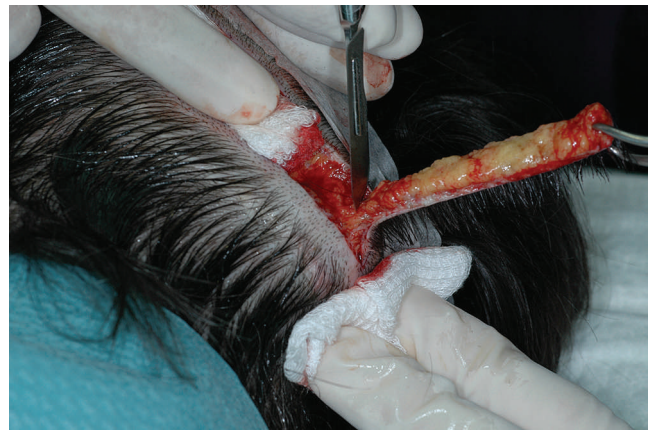

FIG. 3.4. Once the edges are released, the strip is removed by cutting along a plane at the subcutaneous level just below the follicle bulbs.

The strip extremity is then gently grasped with a tissue forceps or a towel clamp, and a scalpel or scissors is used to divide the tethering tissues in the plane just below the follicular bulbs, at the level of the subcutaneous fat, and above the deep vasculature (Figure 3.4). Some bleeding at the wound edge is invariably encountered. Application of moderate manual pressure for a few moments is usually enough to handle this bleeding. Definitive bleeding points can be grasped with small hemostats that are removed on wound closure, but electrocoagulation and/or ligation are usually not required.

TRICOPHYTIC CLOSURE

This technique of closure of the donor wound has been recently introduced in hair transplantation by Dr. Simon Rosenbaum. The fundamental idea of the trichophytic closure is that the deepithelialization of one FU allows the hairs to grow through the scar. The technique is really simple: Once the strip is removed and before closing the defect, the surgeon trims off 1–2 mm of the superior or inferior wound edge using a pair of fine and sharp tip scissors (Figure 3.5). Although the trichophytic closure is still under evaluation, it appears to help make the scar less detectable (Figure 3.6).

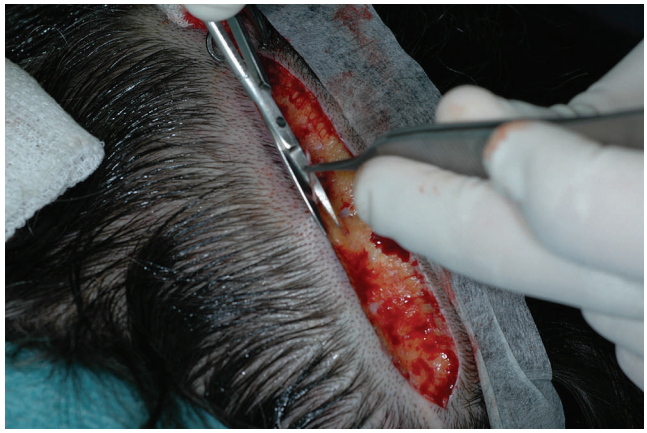

FIG. 3.5. Trichophytic closure. A thin strip of skin is removed from the lower wound border with a pair of fine tip scissors.

FIG. 3.6. Donor scar one year after surgery in which tricophytic closure was performed. Note that hairs grow through the scar (the hairs have been shaved for a better image).

WOUND CLOSURE

After the strip has been removed and hemostasis has been obtained, the wound is ready to be closed. One immutable law on best scar outcome is to close the donor wound with no tension. It is useful to apply two or three towel clamps along the wound edges in order to keep the wound closed while suturing or stapling. Single-layered closure with continuous 4–0 nylon is the most commonly used suture. There are no significant differences in the outcome of the scar whether one uses sutures or staples (Figure 3.7), and both can be removed in seven to ten days. Staples have the advantage of allowing very quick closure and cause less postoperative erythema at the surgical line than is seen with the sutures. A possible explanation for this is the lack of damage to the surrounding follicles. When the patient cannot attend the clinic for suture removal, a fast absorbing suture such as 4–0 polyglactin 910 can be used, which normally dissolves in approximately fifteen to twenty days.

Undermining is not really a requirement in strips with a width of 1 cm or less. In tight scalps or in procedures involving more than 2,500 grafts that require wider strips, undermining or the intradermal suturing should be performed if tension is perceived (Table 3.3).

FIG. 3.7. Complete closure with staples.

TABLE 3.3. Recommendations to Achieve a Thin Scar

1.	No tension on closure (undermine if needed)
2.	The strip should be as long and thin as possible: width equal to or less than 1 cm
3.	In tight scalps and patients with multiple prior procedures, the strip should be even thinner
4.	Use of tricophytic closure
5.	Staples or 4–0 nylon suture with removal in 7–14 days

LINEAR SCARRING

Strip harvesting will inevitably leave a linear scar. As mentioned above, minimal scarring is achieved when the wound is closed with minimal or no tension. Ninety-five percent of donor scars will be thin (1–3 mm) but can become visible if the patient shaves his or her head. However, even when the excision has been done correctly, some patients (5%) are prone to developing wide scars (>3 mm), especially on repeat excision.

Scar revision by serial excision of wide scars has been unsuccessful. FUE and insertion of the follicular units into the donor scar are being increasingly used in the treatment of wide scars.

COMPLICATIONS OF DONOR-SITE STRIP HARVESTING

Complications in the donor site are fortunately very uncommon. Infection of the wound, dehiscence, and necrosis are very rare, and when they occur, it is almost always due to poor surgical technique or to a donor strip that is too wide, resulting in an extremely tight closure.

Keloids are extremely unusual in hair transplantation. The author has not seen keloids forming after strip excision, even in patients with a history of keloids in other parts of the body. Afro-Americans appear to be more susceptible to this complication.

Effluvium (hair shedding) of the hair along the suture line can rarely occur two to three weeks postoperatively. Hair will regrow in approximately three months.

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Chapter 4

FOLLICULAR UNIT EXTRACTION (FUE)

by

James A. Harris, MD, FACS

INTRODUCTION

A recent trend in surgery is to devise techniques that result in less trauma, less scarring, and a more rapid recovery. In hair restoration surgery, the donor area is most affected by these three postoperative sequelae. To address these concerns, a technique of graft production called follicular unit extraction (FUE) has been developed. Hair follicles naturally grow in units of one to four hairs (Figure 4.1). Instead of harvesting a "strip" or ellipse of skin from the scalp, which is then divided into follicular units, the follicular units are removed individually from the donor area. This technique has provided a less invasive method for graft production, and it results in the absence of a linear scar and much less pain and discomfort at the donor site.

Although it is primarily used for scalp graft production, FUE has also been used to produce grafts from various sites on the body including the chest, back, extremities, neck, and pubic areas. This technique, called body hair transfer (BHT), will also be covered in the context of FUE.

The reader should note that many of the statements are based on anecdotal evidence from the author's experience and from other physicians' reports as there is a paucity of published reports on FUE. This may be due to reluctance of physicians to share their knowledge in order to retain a marketing advantage or simply due to the relative infancy of this technique.

Recent internet publicity has elevated expectations about what FUE has to offer the field of hair restoration. The goal of this chapter is to present a realistic view of FUE, including a historical review of FUE, the technological hurdles, the current methodologies, the complications encountered, a review of body hair transfer, and the indications for FUE.

HISTORICAL PERSPECTIVE

In 2002, Rassman and Bernstein were the first to publish their version of FUE, calling it the "Fox Procedure," which is derived from "*F*Ollicular unit e*X*traction." Some of their preliminary work was inspired by the work of Inaba as well as Woods and Campbell in Australia, who were performing FUE. The difficulties of the technique soon became apparent. They included limited patient candidacy (approximately 60% of patients are candidates) because of the high risk of follicle transection or damage due to shearing during the extraction phase. The technique is also difficult to learn. These quickly

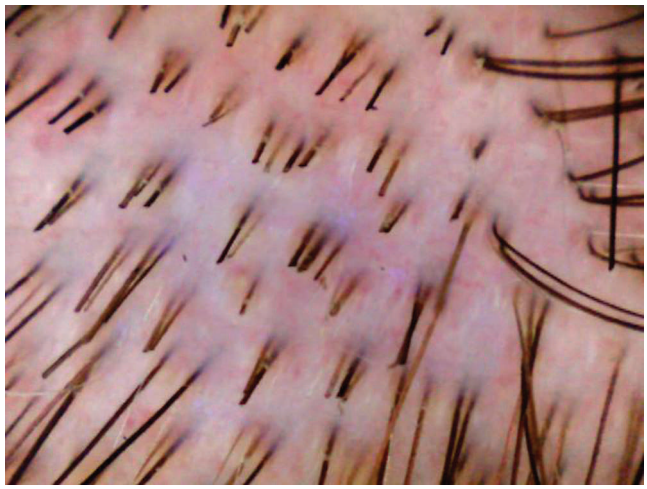


FIG. 4.1. Hair follicles naturally grow in groupings of one to four hairs.

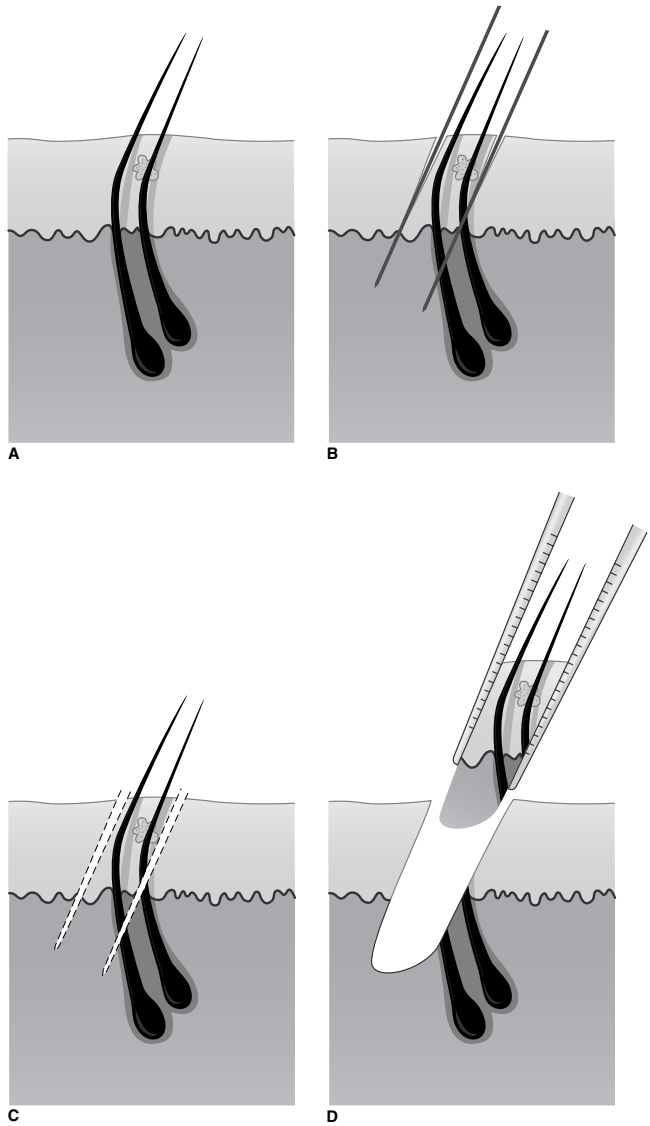


FIG. 4.2. Transection of the follicular unit can occur when the underlying follicle is not in line with the hair shaft.

proved to be effective barriers to the utilization of this FUE technique for the average patient and his or her physician.

One observation made by Rassman and Bernstein was the need to limit the depth of insertion of the sharp punch so that it would not result in transection. Practically, this is difficult to achieve when using a mass-produced sharp dermal punch.

In order to reduce the risk of follicle transection, the author has developed a technique called the SAFE (*S*urgically *A*dvanced *F*ollicular *E*xtraction) System™. This technique allows many patients who are not eligible for the FOX procedure to undergo hair transplantation with the FUE procedure. The primary advantage of the SAFE System over the FOX procedure is that the primary follicular unit dissecting instrument is a dull (no cutting surfaces) punch that significantly reduces the risk of transection and expands candidacy to almost 100% of patients.

RELEVANT ANATOMY AND ETIOLOGY OF FUE DIFFICULTIES

Frequently, the direction of the follicle below the skin is different from that above. Histologically, one can observe curvature, splaying, or abrupt direction changes of hair follicles. These changes make dissection difficult and must be accounted for in any successful FUE technique. Any technique that does not account for these factors is not a viable FUE technique.

Figure 4.2 depicts a hair shaft that is not in line with the subcutaneous course of the follicle. If a sharp instrument is introduced to a sufficient depth, there is a risk of follicle transection.

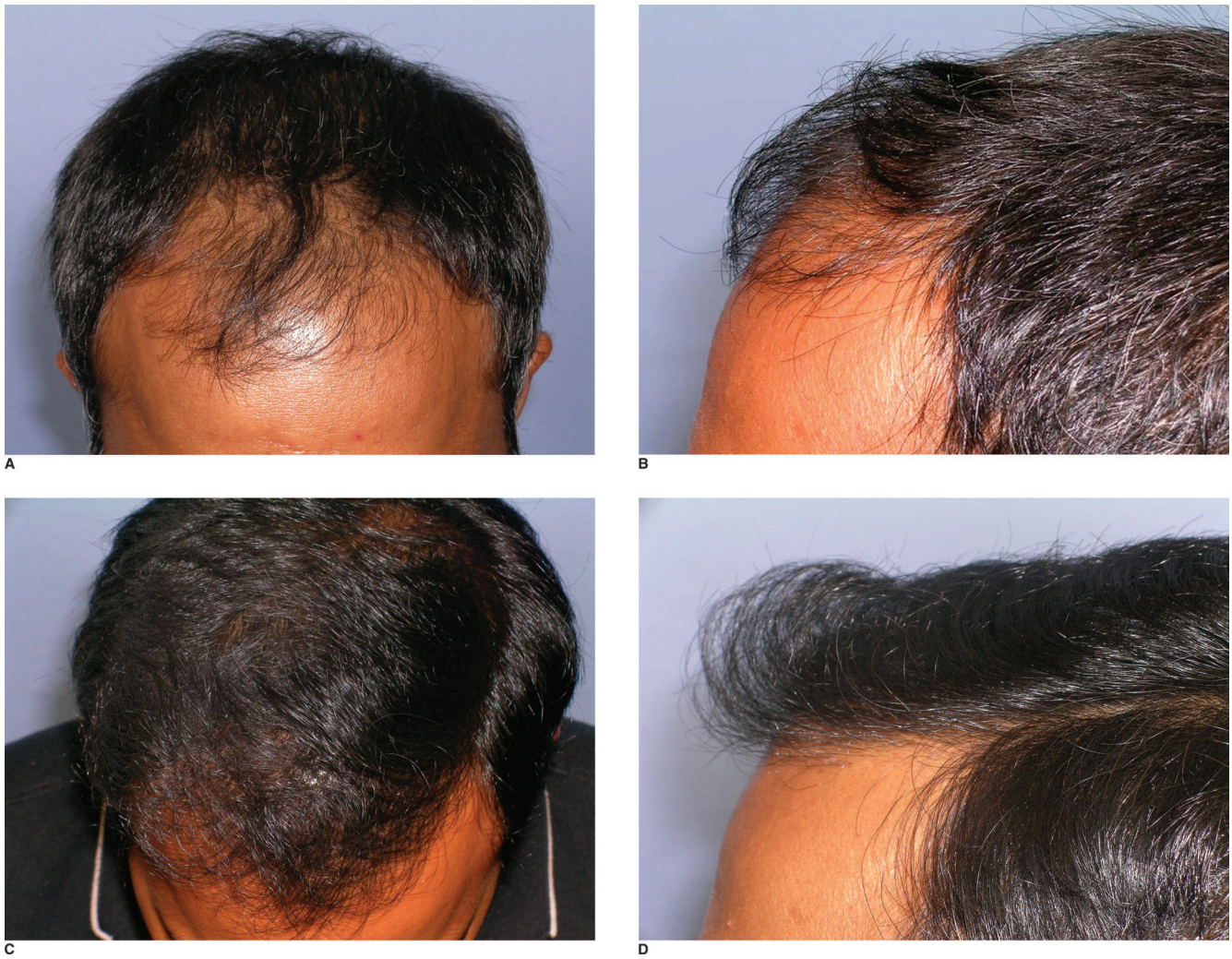


FIG. 4.3. ***(A) Frontal view of the patient before FUE. (B) Side view of the patient before FUE. (C) Frontal view of the patient after FUE. (D) Side view of the patient after FUE.***

FUE CANDIDACY

In general, any patient who is a candidate for hair restoration utilizing strip excision would be a candidate for FUE. They should undergo the same medical evaluation and discussion of expectations. The results from FUE are not unlike those from strip excision, given that the same follicular units comprise the grafts (Figures 4.3A–D).

Several articles and book chapters have listed out criteria for FUE candidacy. However, many of the criteria are based on the surgeon's limitations, expertise, or available resources. Rather, they should be based on patient characteristics. The following list contains patient profiles of "good" candidates for FUE:

1. Patients who might wear their hair very short and in whom a linear scar may be visible
2. Patients with a high degree of scarring from previous surgery that precludes strip excision
3. Patients with no available scalp laxity for strip harvest
4. Patients who heal with thickened or wide linear scars
5. Patients who need to resume a high level of activity soon after the procedure, such as athletes

6. Patients with a significant aversion to pain
7. Patients with extremely wide hair shafts who require finer hair from the supra-auricular or low neck regions to create a finer, more aesthetic result
8. Patients requiring BHT
9. Patients with poor aesthetic results at the frontal hairline due to large grafts; FUE can be utilized to thin grafts one follicular unit at a time.

In general, the only patients who may not be candidates for FUE, other than for the usual reasons such as young age, poor donor capacity, or unrealistic expectations, are those who have conditions that make FUE technically impossible. Some patients have skin characteristics that make FUE more time consuming or difficult and the physician may elect not to perform the procedure based on a preoperative evaluation or test surgery. The primary condition that may make FUE nearly impossible is the presence of scar tissue. It can bind the follicular unit in such a way as to cause excessive transection or follicle damage during extraction.

DESCRIPTION OF PROCEDURES

General Considerations for FUE

Whichever method is chosen to perform FUE, adequate lighting and proper magnification are essential. When performing FUE, the field of view is often restricted due to the high magnification required; therefore, surgical headlights are usually preferable to overhead lighting as the need for frequent adjustment is eliminated. Suction may be required to keep the skin free from blood so that the depth of the incision around the target graft can be visualized.

The FUE process begins with the accurate placement of a sharp punch over the hairs of the follicular unit where they emerge from the scalp. To accomplish this, a magnification of 3.5× to 6.5× is generally required. One of the primary reasons why novice physicians have trouble harvesting high-quality grafts with FUE is inadequate magnification and poor placement of the punch over the emerging hairs. Proper magnification, lighting, and ergonomic seating can help overcome these obstacles.

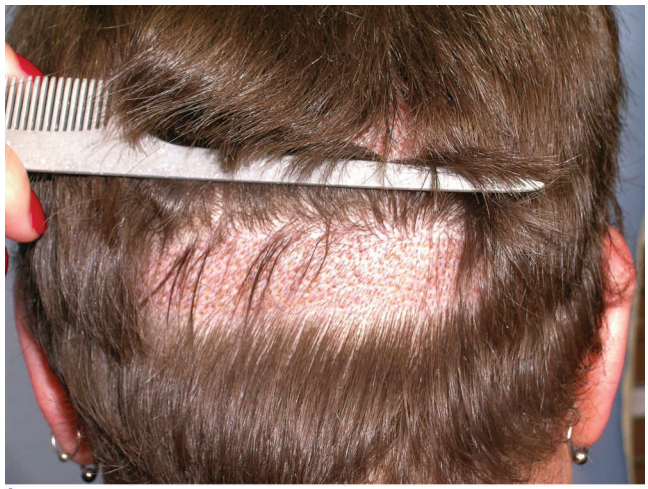
Surgeons who are used to removing a donor strip with the patient in the prone position may perform FUE in the occipital region with the patient in the same position. When extracting from the temporoparietal areas, the patient can lie in the lateral decubitus position. The advantage of these patient positions is that the motion of the arm of the surgeon is toward him or herself. Many feel this provides more accurate control.

Other surgeons prefer that the patient be seated and that the line of sight from the surgeon's eyes to the follicular unit is from inferior to superior. The general direction of the hand and arm motion is away from the surgeon during the dissection process.

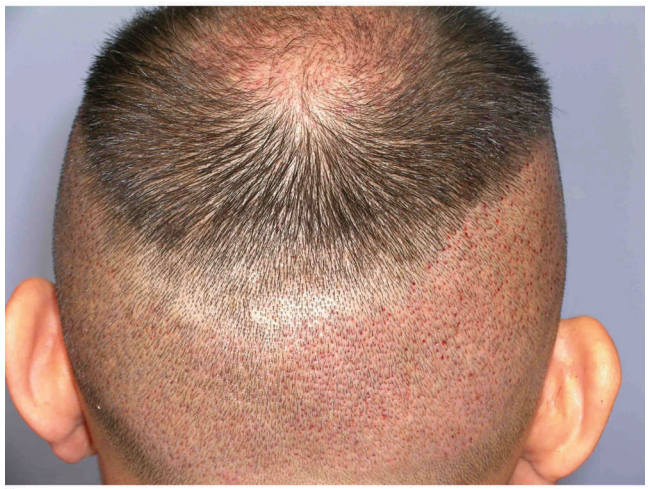
As with strip excision, the traditional donor area for FUE is the appropriate areas of the occipital and temporoparietal scalp. One may also use the low supra-auricular region and the neck to obtain hairs of smaller caliber that are useful for the frontal hairline or anterior temples. The danger is that the patient may experience thinning in these areas with age, which will translate to the loss of grafts. The decision to utilize grafts from these areas is based on the patient's age or family history of thinning in these areas.

The patient's donor area is routinely shaved to a length of 1–2 mm. Better visualization and access are afforded by a wide shave (Figure 4.4A) or total shave (Figure 4.4B).

Some patients will not allow a wide shave, so multiple 3- to 5-mm-wide strips of scalp ("micro-strip prep") are shaved with an intervening strip of 3–5 mm where the hair is left long enough to cover the shaved areas (Figure 4.4C). This method of shaving



A



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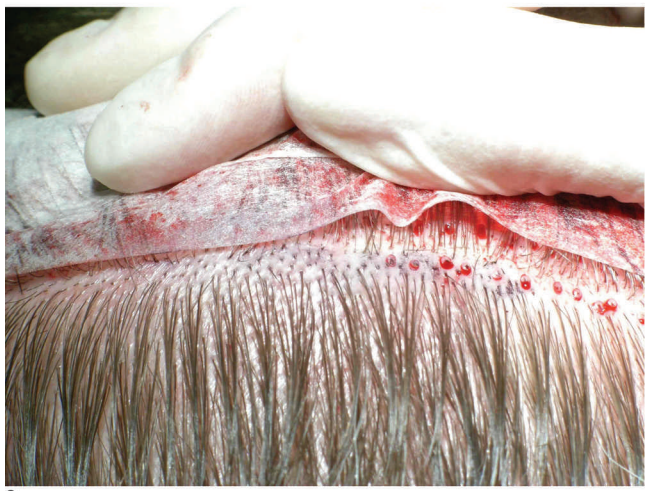

C

FIG. 4.4. ***(A) A wide shave of the donor area allows for good visualization. (B) A complete shave, if permitted by the patient, provides even better visualization. (C) Patients may prefer a partial shave of only those areas needed for graft extraction.***

the donor area is more time consuming and concentrates the harvest in relatively small areas. Subsequent micro-strip prep surgeries must utilize areas not previously harvested so that the overall harvest is randomly distributed over the entire donor region.

One final option for shaving the donor area is cutting the hair short on only the follicular units to be harvested. This method allows for a random distribution of extraction locations but represents the most time-consuming option for donor shaving and preparation.

FOX Procedure

First described by Rassman and Bernstein, the FOX procedure involves the placement of a 1-mm sharp punch over the targeted follicular unit and aligning it to the approximate angle of the hair shafts below the skin surface. The punch is then inserted through the skin to the level of the upper dermis. The isolated follicular unit is then grasped with fine, rat-toothed forceps and gently pulled out from the skin. If necessary, a fine needle is used to separate the follicular unit from the surrounding skin. Figures 4.5 and 4.6 demonstrate the donor area after harvesting follicular units with a 1-mm punch.

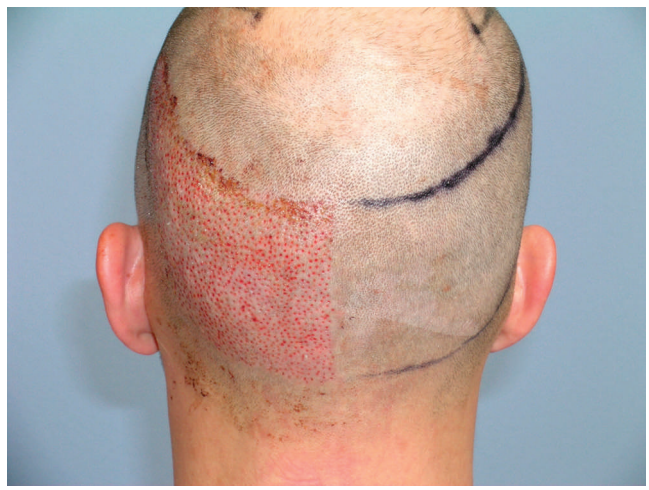

FIG. 4.5. ***Donor area after harvesting with a 1-mm punch.***

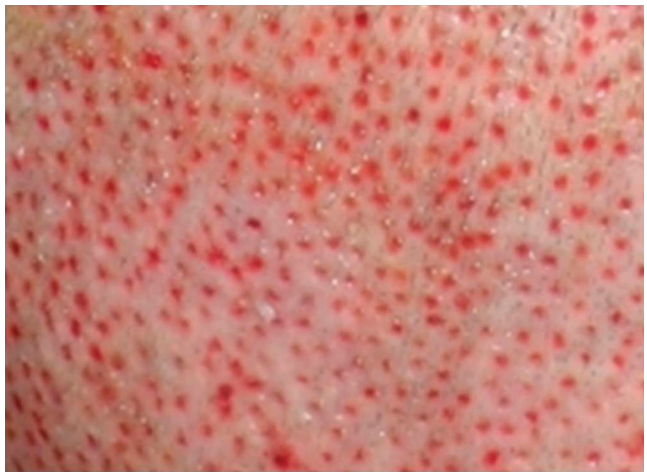

FIG. 4.6. Enlarged view of donor area after harvesting with a 1-mm punch.

As mentioned earlier, it is difficult to anticipate the correct angle of the follicle in the skin to avoid transaction. Another problem is that if dissection is too shallow, excessive traction must be applied to the follicular unit, which can result in a traumatic avulsion.

Rassman and Bernstein felt that approximately 60% of the patients, evaluated by a FOX test (an abbreviated FUE test session evaluating rates of transection), were in fact candidates for this method of FUE. "Good" candidates could have follicle transection rates up to 20%.

Rose and Cole developed a technique called the Follicular Isolation Technique (FIT), which is a variation of the FOX technique. This approach utilizes a punch designed so that the hub is long enough to reach the reticular dermis but stops short of entering the subcutis; this is accomplished by a patented adjusting mechanism. There are no published reports on the FIT technique; however, reports suggest that transection rates of follicles using this technique averaged 5.5% in 200 patients studied.

Tumescence is generally used in sharp dissection techniques. Theoretically, it prevents the movement of the follicular unit due to manipulation of the skin and may help straighten the follicles as well.

SAFE System

The SAFE System utilizes two different strategies, both of which rely on "blunt" instrumentation to minimize the risk of follicle transection. Tumescence is neither required nor recommended for this technique.

The first SAFE System method to be described consists of two dissection steps. The first step is the creation of a 0.3- to 0.5-mm-depth "scoring incision" around the follicular unit. This is followed by the insertion of a blunt, tapered "dissecting" punch to its full depth (approximately 4 mm); the graft is then extracted (Figure 4.7). The blunt tip allows the separation of the follicles from the surrounding tissue and facilitates the gathering of splayed follicles into the lumen of the dull punch. Follicles that are curved can move into the lumen without having to come in contact with a sharp cutting edge. The lack of tumescence means that the follicles are not held rigidly in the dermis and can move freely into the punch. If there is a significant difference between the angle of the punch and that of the follicle, there is a risk of blunt traumatic transection.

The first studies to examine this technique revealed a follicle transection rate of 5.6% in approximately 7,000 extracted grafts. Subsequent analyses have shown that with experience, the transection rates can be less than 2%. This compares favorably with microscopic graft dissection from a strip.

An enhanced version of the blunt punch allows a single-step dissection with a serrated, dull tip. This dissection tip (Figure 4.8) lacks sharp edges, minimizing transaction, but the serrated leading edge allows for direct insertion into the skin. This combination eliminates the need for a scoring incision. Figure 4.9 illustrates the use of a serrated tip. Follicle transection rates depend on the patient and the inside diameter of the punch. They range from 1.3% for the 1-mm punch to 4% for the 0.75-mm punch. Some patients have higher transection rates with serrated

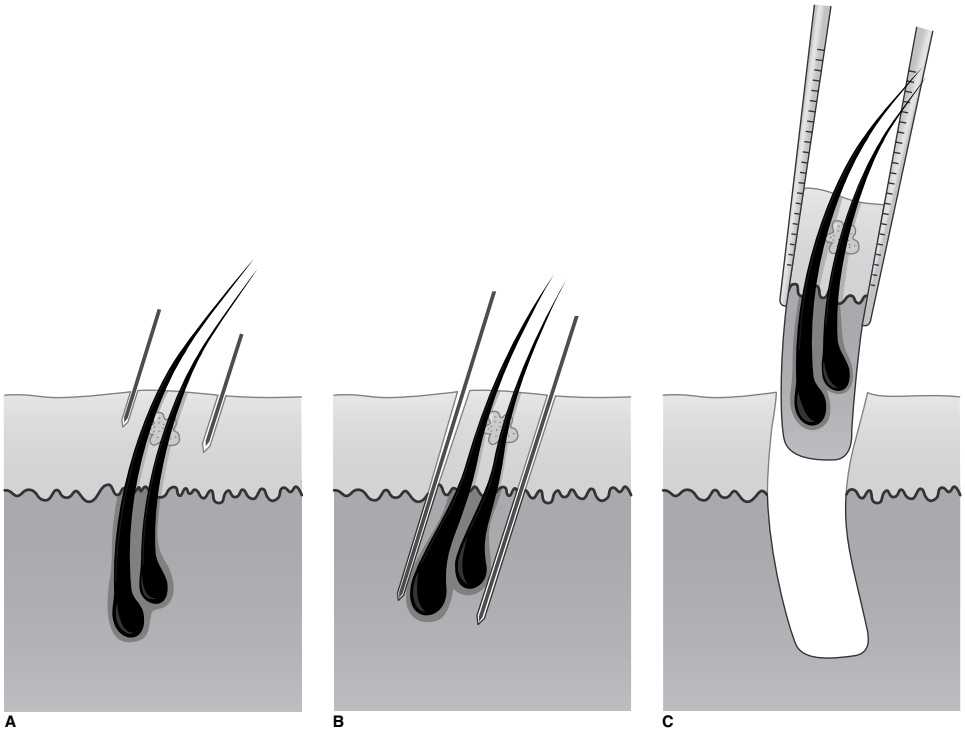

FIG. 4.7. Graft extraction using the SAFE method.

dissecting tips. When this becomes apparent, the remaining extractions are performed using the two-step dissection technique described earlier.

Blunt, sharp, and serrated punches are available in 0.75 and 1 mm inside diameter sizes. The decision to use a particular size depends on the operator's experience and the average configuration and width of the patient's follicular units. The tighter configurations of the follicular units will permit the 0.75-mm punch to be utilized for four to five hair follicular units. If the general configuration of the four and five hair units is more spread out, the 1-mm punch should be used to harvest the graft. In general, the smallest diameter punch should be used to minimize skin trauma and create the smallest scars possible. Punches larger than 1 mm can cause scarring that may be visible and unacceptable.

A variety of instruments should be available for any particular case. Blunt punches measuring 1 and 0.75 mm as well as eight to ten sharp punches of the corresponding sizes should be available for a 1,000 graft extraction case. I would also suggest that the 0.75- and 1-mm serrated tips be available as this methodology can decrease the procedure time substantially.

A potential problem with the use of the dull dissecting tips is the possibility that the leading edge

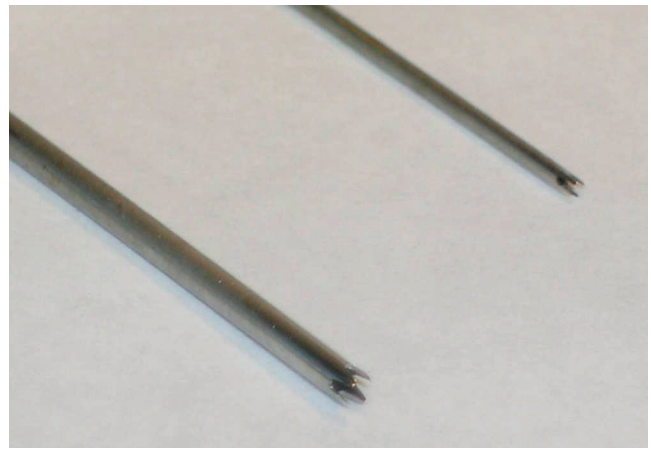

FIG. 4.8. The dull dissecting tip scores the skin but minimizes transection of follicles.

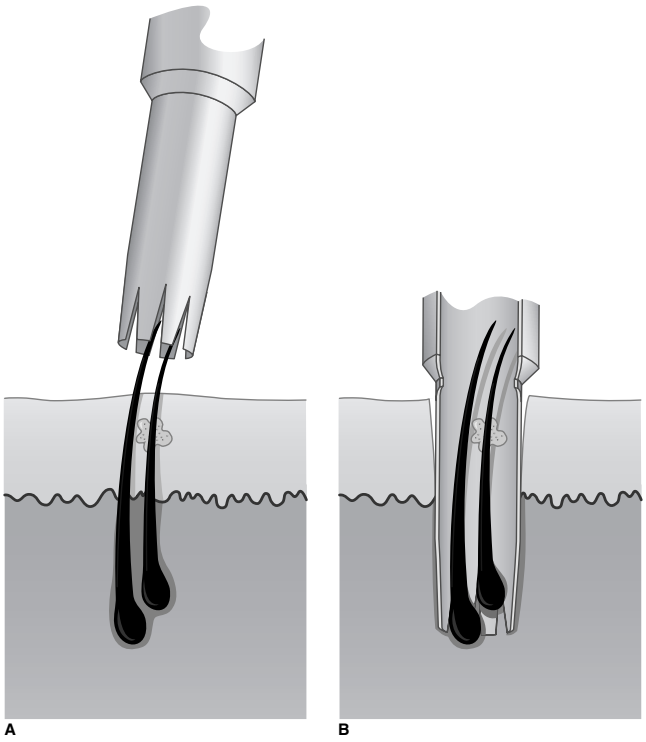

FIG. 4.9. Illustration of a serrated tip as it is used to punch around the follicular unit.

will compress the dermal tissue as the punch is advanced, causing the graft to be buried. The graft burial rate varies with the type of punch utilized (dull versus serrated) and the inside diameter. A 1-mm dull punch may have burial rates from 1–7%, and the 1-mm serrated tip has burial rates of 1% or less.

When a graft becomes buried, the next step is to place the extraction forceps in to the site and grasp for the unit. If this fails, pressure around the site may force graft expulsion allowing removal. The next step is to dilate the extraction site with a fine hemostat; the graft is typically seen at the base of the site. Should all attempts at locating the graft fail, it may be left in place. There is a slight possibility that the graft may cause the formation of an inflammatory cyst that will require excision. The rate of this occurrence is significantly less than 0.002% of all extracted grafts.

Other Methods and Instrumentation

There are several other instruments used by individual physicians to aid in either graft dissection or harvest; however, none are commercially available as of yet. Most involve different configurations of the dissecting tip with different areas having either sharp or blunt configurations.

Of some interest is the use of powered rotating punches for dissecting the graft. The reports of this technique often describe the use of punches 1 mm or greater and relate transection rates greater than those seen with manual techniques. The primary advantage of the powered instrumentation is the speed at which grafts may be harvested. This has to be weighed against the larger donor scars and damage to follicles.

Difficulties in Graft Dissection

Regardless of the technique, the graft dissection process may result in follicle transection. If transection is noted very high in the dermis, affecting all the follicles at a level 1–2 mm below the skin surface, this is called "topping." This finding is related to insertion of a sharp punch at an angle that is significantly mismatched to subcutaneous course of the follicles. This results in a very superficial follicular unit transaction that leaves the underlying follicles intact. The remedy for topping is to insert the sharp punch into the skin at a less acute angle.

If the transection of the follicles occurs at a deeper level, there is a mismatch between the angle of insertion of the punch and the true course of the follicles. In the case of sharp dissection, either the depth of insertion must be more shallow or the angle of insertion must be adjusted. To accomplish this task, the sharp punch may be inserted in small increments while evaluating the course of the follicles and the angle can be changed as needed.

In the case of SAFE extractions, deeper transections suggest that the "superficial" scoring incision is

too deep. An adjustment of the insertion to ensure that the incision is no deeper than 0.3–0.5 mm (the junction of the bevel and the shaft of a sharp punch) should be made. The second possibility is that the dull dissecting punch is inserted in such a way that there is a gross mismatch between the follicle direction and direction of insertion. Evaluation of the transected follicular unit will indicate the required change in orientation.

GRAFT HARVESTING

The next step involves removing the graft from the donor area. Tethering of the distal graft to the deeper dermal tissue must be freed to allow graft removal from the skin. The degree of tethering may vary from one scalp location to another. The neck and temporal region tend to exhibit a higher degree of tethering than the mid-occipital region.

Usually, one can grasp the follicular unit with small forceps near the region of the sebaceous gland and, with minimal pressure and pulling, remove the graft easily from the skin. Different extraction forces may be required in different patients or in different regions of the scalp on the same patient.

Occasionally, when the graft is grasped at or near the epidermis, the skin superficial to the sebaceous glad is inadvertently removed and this is called "capping." If the follicular unit is removed, it still produces a viable graft. If capping occurs frequently, it may mean that the dissection of the follicular unit is too superficial.

Should the graft be tethered, serial grasping of the graft with small forceps in a "hand-over-hand" method with the pulling force exerted parallel to the follicle orientation can be attempted. Great care should be taken not to damage the graft by squeezing too tightly. If the two-step blunt dissection technique was employed, reinsertion of the blunt punch to its full depth may free the graft.

A small (25–27) gauge needle may also be inserted at small intervals into the incision around the tethered graft creating perforations ("postage stamp" effect) to free it from the surrounding tissue. The graft may then be grasped and attempts at removal repeated.

Should the graft remain fixed in position, one may repeat the above maneuvers or leave the graft in place and move on to the next follicular unit. Often, the time spent in freeing a single tethered graft is better spent in pursuing another graft.

CAVEATS

The grafts produced by FUE are essentially stripped of any investing tissue (Figure 4.10). This single fact makes graft handling more difficult and may explain the occasional reports of poor growth from FUE. The extent of this problem has not been published, but it may be higher than the rate seen with strip excision.

The lack of fat around the graft can easily lead to graft desiccation, and the technicians must be aware of the moisture status of the grafts. Usually, fewer grafts can be located outside the storage media at any one time. The lack of connective tissue around the follicles can allow the follicles to splay. This requires that the planter grasp the distal end of the

FIG. 4.10. Microscopic view of grafts after FUE. Note that there is some loss of investing tissue around the follicles themselves.

follicles in order to implant them, which will subject the follicles to the risk of crush trauma.

Another problem that may occur during implantation is the possibility that the graft may become kinked at the distal end during the insertion process. This may lead either to the graft producing a curved or kinky hair or the graft becoming nonviable.

DONOR AREA MANAGEMENT AND CONSIDERATIONS

The number of hairs in the extracted grafts will be determined mostly by the size of the punch used. When utilizing a 1-mm punch, the average hairs per follicular unit can exceed 2.5 as follicular units with higher hair density are preferentially selected. When the punch size is decreased to 0.75 mm, the average hairs per follicular unit decreases to approximately 2.1 hairs, which is similar to hair density of grafts obtained by strip excision.

The overall objective is to harvest fewer than half of the potential grafts in a given area in order to avoid creating a moth-eaten look. If a person has extremely high density with excellent hair characteristics, more than 50% of the hair may be harvested. The density of extractions per square centimeter in a nonharvested area can vary; however, the range for a 1-mm punch may be 8–20 per cm^2 depending on native follicular unit density. The use of a 0.75-mm punch usually allows for extraction densities of twenty five or more sites per cm^2. One should be aware that the area of the extraction hole utilizing a 0.75-mm punch is 56% of the size created by the 1-mm punch; this difference is significant. Figure 4.11 illustrates the difference between the 1-mm-punch (circled in blue) and the 0.75-mm-punch extraction sites.

Care must be taken to avoid harvesting grafts too closely to one another. This may cause the appearance of a small linear scar. To avoid this problem, the surgeon should stagger the punches in a zigzag or random pattern. Although this technique leaves no linear scar, donor sites may be visible in patients who shave their heads. It should be mentioned that subtle extraction patterns or skin color changes may still be visible. Patients under the impression that FUE allows for total camouflage of the harvest process should be cautioned accordingly.

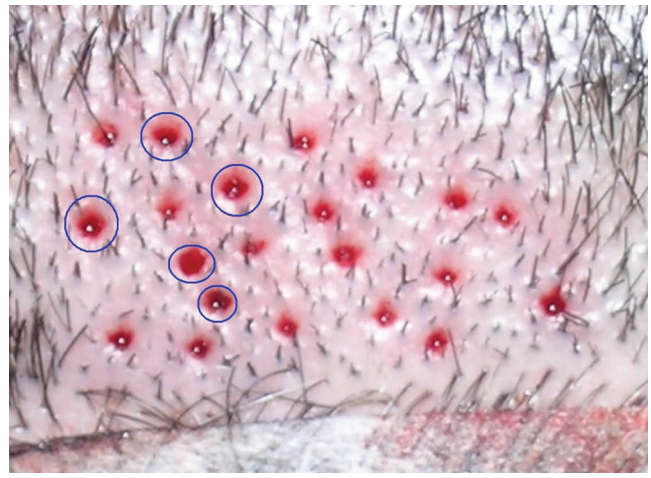

FIG. 4.11. Difference in size between 1-mm (circled in blue) and 0.75-mm punch extraction sites.

Although controversial, scalp FUE after strip harvesting may allow for the removal of a greater number of grafts than conventional strip harvesting alone. It is not uncommon for patients to have had multiple strip surgeries with minimal or no laxity remaining. However, they may still have donor areas with adequate density to allow additional graft harvest. FUE can allow the surgeon to obtain an additional 2,000–4,000 grafts. Another use of FUE is the ability to maximize the number of grafts moved in a single session by combining strip excision with FUE.

BODY HAIR TRANSFER

The advent of single follicular unit harvest has made possible the extraction and implantation of hair from other body sites including the extremities, chest, back, beard, pubis, and labia. However, the capability of performing the surgery does not mean that these

areas provide a realistic and reliable source of donor follicles.

There are several reasons why body hair is not as good an option as scalp hair for transplantation. First, body hair has an inherent growth cycle that is measured in months rather than years. In spite of the excellent work done by Huang, transplanting hair into different body sites, it has not been demonstrated that the recipient area exerts a significant degree of "dominance" in changing the growth cycle of a body hair to that matching scalp hair. In fact, clinical results suggest that the majority of hairs transferred from the body retain the donor area characteristics. The body hair with the most favorable characteristics in terms of growth cycle and shaft diameter is beard hair. It is somewhat coarse, but seems to grow to a reasonable length.

Follicular units from nonscalp locations typically contain fewer than two hairs per follicular unit and average less than 1.3 hairs per graft. Obviously, this will require almost twice as many grafts to provide the same number of hairs as a similar number of scalp grafts. Anecdotally, there is evidence that body hair has poorer graft survival than scalp hair, and this may depend on whether the graft was transplanted during the anagen phase or not. Accurate survival statistics are not available.

In general, body hair grafts do not produce the coverage or density that scalp hair grafts do. They may also not appear as natural depending on the area of the body from which they were extracted. They may be reasonable for providing light coverage in areas where great density is not required, such as the anterior temples or filling in spaces between thinly distributed scalp grafts. At the time of this writing, there are physicians providing BHT sessions as large as 9,000–18,000 grafts to the scalp. This situation is a setup for unhappy patients who may be gravely disappointed with the cosmetic results and extensive donor-site scarring.

CONCLUSION

FUE is a relatively new procedure that is gaining acceptance by physicians and patients alike. Patients are aware of the significant advantages, such as decreased postoperative pain, rapid recovery time, and the ability to wear the hair closely cropped. Patients are usually the first to embrace techniques that offer a less invasive alternative compared to traditional procedures. The production of 1,000 grafts from a strip with 100 follicular units/cm^2 will remove approximately 5,000 mm^3 of tissue. FUE offers less tissue ablation; harvesting 1,000 grafts with a 1-mm punch will remove 3,925 mm^3 of skin and a 0.75-mm punch will remove 2,208 mm^3. This procedure is truly "minimally" invasive. The net effect of this is more rapid healing and minimal pain.

As the techniques and instrumentation improve, the disadvantages of longer operating times and the high cost to the patient will decrease. The advantages, such as more exact planning for the number of grafts required, a decreased reliance on auxiliary staff, and the ability to select the mix of follicular units for the specific case will drive a higher acceptance of this procedure by physicians.

With the future of mechanized manual extraction devices and the possibility of robotic technology, this technique may be the future of graft production. It offers the patient the possibility of the natural, undetectable results that we have with the standard follicular unit transplantation with the added advantages of significantly less pain, more rapid recovery, and less visible scarring.

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Chapter 5

FRONTAL HAIRLINE DESIGN

by

William M. Parsley, MD

INTRODUCTION

The design of the hairline is the heart of hair restoration surgery. No other part of the procedure will have as much impact on the patient's appearance, and it is the template on which present and future surgery is patterned. The hairline design requires an understanding of both intact and balding patterns in order to create a successful plan. Many factors must be considered, including age and donor supply. The importance of a good hairline design cannot be overemphasized, as improper design is one of the major reasons for poor outcomes and for the need of repair work.

Recession of the frontal hairline removes the framework of the face, often leading to a loss of self-confidence and esteem. Therefore, the goal of frontal hairline restoration is to reframe the face.

GENERAL APPROACH

The success of frontal hairline restoration depends on the creation of a cosmetically pleasing design that takes into consideration the patient's desires, donor supply, donor hair quality, and expected future balding. With good judgment and foresight, a proper design should remain beneficial and natural for a lifetime. "After" pictures at thirty years are more telling than "after" pictures at five years.

Most cosmetic surgeons consider it important that the patient maintains a sense of self. A common approach is to evaluate a patient's hair loss and try to rewind their personal balding timeline to a point, which would not only be pleasing but also be supported by the patient's donor supply. Patient satisfaction in cosmetic surgery tends to be much greater when the person's natural identity is preserved. Creating a pattern that is too different from the patient's and acquaintance's perception of him or her is often not received well. Communication with the patient and trying to realistically achieve his or her goal is needed. However, there are few firm rules, and all decisions must be individualized.

NATURAL PATTERNS

Glossary of Terms

A few landmarks and terms used in hair restoration must be understood before entering into further discussion of natural patterns and design (some are listed in Figure 5.1):

Apex – the most posterior point of temporal recession on either side at a given time, which may be

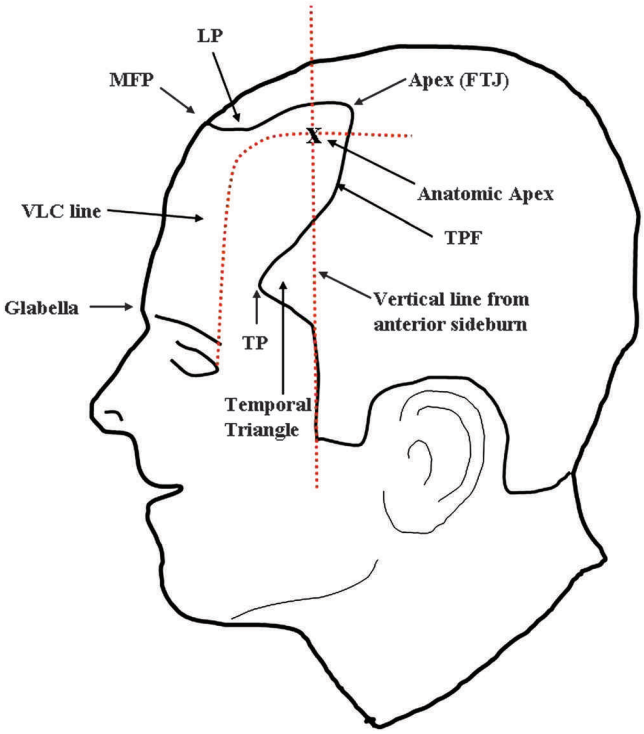


FIG. 5.1. Anatomic Landmarks. The following are important landmarks used in hairline design: VLC line – vertical lateral canthal line, MFP – midfrontal point, LP – lateral point, Apex – the fronto-temporal junction, TPF – temporo-parietal fringe, TP – temporal point. Anatomic Apex is a created term for this chapter marking the junction of the VLC line and a vertical line from the anterior border of the sideburn. The temporal triangle is the portion of the temple zone anterior to the anterior border of the sideburn.

original, transplanted, or recessed. It is also known as the frontal–temporal junction (FTJ). The term "original apex" is used for the person's apex before balding.

Anatomic apex (AA) – the junction of the vertical lateral canthal line (VLC) and a line drawn vertically from the anterior sideburn. Usually, the patient's original apex is at or close to this junction, so it serves as a useful reference point.

Flares – lateral (concave) curvatures of the posterior aspects of the frontal hairline. They are primarily, but not always, due to the posterior/medial recession of the frontal zone meeting with a retained midscalp (Figure 5.2).

Follicular units (FUs) – natural clusters of hairs as they reside in the skin. There are usually one to five hairs in each FU.

Frontal peaks – natural protrusions of the frontal hairline, possibly created by frontal whorls. The centermost of these is called the widow's peak.

Fronto-temporal junction (FTJ) – the junction of the frontal hairline and the temporo-parietal fringe (TPF). Considered synonymous with the apex, it is a very important design point.

Fronto-temporal triangle (FTT) – the triangle formed between the borders of the frontal hairline and the TPF. It is present in all intact hairlines except for the crescent pattern.

Glabellar-midfrontal point (MFP) distance – the vertical distance from the mid-glabella to the MFP. This distance is generally regarded as the height of the hairline and is always measured during hairline design.

Lateral point (LP) – when the patient is viewed from the side (lateral view), this point represents the most inferior aspect of the frontal hairline in patients with an oval frontal hairline. It usually occurs along a line running vertically from the lateral canthus.

Midfrontal point (MFP) – the most anterior point of the frontal hairline, located directly above the glabella. It can be natural or designed.

Parietal hump – the convex superior border of the parietal fringe. The natural existing height of this border is very important when selecting the hairline design. If it drops below the VLC line, it may have to be reconstructed.

Rule of thirds – used by Leonardo da Vinci and Michelangelo, this standard of facial proportions observes that the most aesthetically pleasing faces are divided equally into thirds: MFP > glabella, glabella > base of nose, base of nose > tip of chin (Figure 5.3).

Temporo-parietal fringe (TPF) – the junction of the upper temporo-parietal border with the glabrous

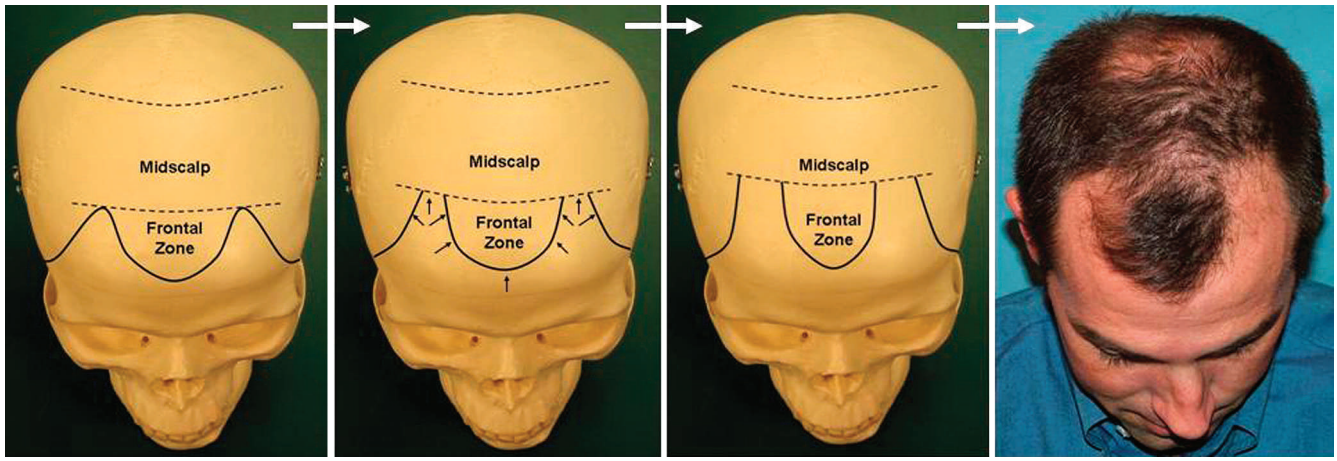


FIG. 5.2. Frontal Flare Formation. A primary etiology of the distal lateral flare is the posterior and medial recession of the frontal scalp into a retained midscalp, creating what looks like a flare of the frontal hairline. The "flared" portion is usually the midscalp, which is commonly also in a state of recession. The start of the flare is generally at or slightly posterior to the anterior border of the sideburn.

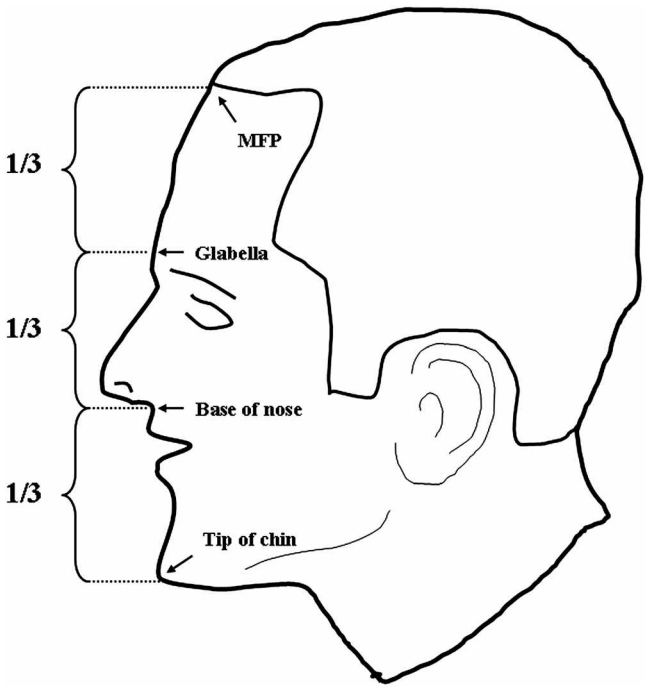


FIG. 5.3. Rule of Thirds. Developed 500 years ago by Leonardo da Vinci, the ideal face was divided into three portions: (1) MFP to the glabella, (2) glabella to the base of the nose, and (3) base of the nose to the tip of the chin. While still aworthy goal, individual situations often make these portions unachievable.

skin or balding scalp. This fringe begins at the temporal points and ends where the parietal borders blends into the occipital scalp. The term is used because the temporal and parietal margins are a continuum (Beehner suggests the dividing line as a line drawn vertically from the external auditory meatus).

Transition zone (TZ) – the peripheral edge of the frontal hairline where a soft transition exists between the glabrous skin of the forehead and the full density of the frontal scalp. This zone is made up predominantly of single hair FUs with hairless gaps, clusters of hairs, and randomly scattered hairs.

Trichion – the patient's natural MFP before the onset of hair loss.

Troughs – these are concave areas that occur as the posterior limb of the frontal hairline moves medially. As the troughs deepen, they may isolate a frontal forelock. Natural flared hairlines rarely move medially at any point as they travel from the MFP to the FTJ. Any medial movement usually creates troughs.

Vertical lateral canthal line (VLC line) – this important line runs vertically from the lateral canthus of the eye. When facing the patient, this line will usually cross the patient's natural FTJ or be very close to it. This line curves with the scalp but remains on the sagittal plane.

Frontal Hairline

Women with female pattern loss, as opposed to androgenetic alopecia (AGA), will normally have thinning but will maintain their original hairline. Thus, the design will generally but not always follow the existing hairline. The design outline is more complex in men as both thinning and recession must be considered. In this chapter, we will focus on this more challenging task of hairline design in men.

Variation in Patterns of the Intact Male Hairline

There has been little work in classifying the various frontal hairline patterns in men. In the spirit of simplicity, there are four general patterns with many gradients in between (Figure 5.4).

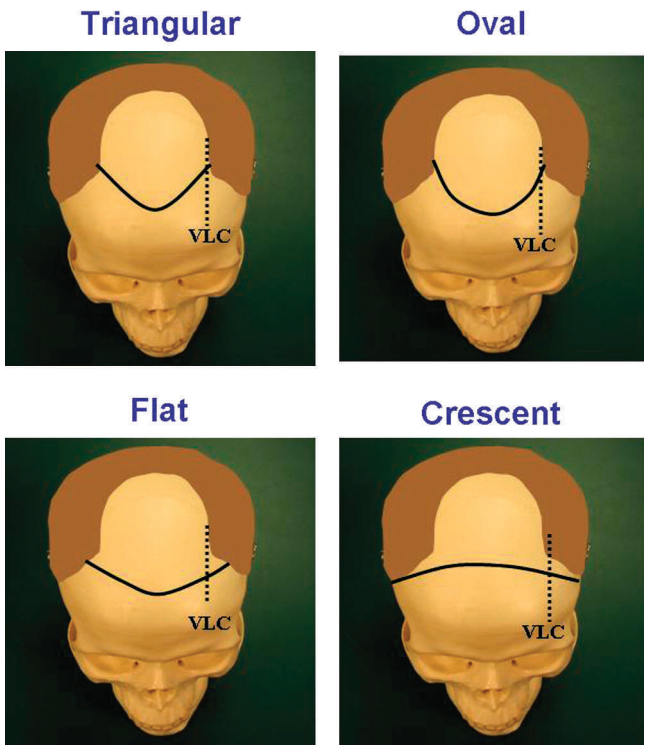


FIG. 5.4. Frontal Hairline Patterns. There are four basic patterns of the nonbalding male frontal hairline: (1) Oval – the hairline moves in a convex curve from the frontal hairline to the apex without crossing the VLC line, (2) Triangular – forms a triangle with a narrow, anterior border and has an apex at or medial to the VLC line, (3) Flat – moves more laterally than posteriorly and crosses the VLC line, meeting the temporal fringe anterior and lateral to the AA, (4) Crescent – takes the form of an arch between the temporal points, creating no FTT. The apex is the temporal point.

Triangular – this hairline has a narrow anterior margin and widens posteriorly to meet, but not cross, the VLC line. The entire frontal hairline is easily visible from the frontal view.

Oval – compared to the triangular pattern, this pattern has a wider anterior margin and a more limited view of the posterior segments of the hairline from the frontal view. Like the triangular pattern, it does not cross the VLC line. This is also the most common balding pattern in men.

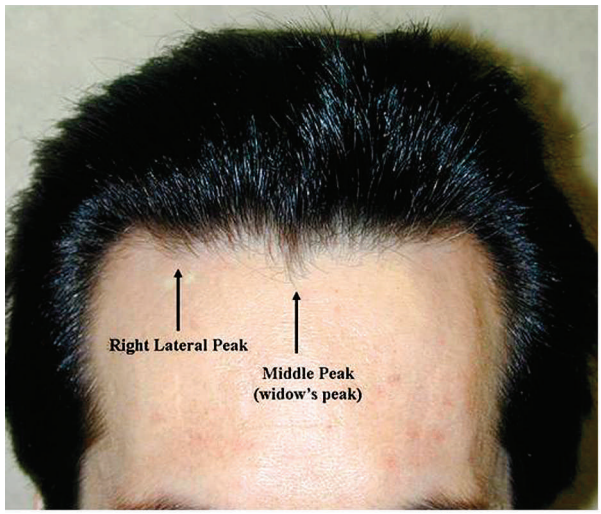
Flat – this hairline runs laterally with only slight-to-moderate movement posteriorly. As opposed to the triangular pattern, the FHL crosses the VLC line and creates an apex anterior to the anterior border of the sideburn. As the frontal hairline moves from the MFP to the temporal fringe, it can be slightly convex, nearly straight, or slightly concave.

Crescent – this arched hairline moves laterally and inferiorly from the MFP to the temporal points. It arches along the top of the forehead and has the same appearance as a full female hairline.

Natural Frontal Hairline Irregularities

Peaks – Approximately half of both men and women have naturally occurring irregularities or peaks along the frontal hairline (Figure 5.5). The etiology of peaks is not known, but they may be created by frontal whorls whose centers are on the glabrous skin of the forehead. There appear to be a maximum of three potential peaks: a central "widow's peak," and right and left lateral peaks.

Most commonly, the hairs of the middle peak (widow's peak) exit the skin at a very acute angle and are directed laterally and/or posteriorly, often toward one ear. The peaks can be triangular or more rounded, leading them to also be called "mounds." A given person may have no peaks (50%) or between one and three peaks. If a patient has all three peaks,



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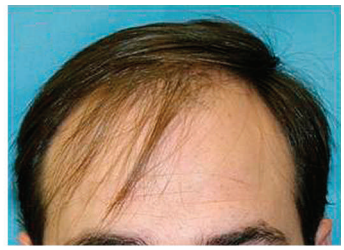

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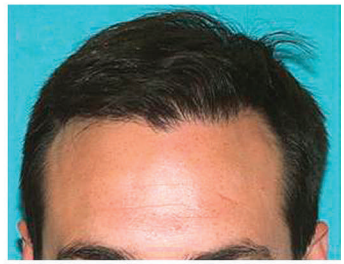

C

FIG. 5.5. Frontal Peaks. ***Roughly half of nonbalding men and women have at least one frontal peak that changes the contour of the frontal hairline. There are three potential peaks, and they can occur in any combination of one to three of the following: right lateral peak, middle peak (widow's peak), and left lateral peak. (A) Patient with a natural widow's peak and right lateral peak – note the acute hair angle in the widow's peak. (B,C) Before and after picture of an FHL restoration with a widow's peak and left lateral peak – one session.***

the central frontal hairline has a double concave curve, giving a "gull wing"–like appearance.

Transition zone – At the junction of the forehead and frontal hairline, there is a transition zone of finer hairs with follicular units containing mostly single hairs with only a few two-haired units. A common pattern is clusters of hair, generally triangular, with intervening hairless gaps. Lines of single hairs may extend laterally or at a 45 degree angle to the hairline, and the far periphery usually has many randomly scattered hairs. This zone softens the hairline without changing its natural contour (Figure 5.6).

BALDING PATTERNS

Men not only have thinning but usually also have recession, giving rise to a variety of natural balding patterns. These patterns are addressed in the Norwood–Hamilton classification of MPB. However, this classification needs to be expanded to include other male balding patterns such as diffuse patterned alopecia, diffuse unpatterned alopecia, and vertex patterns. These patterns are of great importance to the field of hair restoration. Firstly, they are a way hair specialists communicate with each other in describing the balding status of patients. Secondly, they are templates doctors often use in designing patterns.

The Norwood–Hamilton (NW) classification is shown in Figure 5.7. Note that in this slightly modified scheme, standard NW and NW A patterns can evolve into NW VI and VII patterns. There are

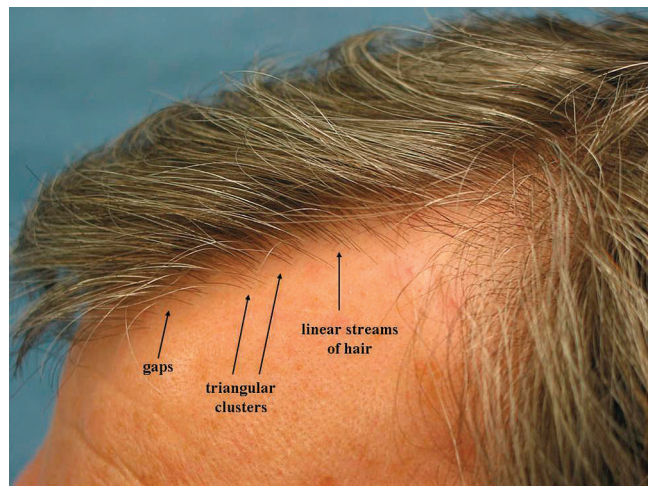

FIG. 5.6. Transition Zone. A transition zone occurs in every patient. It serves to soften the hairline without changing the contour. It consists of clusters of hairs separated by relatively hairless gaps and linear streams of single hairs. At the periphery are randomly scattered single hairs, which are more prominently seen in balding men.

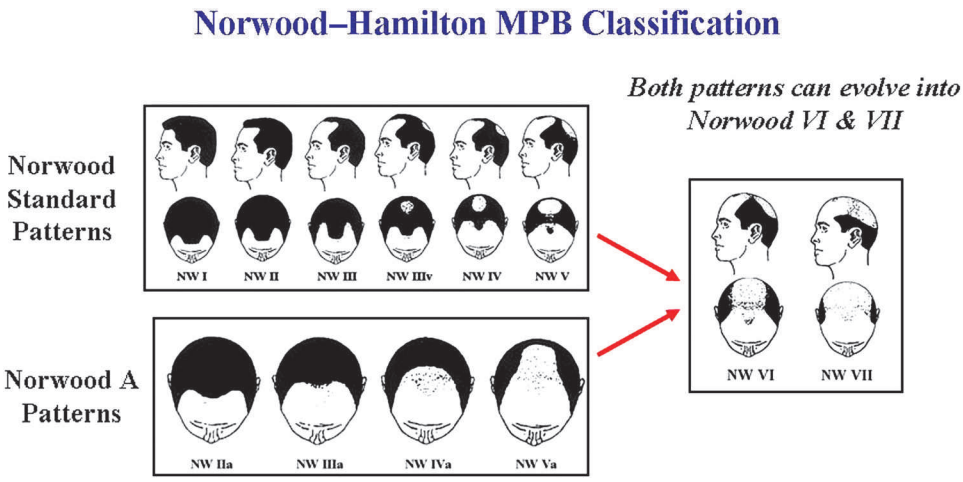

FIG. 5.7. Norwood–Hamilton Classification of MPB. The Norwood–Hamilton Classification has been the primary classification system used since 1975. The standard patterns relate to the M type recession patterns and the NW A patterns are the anterior recession patterns. Earlier is a slight modification suggested by Beehner to illustrate that both standard patterns and A patterns can evolve to NW VI and VII. Some patterns such as diffuse patterns, temple patterns, forelock patterns, and "vertex-only" patterns need to be included.

several natural balding patterns not addressed in the NW classification; among them are vertex-only patterns, isolated frontal forelocks, and diffuse patterns (Figure 5.8). An expanded classification is needed.

DESIGN PATTERNS

General Design Patterns of the Frontal Hairline

In men, there are a variety of patterns that can be created, and all should be patterns that exist in nature. Basically, created patterns fall into two categories: 1) contiguous with another zone, such as the TPF or the midscalp and 2) as an isolated forelock (Figure 5.9).

I. Contiguous/connected

A. With Temporo-parietal fringe
   1. Oval design
   2. Triangular design
   3. Flat design

B. With midscalp – creates a flare
   1. Oval
   2. Troughs
   3. Triangular

II. Isolated frontal forelock

A large variety of sizes and shapes may be used.

Contiguous or connected patterns imply that the designed frontal hairline is adjoining another zone – either the temporo-parietal zone or the midscalp. The adjoining zone may be naturally existing or created. If there is enough donor hair available, the preferred connection is to the TPF. If a person has a limited donor supply and low parietal humps, this connection may not be possible. Assuming it is reasonable to have a connection to the TPF, there are three reasonable patterns to use – oval, triangular, and flat. The crescent design can also be used, but it is not included because it is extremely aggressive and rarely wise to use on a man. The oval design may also be used. In this pattern, LPs should be established. After the frontal hairline (starting from the MFP) meets the LP, it should stay horizontal or move superiorly as it travels to the apex. When designing this pattern, simply place the LP horizontally level with or slightly inferior to the level of the apex. The designed line should be drawn as a subtle convex curve. Triangular hairlines are also popular. They allow the MFP to be placed as low as with the oval pattern but use fewer grafts for the coverage. The trade-off is that some find a dropping lateral hairline

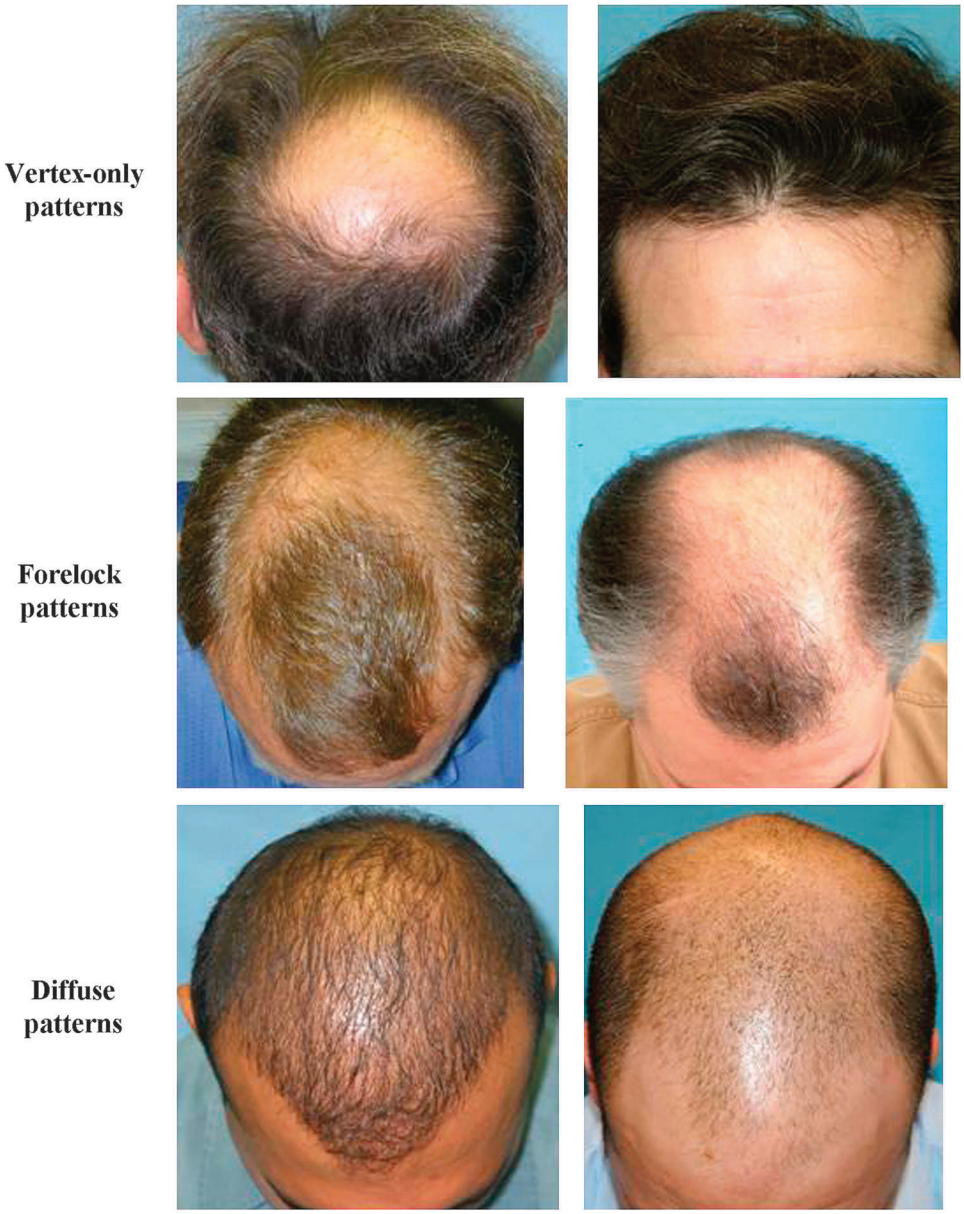

FIG. 5.8. Patterns Not Covered by Norwood–Hamilton Classification. *Shown are three baldness patterns not included in the Norwood–Hamilton Classification. The top line is the frontal and vertex view of the same patient with vertex-only loss. The middle line shows two of the many patterns taken by isolated forelocks. The bottom line shows diffuse patterns that can be (1) patterned with thinning by miniaturization on top with thick hair in the occipital and parietal zones (diffuse patterned alopecia) or (2) generalized over the entire scalp (diffuse unpatterned alopecia).*

a little less natural in appearance, and it might make brushing the hair back less attractive. Still, triangular designs can look very good in the hands of experienced hair surgeons (Figure 5.10). Flat hairlines are more aggressive and should only be considered in a mature man with modest balding and stable hair loss. Crescent hairlines are so rarely used that they are not included in the design patterns. If it ever were to be used, it should be on a very mature male with frontal thinning but little loss elsewhere.

Patterns adjoining the *midscalp* create a flare. If one is connecting to an existing retained midscalp, the doctor must have future plans because midscalps are unstable and will thin and recede with time. If the patient has a good existing midscalp, there are three basic choices for future plans:

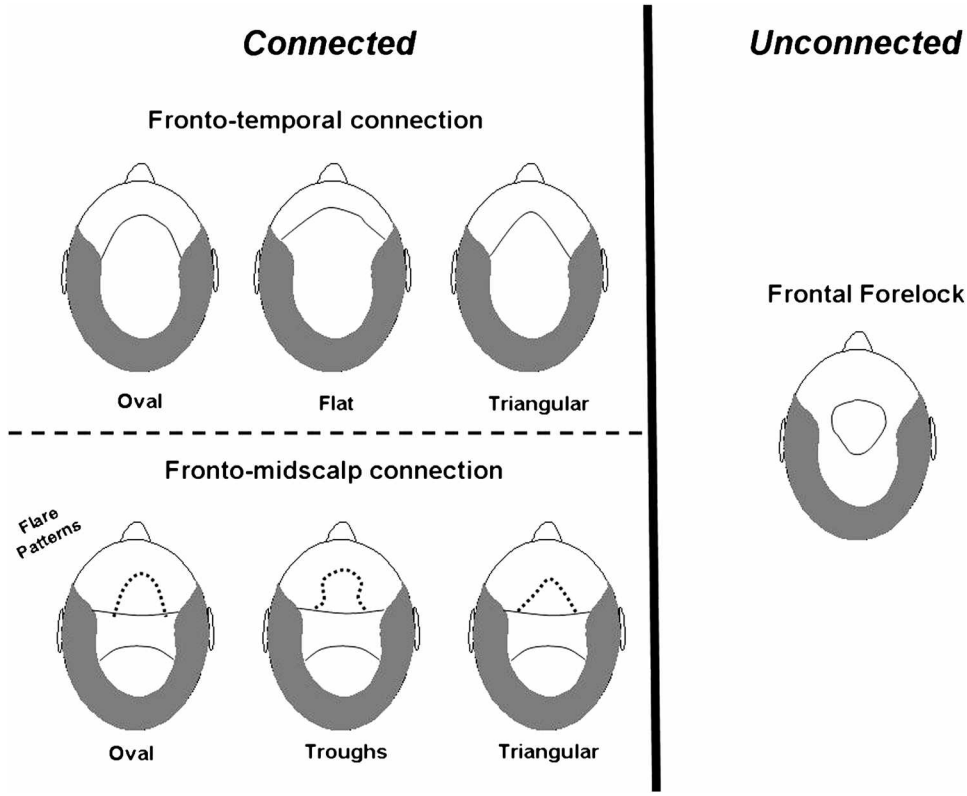

FIG. 5.9. Hairline Design Patterns. This is a suggested classification of patterns to use in frontal hairline design. The FHL can be connected to another zone (TPF or MS) or unconnected (isolated forelock). The TPF is more stable than the MS and is the preferred connection if adequate donor hair exists. If the connection is to a retained MS, the MS will certainly need to be bolstered as it recedes and thins with time. Isolated forelocks are good if there is considerable shortage of donor hair, but most surgeons will transplant a very thin "blur" zone of fine hairs between the forelock and the TPF to give it a softer, more natural look.

1. Maintain and bolster the existing midscalp with grafts as balding progresses. This will preserve the flare pattern that was designed.
2. Build up the parietal humps to create a frontal hairline connection to the TPF as the midscalp is lost to baldness. This will convert the pattern back to a TPF connection, but with the apex posterior and medial to the anatomic apex (AA), forming fairly deep fronto-temporal triangles.
3. Do not maintain the midscalp and allow the frontal hairline to be converted into an isolated frontal forelock.

If a midscalp is created along with the frontal scalp, then the pattern is permanent unless surgically changed. Oval patterns may occasionally be created with troughs. Troughs require that the frontal hairline move medially as it travels posteriorly to meet the midscalp. Troughs are helpful in conserving the donor supply. They can be used in patients wishing to brush their hair back. In a connection to an existing midscalp, troughs can later be easily converted to an isolated forelock.

An *isolated frontal forelock results from placing grafts centrally on the scalp without trying to maintain a connection with existing scalp hair.* There are a large variety of natural forelock sizes and patterns for design consideration. Forelocks are generally used when donor supply is very limited, and patients simply want some framing of the face (Figure 5.11).

Steps in Design

General Approach

After a design has been selected (considering the patient's age, desires, and donor quality), it is time to sketch the design on the patient's scalp. A dry-erase pen is good for this purpose, and sketch marks

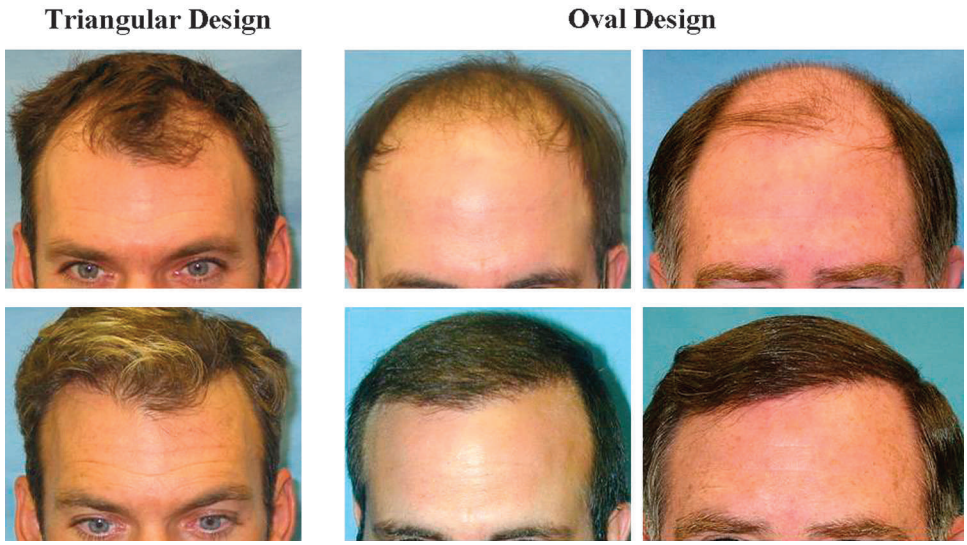

FIG. 5.10. Hairline Design – examples. *Shown are some examples of before and after pictures comparing a triangular design to an oval design. The oval pattern has a wider anterior border, but both have their apex at or medial to the VLC line.*

can be easily wiped off with a dry cloth when adjustments are needed. Regardless of the pattern, the first step is to create an MFP, which will usually be somewhat posterior to the patient's trichion, or natural MFP. If using a *fronto-temporal connection*, the next step is to delineate the apex on each side. If using an oval or triangular design, the apex will generally be slightly medial and posterior to the anatomic apex (AA). If using a flat design, the apex will be lateral and anterior to the AA. The last step is to create LPs. In the oval pattern, one should make sure they are horizontal or slightly inferior to the designed apex when viewed laterally. In the flat and triangular patterns, LPs will need to be superior to the apex.

When designing a *fronto-midscalp connection*, the first step is again to select the MFP, which is placed a little higher (i.e., 8–12 cm) than with fronto-temporal connections. The next step is to design the midscalp if it has not been retained. An oval, trough, or triangular design is then drawn, connected to the midscalp and checked for symmetry.

In designing an *isolated pattern*, the MFP is also designed first. Since this pattern represents frontal retention, the MFP can be placed as low as 7 cm. The frontal forelock can be of a variety of sizes and

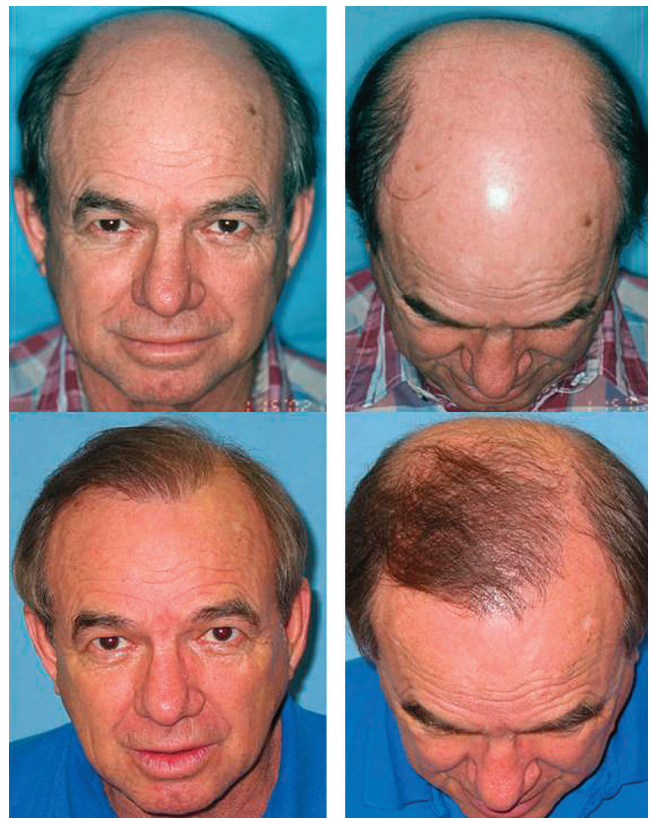

FIG. 5.11. Isolated Forelock – example. *This set of before and after pictures using an isolated forelock design illustrates that patients with a shortage of donor hair can often be suitable candidates for hair restoration.*

shapes. Even though technically isolated, most doctors create a surrounding "blur" zone of one- to two-haired grafts to give an impression of a connection to the TPF.

Looking more closely at the different landmarks:

1. Midfrontal point (MFP). This step is the first step in all designs. It should be made along a line extending vertically from the mid-glabella. The height above the mid-glabella is generally 7–11 cm but should be individualized to the patient. Sandoval describes the "shingling point" where the forehead transitions from mostly vertical to horizontal. This can be found by pushing the fingers against the upper forehead. The point at which the fingers start slipping posteriorly is the shingling point. It is advisable to not put the MFP below this point.
2. Apex. The apex (or FTJ) is designed in all frontotemporal connected hairlines. It can be placed at the anatomical apex but normally is posterior to it. From the frontal view, it should be along the VLC line or just medial to it when using an oval or triangular design. The more medial the apex placement, the more posterior it should be situated. Remember that the TP fringe moves posteriorly as it travels vertically. If a flat hairline is being designed, the apex will be lateral and anterior to the AA, placing it slightly on the vertical wall.

If a midscalp connection is being designed, the connection should be mainly medial to the AA. If the patient has a retained midscalp, then only slight midscalp reinforcement is necessary. If the midscalp needs to be created, its anterior border should be roughly along a line connecting the anterior borders of the sideburns.

3. Lateral points (LPs). These are most helpful with the oval pattern design to assure that the lateral portion of the hairline does not continue to drop inferiorly. If another design is used, they can still be helpful in centering the design on the scalp. LPs should be placed along a line drawn vertically from a point 0–1.0 cm posterior to the lateral canthus. It represents the most inferior point along the frontal hairline when viewed laterally and is generally 9–11 cm in height measured from the lateral canthus. From the LP to the apex, the frontal hairline should move horizontally or slightly vertically. LPs should be placed after the apex is located, making sure they are horizontal or inferior to the apex. They are also useful in placing the design symmetrically on the scalp. LPs are not used in flat or triangular designs as the frontal hairline in these designs continues to move inferiorly until it meets the apex (Figure 5.12).

Accounting for Differences in Head Shapes

Because most of the earlier mentioned measurements are based on vertical measurements, there is a built-in correction for patients with wider heads. For example, if the LPs are at 10 cm, the wider head will naturally have a wider pattern and a narrow oval head will have a narrower pattern. However, it is still necessary to visually check the pattern to make sure it is balanced and pleasing.

Design of Frontal Irregularities

Peaks

The decision to include peaks must be made jointly by the surgeon and patient. There are several important reasons to place peaks: 1) eliminating the rounded or "bowl" look of the transplanted hairline, 2) recreating the patient's natural peaks, 3) lowering the MFP slightly without expending many grafts, and 4) widening the anterior margin of the hairline with lateral peaks to improve the appearance in a patient brushing his hair back. Widow's peak hairs look best when the hairs are directed laterally or toward one ear and exit the skin at a very acute angle.

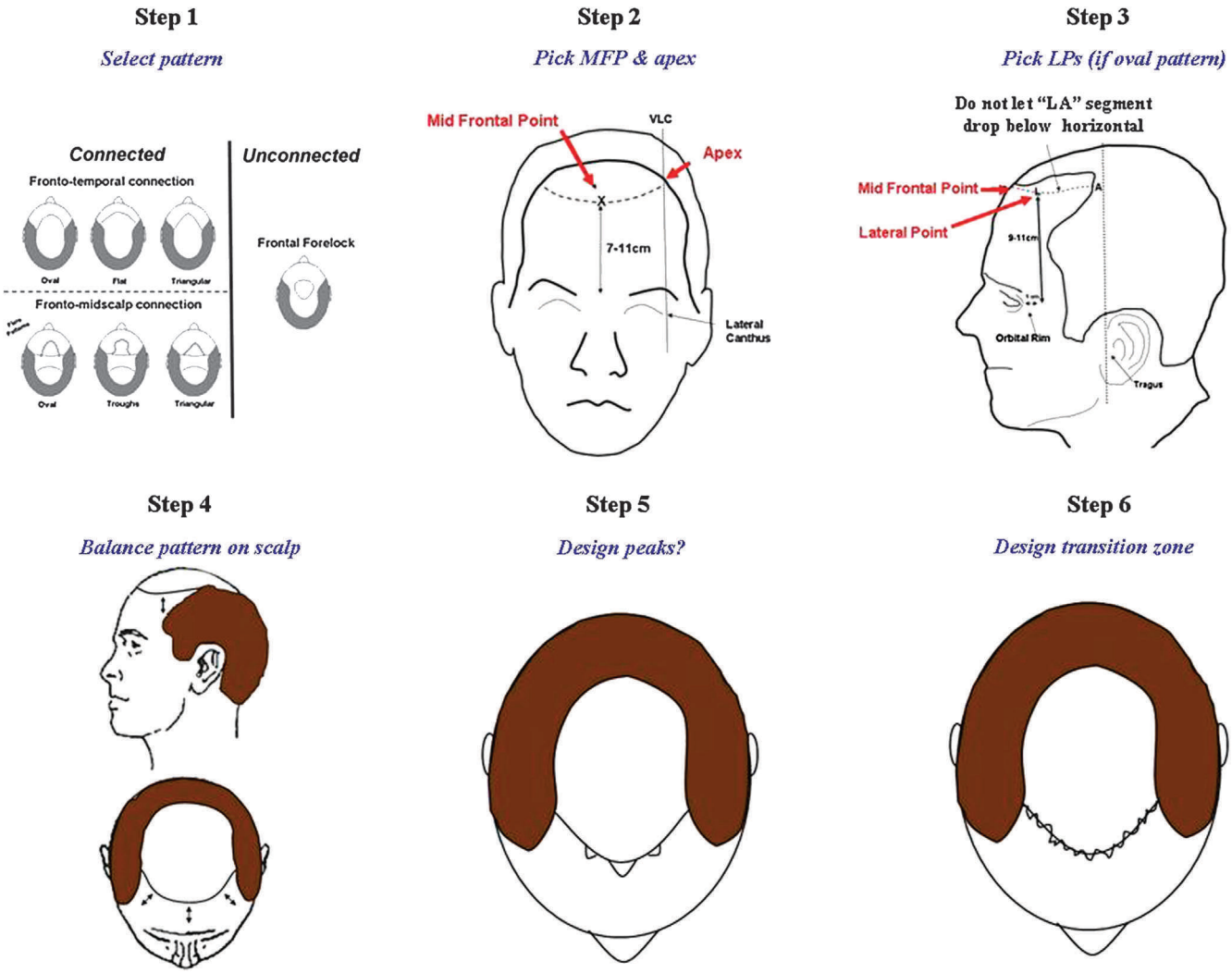

FIG. 5.12. Steps in Hairline Design. The following are suggested steps in designing the frontal hairline: (1) select a pattern, (2) pick the MFP and apex – usually the MFP is 7–11 cm above the glabella and the apex is medial and posterior to the AA, (3) pick the LPs – the right and left LP should be roughly equal in height and should be lower than the apex if using an oval design. If desired, LPs can also be used with flat and triangular designs to help center the pattern, (4) Balance the pattern on the scalp – this should be done by a combination of measurements and visual inspection, (5) design peaks if they are to be used, and (6) design the transition zone – shown is the zigzag approach (Knudsen).

Transition Zone

Creating an attractive transition zone is an art form. It can be difficult to find and place enough fine hairs to keep the hairline looking soft. One technique is to create a zigzag line across the designed hairline (Knudsen), where the amplitude of the zigzags is no more than 4–5 mm. By varying the width and height of the protrusions in an irregular fashion, natural-appearing clusters and gaps will be created.

Because transplanted hairs will have a greater diameter than existing miniaturized hairs, they may look less natural when placed along the hairline. A helpful compensating technique is to angle the grafted hairs 30 degrees or less to the skin. This will soften the hairline and draw less attention to the peripheral grafts. Be sure not to plant hairs that are in the process of miniaturizing as they may not have adequate longevity. Try to select fine hairs whose

bulbs are sitting as deep as the surrounding terminal hairs. Temporal or lower occipital hairs are finer in diameter and are excellent in the TZ. Generally, the direction of the grafted hairs should follow the existing hair. If there is no nearby existing hair, they should be directed anteriorly or toward the nose. On the nonpart side, some surgeons will angle the hair slightly lateral to the sagittal plane.

SUMMARY

Using common sense and following established guidelines, the hair surgeon should be able to design successful hairlines in his or her patients. At the same time, one must also use intuition in choosing a pattern that is appropriate and attractive for each patient. If a hairline is placed conservatively high, it is easy to adjust it lower at a later date if desired. However, it is far more difficult to later raise an overly aggressive low hairline. Technical and transplanting skills are extremely important, but without good design skills, the results may be less than ideal. It is important to observe natural hair patterns of people encountered in everyday life, as this will help hone one's skills to allow good judgment and results.

PEARLS

1. When designing the hairline, try to avoid perfectly straight lines. Remember that nature moves in curves.
2. Confine your creativity to the common natural patterns. Do not create what does not exist in nature.
3. Be conservative on the height and width of the frontal hairline, particularly in men under forty. It is easy to lower the hairline but hard to raise it.
4. Hairlines are deceptively difficult to understand and reproduce. Spend a lot of time studying them before starting hair restoration.
5. Do not fall a prey to wishful thinking. Male pattern baldness is progressive throughout life. Plan accordingly and design the hairline with the idea that future balding will be worse than expected.
6. Avoid being too critical of the work of other doctors. You have no way to know all of the circumstances involved. Critical analysis of your own work will be more productive.
7. Do not allow the frontal hairline to stray onto the vertical wall of the forehead or temples. It rarely looks good. For that reason, flat hairlines can be risky because they cross the VLC line, which is usually near the top of the temporal wall.
8. Avoid abrupt hairlines. A well-designed transition zone is extremely important to give softness to the hairline.
9. Create symmetry with the basic design. Use peaks and a transition zone to create the irregularities. A good hairline is always irregular. Slight asymmetry is sometimes acceptable but should be used with caution.
10. Do not totally trust measurements. Visually inspect the hairline for symmetry and cosmetic appearance as a final check. One helpful hint is to stand behind the patient and look at the patient's face and scalp through a mirror held in front of the patient's face.
11. The more receded the hairline design, the softer the transition zone should be. It is rare for a moderate to severely receded hairline to be abrupt.

12. Do not base the transplant design on the assumption that the patient will take hair loss medications.

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Chapter 6

CORRECTIVE HAIR TRANSPLANTATION

by

Marc R. Avram, MD

Cosmetically unnatural-appearing transplanted hair is an unfortunate public legacy of ten to twenty hair large graft surgery and poor hairline design performed from the 1960s to the 1990s. Patients with cosmetically unnatural-appearing surgeries consider repair of the transplant mandatory and not elective. Fortunately, the vast majority of patients can be substantially improved through different methods: 1) adding one to four hair follicular groupings between larger grafts to reduce their "pluggy" appearance (Figures 6.1–6.3), 2) surgically removing unnatural, inappropriately placed grafts (Figures 6.4 and 6.5), and 3) laser hair removal to noninvasively reduce unwanted pigmented hair follicles (Figures 6.6 and 6.7, Table 6.1). During the consultation, all options should be reviewed with the patient. The amount of cosmetic improvement and number of procedures needed should be discussed. As with any hair transplant procedure, it is vital that the patient and the physician have realistic expectations as to what corrective procedures can and cannot achieve. The advantages of the different types of corrective surgery are listed in Tables 6.2–6.5.

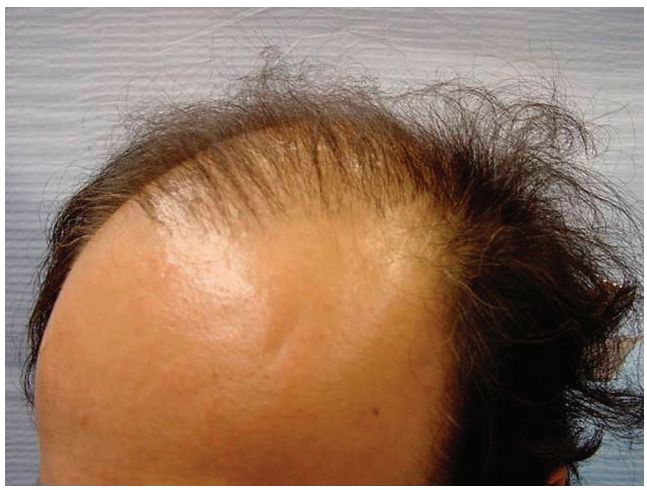

FIG. 6.1. Patient who has had large pluggy grafts.

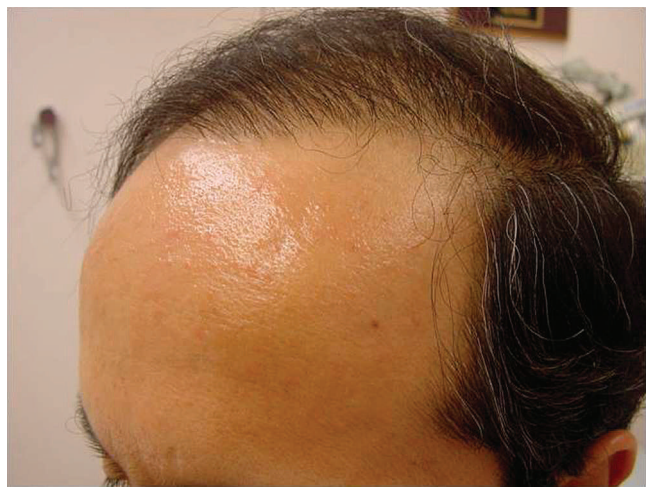

FIG. 6.2. After 900 one to four hair grafts between large pluggy grafts.

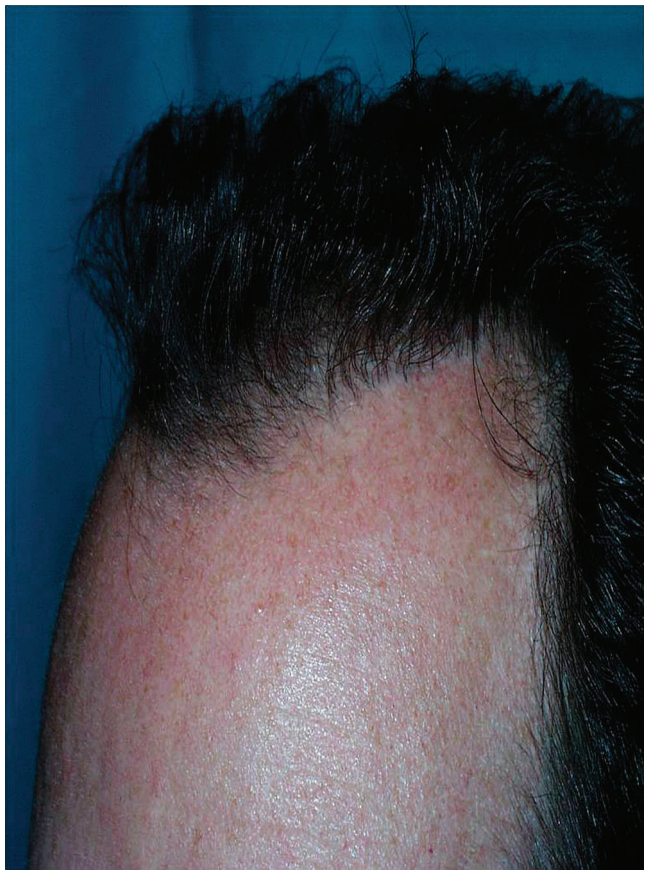

FIG. 6.3. Five to six hair grafts in frontal hairline.

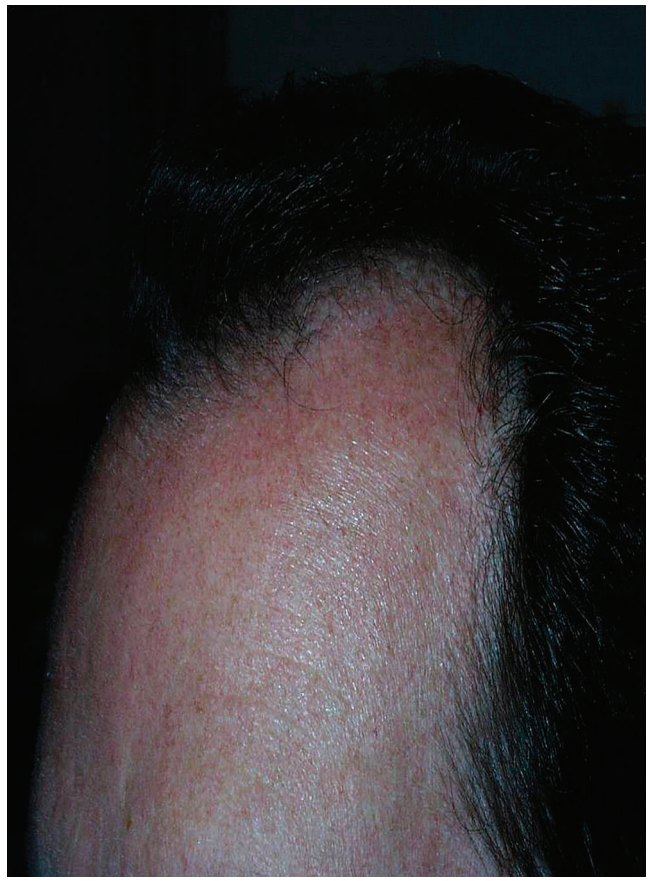

FIG. 6.4. After four laser hair removal sessions to soften hairline.

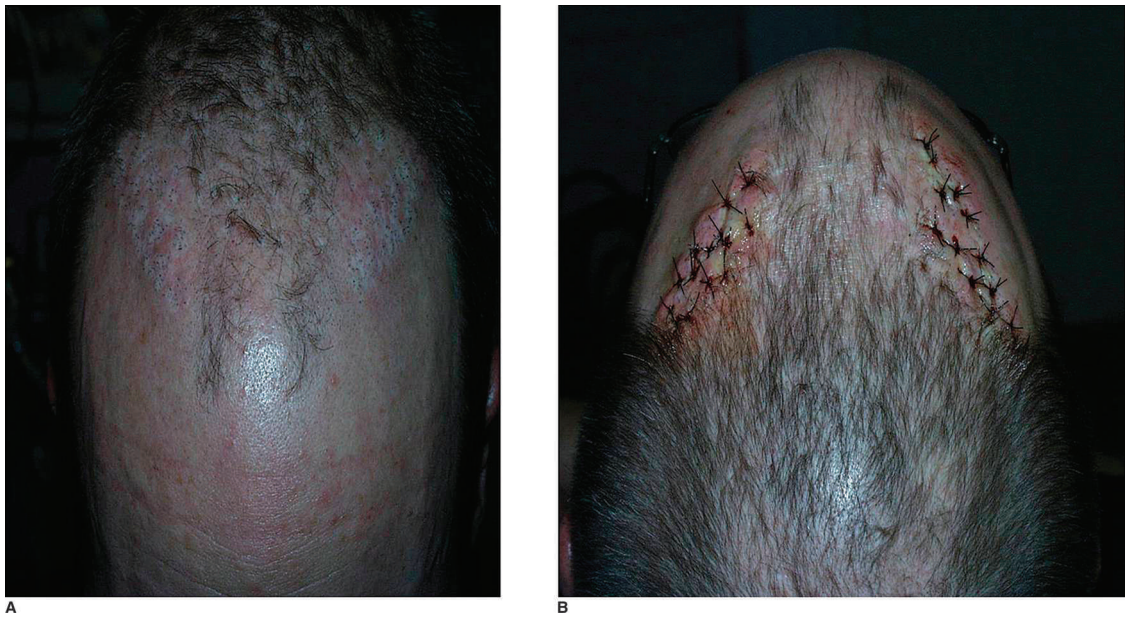

FIG. 6.5. (A,B) Removal of large plugs. Note hyperpigmented perifollicular scarring associated with large grafts.

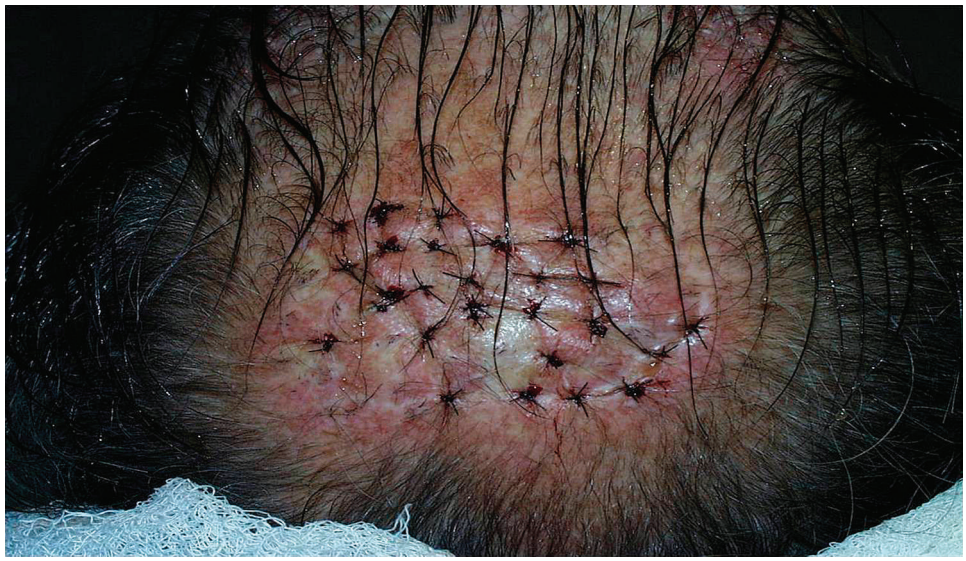

FIG. 6.6. Removal of large plugs with cold steel.

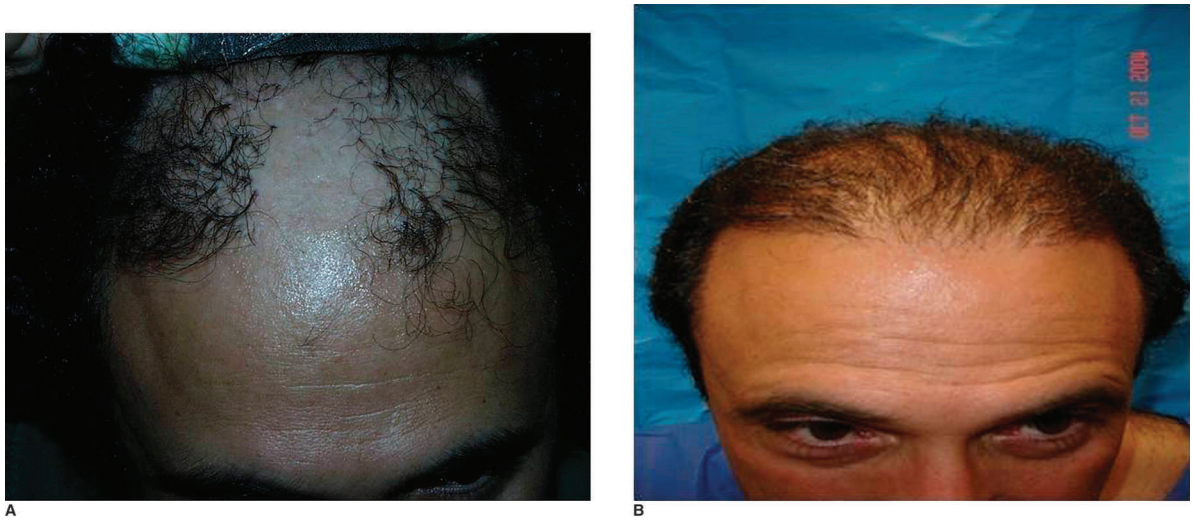

FIG. 6.7. (A) Pluggy grafts. (B) After adding one to four hair grafts two years later. (C) After adding more one to four hair grafts four years later.

TABLE 6.1. Treatment Options to Correct Unnatural-Appearing Transplanted Hair

1	Add a large number of 1–3 hair grafts between, behind, and in front of existing large 15–25 hair grafts
2	Surgical removal of plugs
3	Laser-assisted hair removal
4	Combination of any of these options

TABLE 6.2. Advantages of Adding One to Four Follicular Groupings between "Pluggy" Grafts

"Bushes" between trees to soften the hairline
Excellent option to increase density and soften the hairline
Cosmetically makes an unnatural hairline less noticeable and adds more density

TABLE 6.3. Disadvantages and Limitations of Corrective Surgery Using One to Four Hair Grafts

Limited or no occipital donor hair, which may be depleted from previous procedures
Existing hairline not only too straight and "pluggy" but also in an inappropriate location. Adding hair will only compound the problem.

TABLE 6.4. Advantages and Disadvantages of Surgically Removing Grafts

Advantages	Disadvantages
-Correction of low or bizarre hairlines	Unpredictable scarring
-Return to status quo ante	-Cobblestoning from large graft remains
	-Potential post surgical erythema
	-Visible sutures in postop period

TABLE 6.5. Advantages and Disadvantages of Laser-Assisted Hair Removal

Potential Advantages	Disadvantages
-Noninvasive	-Permanent removal of this hair; cannot be replaced elsewhere on the scalp
-No downtime	-Patients must return for five to eight treatments
-Converts larger plugs to smaller follicular groupings by reducing 50–80% of hair follicles in treated area	-Works only on pigmented hair

SUMMARY

Unnatural-appearing transplanted hair is emotionally upsetting for many patients. Most can be improved by a variety of techniques reviewed earlier. It is important for the physician to review the options and create a surgical plan that is most appropriate, based on each individual patient's physical examination and goals.

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Chapter 7

CICATRICIAL ALOPECIA

by

Nina Otberg, MD, Andreas Finner, MD, and Jerry Shapiro, MD

INTRODUCTION

Cicatricial or scarring alopecias comprise a diverse group of scalp disorders that result in permanent hair loss. The destructive process can occur as a primary or secondary cicatricial alopecia. Primary cicatricial alopecia refers to a group of idiopathic inflammatory diseases, characterized by a folliculocentric inflammatory process that ultimately destroys the hair follicle. Secondary cicatricial alopecias can be caused by almost any cutaneous inflammatory process of the scalp skin or by physical trauma, which injures the skin and skin appendages. Regardless of whether a cicatricial alopecia is primary or secondary in nature, all scarring alopecias are characterized clinically by a loss of follicular ostia and pathologically by a replacement of hair follicles with fibrous tissue.

Cicatricial alopecias are psychosocially distressing for the affected patient and medico-surgically challenging for the treating physician.

Hair restoration surgery in cicatricial alopecia is possible when the patient has a suitable occipital donor area and the scarring alopecia, and its underlying inflammatory process has reached a "burnt-out" stage. However, graft survival rates and cosmetic outcome may be diminished due to changes in skin properties such as fibrosis and limited blood supply. Moreover, one must consider that a reactivation of the inflammatory process may occur at any time after surgery.

This chapter is a brief review of primary and secondary cicatricial alopecias. Emphasis is placed on their clinical recognition, on patient management and treatment options as well as on their amenability to hair restoration surgery.

PRIMARY CICATRICIAL ALOPECIA

Etiology and Pathogenesis

The etiology of this diverse group of primary cicatricial alopecias is unknown. Primary cicatricial alopecias are characterized by an inflammatory infiltrate affecting the upper, permanent portion of the follicles referred to as the infundibulum, and below it, the isthmus of the follicle. The isthmus is the home of pluripotent hair stem cells, which are found in the bulge region where the arrector pili muscle attaches to the outer root sheath. Pluripotent hair follicle stem cells are responsible for the renewal of the upper part of the hair follicle and sebaceous glands and for the restoration of the lower cyclical component of the follicles at the onset of a new anagen period.[1,2] Damage to the

bulge area and the sebaceous gland with the isthmus may result in an incomplete hair cycle and can be associated with chronic follicular inflammation and foreign body reaction.[3]

It has been assumed that scarring hair loss is a consequence of damage to the isthmus, affecting either stem cells or sebaceous glands.[4–7]

Classification

According to a consensus meeting on cicatricial alopecia held at Duke University, North Carolina, in February 2001 by the North American Hair Research Society, primary cicatricial alopecias were classified into three main groups: 1) lymphocytic, 2) neutrophilic, and 3) mixed based on the nature of the inflammatory cells observed histologically around affected hair follicles.[8]

Although each disease has specific clinical and histopathological characteristics, the presentation of scarring alopecia in a patient can show overlapping findings and symptoms.

Clinical Features and Diagnosis

Primary cicatricial alopecia usually affects the central and parietal scalp before progressing to other sites of the scalp. Isolated alopecic patches showing atrophy and a lack of follicular ostia with inflammatory changes such as diffuse or perifollicular erythema, follicular hyperkeratosis, pigment changes, tufting, pustules provide hints for the diagnosis.[9,10] However, clinically visible inflammatory change might be absent in the affected lesions and may present histologically as inflammatory infiltrates in the deep dermis and subcutaneous tissue. Diagnostic tools such as a 3-fold magnifying lens, a 10-fold magnifying dermatoscope, or a 60- to 200-fold magnifying Folliscope® with and without polarized light can help to identify the presence or absence of follicular ostia, perifollicular erythema, and follicular hyperkeratosis in the affected areas.

A thorough examination of the entire scalp, a detailed clinical history, and skin biopsies of an active lesion are crucial in the correct diagnosis of cicatricial alopecia. Patient-reported symptoms such as itching or pain may help indicate disease activity but can also be completely absent. Presence of other indirectly related symptoms, such as sun sensitivity, can also help support a particular diagnosis (e.g., discoid lupus erythematosus, DLE).

A scalp biopsy is necessary to confirm a scarring alopecia diagnosis. The following recommendations were developed at the consensus meeting on cicatricial alopecia[8] in February 2001: One 4-mm punch biopsy including subcutaneous tissue should be taken from a clinically active area, processed for horizontal sections, and stained with hematoxylin and eosin. Elastin (acid alcoholic orcein), mucin, and periodic acid–Schiff (PAS) stains may provide additional diagnosis-defining information. A second 4-mm punch biopsy from a clinically active, disease-affected area should be cut vertically into two equal pieces. One half provides tissue for transverse cut, routine histological sections, and the other half can be used for direct immunofluorescence (DIF) studies.[11]

LYMPHOCYTIC PRIMARY CICATRICIAL ALOPECIA

Chronic Cutaneous Lupus Erythematosus (DLE) (Table 7.1)

Epidemiology

Chronic cutaneous lupus erythematosus, also known as discoid lupus erythematosus (DLE), together with lichen planopilaris (LPP), is the most common cause of inflammatory cicatricial alopecia.[9] Women are more often affected than men, and the disease is more common in adults (with the first onset typically at the age of twenty to forty years) than in children.[12–14]

Twenty-six to thirty-one percent of children with DLE and approximately 5–10% of adult

TABLE 7.1. Primary Cicatricial Alopecias

Lymphocytic primary cicatricial alopecia
-Chronic cutaneous lupus erythematosus, ordiscoid lupus erythematosus (DLE)
-Lichen planopilaris (LPP)
-Frontal fibrosing alopecia
-Graham–Little syndrome
-Classic Pseudopelade of Brocq (PPB)
-Central centrifugal cicatricial alopecia (CCCA)
-Alopecia mucinosa
-Keratosis follicularis spinulosa decalvans
Neutrophilic primary cicatricial alopecia
-Folliculitis decalvans
-Dissecting cellulites/folliculitis (perifolliculitis abscedens et suffodiens)
Mixed cicatricial alopecia
-Folliculitis (acne) keloidalis
-Folliculitis (acne) necrotica
-Erosive pustular dermatosis

patients will develop systemic lupus erythematosus (SLE).[14,15]

Patients with DLE are found to have a higher incidence of concurrent alopecia areata. Moreover, DLE has also been associated with veruciform xanthoma and papulonodular dermal mucinosis.[16]

Clinical Presentation

DLE usually presents with one or more erythematous, atrophic, and alopecic patches on the scalp. Follicular hyperkeratosis, hyperpigmentation, hypopigmentation, and telangiectasia can be present.[5,6] Hyperpigmentation is frequently found in the center of the lesion. Active lesions can be sensitive or pruritic, and the patient might report a worsening after UV exposure (Figure 7.1).

Diagnostic Procedures

Besides a scalp examination, a thorough medical history and physical examination, as well as serum antinuclear antibody titer, complete blood count, and urine analysis should be performed in every patient with DLE to rule out possible systemic involvement.[9,17] According to the consensus meeting on

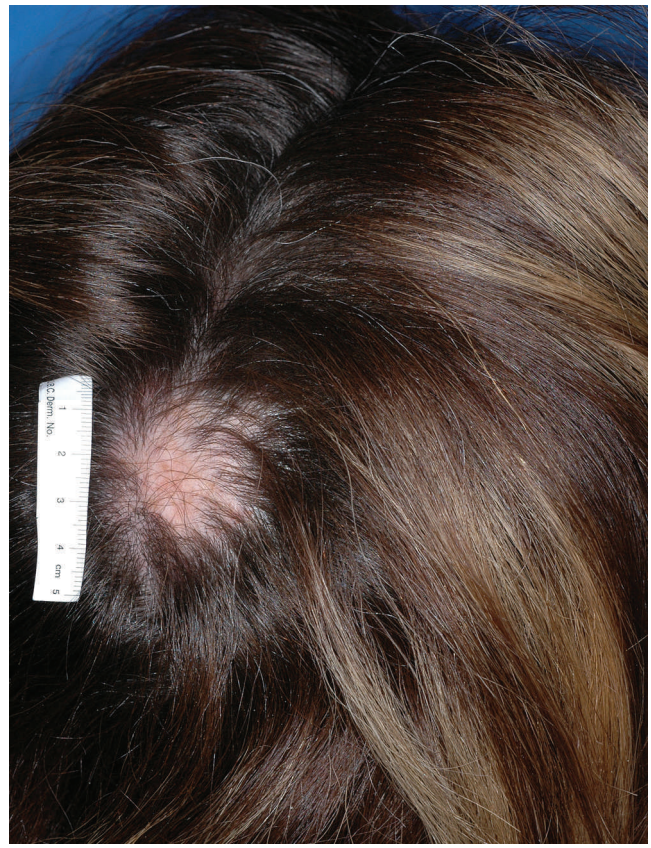


FIG. 7.1. A forty-one-year-old female patient with discoid lupus erythematosus. The lesion is devoid of follicular ostia and shows central hyperpigmentation.

cicatricial alopecia, two biopsies are needed to confidently confirm the diagnosis.

Long-standing DLE lesions are prone to develop squamous cell carcinomas[18] with a high occurrence of metastasis;[19] therefore, every hyperkeratotic or ulcerated lesion in a DLE patch should be biopsied early.[9]

Pathology

Characteristic features of early, active DLE lesions are lymphocyte-mediated interface dermatitis with vacuolar degeneration of the basal cell layer and necrotic keratinocytes, a thickening of the basement membrane, and destruction of sebaceous glands. Elastic fibers are frequently destroyed throughout the reticular dermis.[4,11] The lymphocytic infiltrate

is predominantly found not only in the upper part of the follicle but also in deeper parts of the follicle, in the interfollicular epidermis, and around the periadnexal vessels.[20–23] The hair follicle infundubula are filled with laminated keratin, which corresponds to the clinically observed follicular plugging. DIF typically shows a linear granular deposition of IgG and C3 at the dermo-epidermal junction. IgM, C1q, and rarely IgA can also be found.

Management and Treatment

Hydroxychloroquine at a dose of 200–400 mg daily in adults or 4–6 mg/kg in children has been shown to be highly effective. A baseline ophthalmologic examination and complete blood count are required before the therapy is started.[12,14] Bridge therapy with oral prednisone (1 mg/kg) tapered over the first eight weeks of treatment might be helpful in adult patients with rapidly progressive disease.[9,10]

In limited or slowly progressive DLE, intralesional triamcinolone acetonide should be used at a concentration of 10 mg/cc every four to six weeks, alone or in addition to oral therapy.[9] Intralesional triamcinolone acetonide can be used with or without topical class I or class II corticosteroids. Topical corticosteroids alone have also been shown to be effective in milder forms of DLE.[10,11,14,21] Oral acitretin and isotretinoin have also shown some effectiveness.[24,25] Immunosuppressive therapies such as mycophenolate mofetil, methotrexate, or azathioprine should only be considered if the above therapies fail.

Multimodal aggressive therapy in rapidly progressive DLE might reverse early alopecic patches and save hair follicles from the destructive process.

Hair restoration surgery can be considered in patients with burnt-out DLE. The patient should have no disease progression, no signs of inflammation such as erythema or follicular hyperkeratosis, and no symptoms such as itching, burning, or pain for at least one year without therapy. The physician and the patient have to be aware of a possible reactivation of the disease after surgery. The risk of squamous cell carcinoma in long-standing DLE lesions has to be taken into consideration and should lead to regular follow-up examinations of the affected areas. Patients with documented SLE should not be considered as hair transplant candidates.

Lichen Planopilaris

Epidemiology

Lichen planopilaris (LPP) is a follicular variant of lichen planus. Together with DLE, this is the most common cause of primary cicatricial alopecia. LPP can be categorized into classic LPP, frontal fibrosing alopecia (FFA), and Graham–Little syndrome. The typical age of onset of classic LPP is around the fifth decade, and women are more often affected than men. Extracranial lichen planus may occur in up to 28% of patients.[26–28] Frontal fibrosing alopecia predominantly affects postmenopausal women. Graham–Little–Piccardi–Lassueur syndrome is a very rare condition that predominantly affects female adults. It is characterized by lichen planopilaris of the scalp; noncicatricial alopecia of the eyebrows, axilla, and groin; and keratosis pilaris.

Lichenoid drug eruptions can be triggered by many drugs and might present as lichen planopilaris. Some of the most common drugs causing lichenoid drug eruption are gold, antimalarials, and captopril. Actinic lichenoid drug eruption is confined to sun-exposed sites. The most likely drugs to cause this are quinine and thiazide diuretics.[29,30]

Clinical Presentations of LPP

Classic LPP typically starts at the crown and vertex area. In classic LPP, the affected areas usually show perifollicular erythema and follicular hyperkeratosis. The alopecic areas of LPP are often smaller, irregularly shaped, and interconnected, which can lead to a

reticulated clinical pattern as compared to DLE. However, overlapping clinical features with those of DLE are frequently seen. Patients complain of itching, burning sensations, and sensitivity of the scalp.

FFA is characterized by a frontal, bandlike, or circumferential scarring alopecia.[4] In some cases, a few hairs are spared in the original frontal hairline. Follicular hyperkeratosis and perifollicular erythema may be found in a bandlike pattern in the frontal hairline. Alopecia of the eyebrows is also frequently seen in FFA.

Graham–Little syndrome presents with lesions of classic LPP on the scalp, nonscarring alopecia of axillae, pubic area, and eyebrows as well as keratosis pilaris of the trunk and extremities (Figure 7.2).

Diagnostic Procedures

According to the consensus meeting on cicatricial alopecia,[8] a thorough skin examination of the entire integument including the oral cavity and two 4-mm punch biopsies are necessary to confirm the diagnosis of LPP. In FFA, one 4-mm punch biopsy for horizontal sections might be sufficient to confirm the diagnosis because of its distinct clinical presentation. A systematic medical history, with review of the patient's medications, is necessary to identify possible drug-induced LPP.

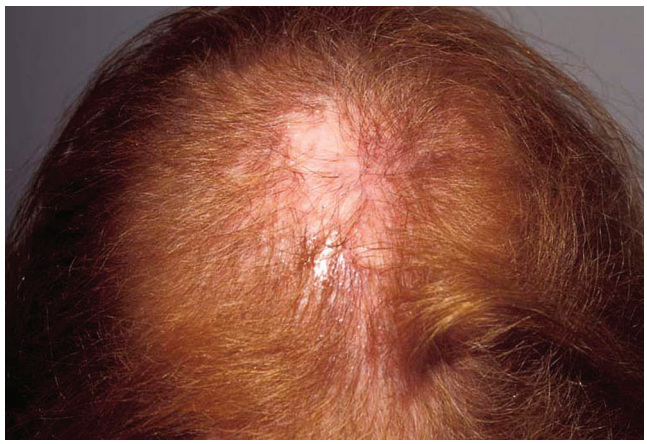


FIG. 7.2. A fifty-seven-year-old female patient with classic lichen planopilaris.

A higher incidence of hepatitis C in patients with lichen planus has been described.[31] Hepatitis C testing should be considered in patients with extensive LPP lesions.

Pathology

The three subgroups of LPP show similar histopathological features. A lymphocytic infiltrate and interface dermatitis are predominantly found in and around the upper, permanent part of the hair follicle. LPP typically presents with a loss of elastic fibers only in the area of the follicular infundibulum.[32] Sebaceous glands are often destroyed in an early stage of the disease. Unlike DLE, the vascular plexus is not affected by inflammation and mucin deposits are absent.[4] DIF typically shows globular cytoid depositions of IgM, and rarely IgA, IgG, or C3, in the dermis around the infundibulum.[33]

Management and Treatment

First-line treatment for moderately active classic LPP lesions is intralesional triamcinolone acetonide at a concentration of 10 mg/cc every four to six weeks or in combination with topical class I or class II corticosteroids.[9,25] Literature on the efficacy of oral medication is limited. Oral cyclosporine, retinoids, antimalarials, and griseofulvine[5,6,34–37] have shown to have a positive effect in patients with rapidly progressive LPP. Oral corticosteroids in the first few weeks of treatment as bridge therapy might be considered in very active cases. In FFA, a lower dose of intralesional triamcinolone acetonide (2.5–5 mg/cc), topical application of minoxidil or topical tacrolimus can be considered, although no effective treatment has been reported yet. The treatment of Graham–Little syndrome is typically similar to the management of classic LPP.

Patients should be advised about camouflage techniques, hairpieces, and wigs. Women with extensive LPP lesions on the crown and vertex benefit highly

from a well-designed hairpiece, which can look very natural, particularly if the frontal hairline is preserved and is usually more comfortable to wear compared to a full wig.

Hair restoration surgery is an option if no disease activity occurs on the scalp for at least one year without therapy. The patient has to be warned about a possible disease recurrence and limited graft survival. Patients with clinically very obvious lesions might be very grateful for the cosmetic improvement and might accept lower hair density and even a mild flare of their LPP after surgery.

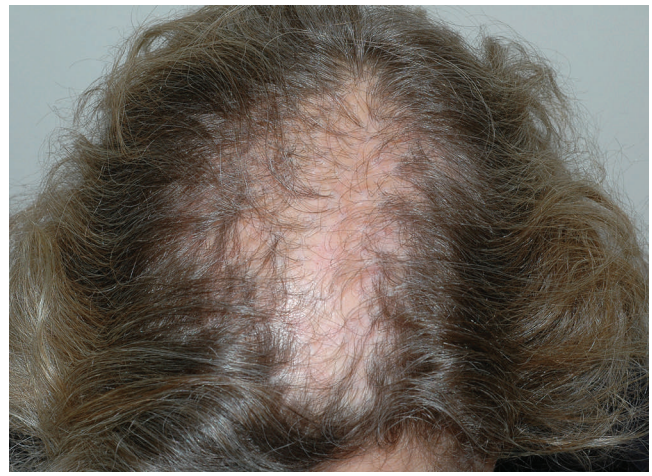


FIG. 7.3. A sixty-five-year-old female patient with pseudopelade of Brocq.

Classic Pseudopelade of Brocq

Epidemiology

Pseudopelade of Brocq (PPB) is classified as an idiopathic lymphocytic primary cicatricial alopecia that predominantly affects the scalp. It is the second most common cause of primary cicatricial alopecia.[27] Women between thirty and fifty years of age are most frequently affected.

Clinical Presentation

PPB usually affects the vertex and occipital area of the scalp. It presents with small, flesh-toned alopecic patches with irregular margins. This pattern has been described as "footprints in the snow."[38] PPB can also present as a noninflammatory centrifugally spreading patch of alopecia, which might be seen as a variant of central centrifugal cicatricial alopecia (CCCA) in Caucasians. Follicular hyperkeratosis and perifollicular or diffuse erythema are mostly absent.[6] Clinically, the features may overlap with LPP (Figure 7.3).

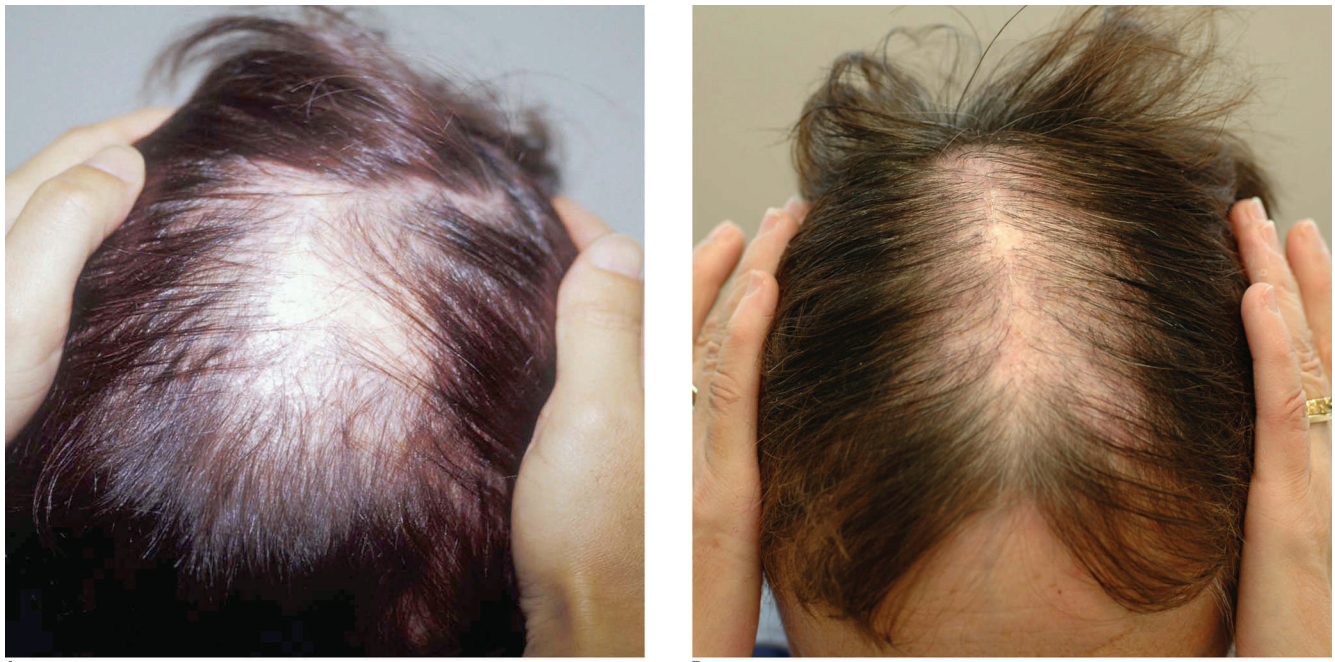
Pathology

Early PPB lesions typically show a sparse-to-moderate lymphocytic infiltrate around the follicular infundibulum with a complete destruction of the sebaceous glands.[39] In later disease stages, hair follicles are completely replaced by fibrous tracts. Unlike DLE and LPP, interface dermatitis is usually absent, and the elastic fibers are preserved and thickened in PPB.[32]

Management and Treatment

Intralesional triamcinolone acetonide at a concentration of 10 mg/cc every four to six weeks in combination with topical corticosteroids is the treatment of first choice. Hydroxychloroquine, oral prednisone, and isotretinoin have shown some effectiveness in treating PPB.[6,27,40]

Hair restoration surgery is an option for PPB if the condition is stable without treatment and the patient has a suitable donor supply. Since clinical signs and symptoms of inflammation are frequently absent, activity of the disease is sometimes difficult to appreciate. Photographs, hair pull test, and measurements of the size of the lesions can help to identify active areas of disease. A small test area with a limited number of grafts (twenty to thirty grafts per cm^2 with a maximum total of 100 grafts) six months to one year before a larger session is helpful in minimizing the risk of disease progression and assuring the success of a hair transplant procedure (Figure 7.4A,B).



A B

FIG. 7.4. A fifty-six-year-old female patient with classic burnt-out pseudopelade of Brocq A) before hair restoration surgery, B) two years after the first session.

Central Centrifugal Cicatricial Alopecia

Epidemiology

Central centrifugal cicatricial alopecia (CCCA) is classified as a lymphocytic primary cicatricial alopecia primarily affecting women of color. It remains unclear as to exactly which of the following most contribute to its formation: chemical processing, heat, traction, or other traumas.[21,41] CCCA can rarely be seen in Caucasians (sometimes called "central elliptical pseudopelade") and African-American men. Due to clinical and histopathological similarities, it has been debated whether CCCA is a variant of Pseudopelade of Brocq.

Clinical Presentation

CCCA presents with a skin-colored patch of scarring alopecia on the crown, gradually progressing centrifugally to the parietal areas. Perifollicular hyperpigmentation and polytrichia might be present.[9] Patients may complain of itching, tenderness, and "pins and needle" sensations[42] (Figure 7.5).

Pathology

Limited studies suggest that histopathological features of CCCA seem to be similar to those of PPB.[5,21]

Management and Treatment

Topical corticosteroids and tetracycline have shown to be effective in active progressive cases.[21] Since a

FIG. 7.5. A thirty-five-year-old female patient with central centrifugal cicatricial alopecia.

multifactoral etiology is debated for CCCA, some dermatologists recommend a switch to more natural, less traumatizing, hair care practices.[6,11,43] Wigs and hairpieces can help camouflage the alopecia and are frequently used by women with CCCA.

Hair transplant surgery is possible in a "burnt-out" stage and might provide a good cosmetic outcome in patients with very curly hair even with lower hair density.

Alopecia Mucinosa

Alopecia mucinosa (AM) can present as indurated, well-demarcated, erythematous or skin-colored patches of scarring or nonscarring alopecia that can be accompanied by diffuse hair loss[44] and alopecia of the eyebrows.[45] AM can clinically be mistaken for alopecia areata or other cicatricial hair loss conditions. Grouped follicular papules, follicular cysts, and follicular hyperkeratosis might be present in some cases. Lesions on the neck, the trunk, and the extremities have been described.[45] Early lesions of AM show mucin deposition in the outer root sheath and replacement of the entire pilo-sebaceous unit by pools of mucin in more advanced lesions.[4,45] By strict definition, AM is not a primary cicatricial alopecia because the hair follicle is not replaced by a true scar.[4]

AM can occur idiopathically or in the setting of cutaneous T-cell lymphoma or mycosis fungoides.[46] Cell atypia and monoclonal populations of T-lymphocytes can be present in the idiopathic form of AM as well as in the latter form.[46]

Management and Treatment

A complete workup is necessary to rule out an underlying malignancy such as mycosis fungoides and Sézary syndrome, its advanced endpoint. Oral corticosteroids, minocycline and isotretoin, have been shown to be effective. Topical and intralesional corticosteroids, dapsone, indomethacin, and light therapy have also been used with variable outcomes.[47]

Excision of stable lesions is a possible treatment approach. Hair transplant surgery should only be considered in patients without underlying lymphoproliferative disease or cell atypia and should be reserved for exceptional cases if an excision is not possible or alone does not provide an acceptable cosmetic result.

Keratosis Follicularis Spinulosa Decalvans

Keratosis follicularis spinulosa decalvans (KFSD) together with keratosis atrophicans faciei (also called ulerythema oophrygenes or keratosis pilaris rubra atrophicans faciei) and atrophodermia vermiculata belongs to a heterogeneous group of congenital follicular keratinizing disorders. KFSD is X linked and usually develops during adolescence and mostly presents with scarring alopecic patches, follicular hyperkeratosis, and rarely pustules.[4] Eyebrow and eyelash involvement can also be present.

KFSD shows an inflammatory infiltrate consisting of lymphocytes and neutrophils in the infundibular area in early lesions. Later, the infiltrate is predominantly lymphocytic and the follicle is eventually replaced by fibrous tissue.

The condition might improve with age. Careful calculation of risks and benefits in the treatment of children, teenagers, and young adults is important. Topical and intralesional corticosteroids as well as oral retinoids have shown some effectiveness.[48] Hair restoration surgery can be considered in adult patients with long-standing stable disease.

NEUTROPHILIC PRIMARY CICATRICIAL ALOPECIA

Folliculitis Decalvans

Epidemiology

Approximately, 11% of all primary cicatricial alopecia cases are diagnosed with folliculitis decalvans

(FD).[5,27] FD predominantly occurs in young and middle-aged adults with a slight preference of the male gender. FD seems to occur more frequently in African-Americans compared to Caucasians.[5,27]

A bacterial infection involving *Staphylococcus aureus* (*S. aureus*), in combination with hypersensitivity reaction to "superantigens," and defect in host cell–mediated immunity have all been suspected as possible pathogenetic factors.[5,49,50]

Clinical Presentation

FD frequently starts at the vertex area of the scalp with erythematous alopecic patches, follicular pustules, and follicular hyperkeratosis. Tufted folliculitis is typically found not only in FD but can also occur in other cicatricial inflammatory alopecias. Tufted folliculitis is characterized by multiple hairs (five to fifteen) emerging from one single, dilated follicular orifice. In older lesions, pustules might be absent, but progressive scarring may still continue. An overlap with acne keloidalis is possible since some patients with acne keloidalis not only develop cicatricial lesion on the nape of the neck but also develop progressive cicatricial alopecia that resembles FD in other areas of the scalp. Patients frequently complain of pain, itching, and/or burning sensations (Figure 7.6).

Pathology

Early lesions are characterized by keratin aggregation in the infundibulum with numerous intraluminal neutrophils, as well as an intrafollicular and perifollicular neutrophilic infiltrate.[4–6] Sebaceous glands are destroyed early. In advanced lesions, the infiltrate may consist of neutrophils, lymphocytes, and plasma cells and extend into the dermis.[6,9] Hair shaft granulomas with foreign body giant cells can frequently be found.[5,6] In end-stage lesions, follicular and interstitial dermal fibrosis as well as hypertrophic scarring can be observed.[6]

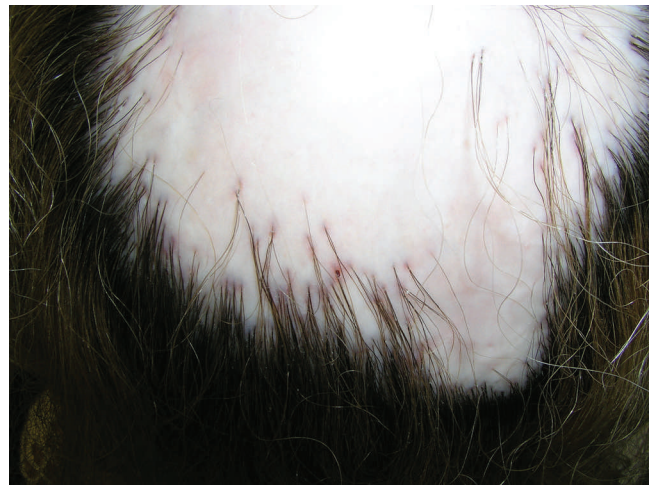


FIG. 7.6. A forty-six-year-old female patient with long-standing extensive folliculitis decalvans. The scarred area is thickened, the margins show follicular tufting and perifollicular erythema.

Management and Treatment

Bacterial cultures with the testing of antibiotic sensitivities are recommended. Eradication of *S. aureus* with minocycline, erythromycin, cephalosporins, and sulfamethoxazole–trimethoprim has shown some effectiveness. Relapse can often be observed after the antibiotics are discontinued,[10,49,51] in which case, the patient might have to stay on low-dose antibiotics for many years. Rifampin in combination with clindamycin has shown good response; however, this combination shows a higher incidence of side effects.[49,52] Oral fucidic acid alone or in combination with other agents has also been shown to be effective in some patients.[53] Oral therapy should be combined with topical antibiotics such as mupirocin, 1.5% fusidic acid and 2% erythromycin,[52,53] and antibacterial cleansers. Intralesional triamcinolone acetonide at a concentration of 10 mg/cc every four to six weeks might help to reduce the inflammation and reduces symptoms such as itching, burning, and pain.[10,27] Intranasal eradication of *S. aureus* with topical antibacterial agents has been described to be useful.[6]

Treatment of FD in general is difficult, and disease activity can be noted over many years. Both flare-ups of the condition as well as initial manifestations of FD have occurred after scalp and hair restoration surgery. Therefore, hair transplant surgery should only be considered for exceptional cases in which the patient did not show any signs of inflammation for several years without any treatment. The risk of reactivation after surgery might be much higher in FD compared to other inflammatory cicatricial alopecias. If surgery is considered as a management of burnt-out FD, transplantation of a small test area one year before a larger session is mandatory (Figure 7.7).

Dissecting Folliculitis

Epidemiology

Dissecting folliculitis (DF) (also known as dissecting cellulitis or perifolliculitis capitis abscedens et suffodiens of Hoffman) is related to acne conglobata and hidradenitis suppurativa. These three diseases have been described as the follicular occlusion triad. DF predominantly occurs in young men between eighteen and forty years of age.[9] African-American men seem to be more commonly affected compared to Caucasian men. The pathogenesis of DF may include follicular occlusion, seborrhea, androgens, and secondary bacterial overpopulation as well as an abnormal host response to bacterial antigens.[54–61]

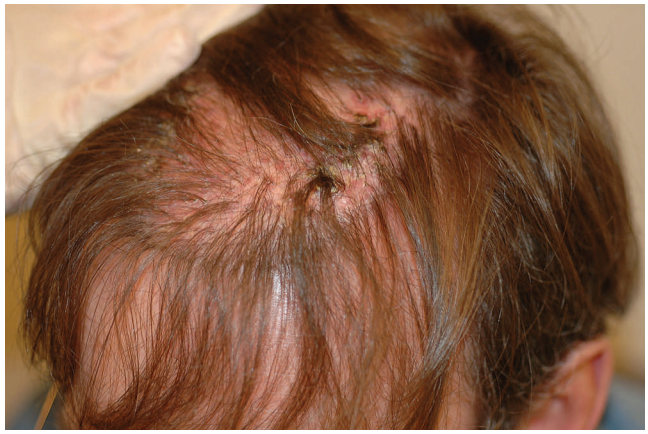


FIG. 7.7. A forty-three-year-old male patient who underwent hair restoration surgery in 1984 (four sessions, using punch graft technique). Twenty-one years after the surgery, he developed folliculitis decalvans, which was restricted to the punch grafts.

Clinical Presentation

DF typically presents with fluctuating nodules, abscesses, and sinuses, which frequently show spontaneous discharge of pus, as well as with erythematous, follicular papules, and pustules. Initial lesions are mostly found on the vertex and occipital scalp. Multifocal lesions can form an intercommunicating ridge, and seropurulent exudates can be discharged when pressure is applied to one region of the scalp. The lesions can be pruritic and tender. Chronic and relapsing courses may result in cicatricial alopecia, which can occur as hypertrophic or keloidal scars.[61]

Pathology

The main histological feature is an intrafollicular and perifollicular neutrophilic infiltrate with follicular occlusion in early lesions.[4] In more advanced stages, interconnecting sinus tracts lined by squamous epithelium, follicular perforation, and perifollicular and deep dermal abscesses are typical findings.[4,6,23]

Management and Treatment

Multimodal treatment has been reported with successful results; this involves the use of systemic antibiotics, such as minocycline, tetracycline, cloxacillin, erythromycin, cephalosporin, or clindamycin, intralesional corticosteroids, and oral prednisolone.[62,63] The benefits of systemic antibiotics are most likely due to their anti-inflammatory effects rather than to their antibacterial action. Isotretinoin at a dose of 0.5–1 mg/kg/day has shown prolonged remission.[64,65] Incision and drainage of therapy-resisted, painful nodules, marsupialization with curettage of the cyst wall, complete scalp extirpation with skin grafting

have been reported but should be an exception for extreme and therapy refractory cases.[65,66]

Scalp reduction can be considered for smaller burnt-out areas. Hair restoration surgery might be especially difficult because of hypertrophic or keloidal scar tissue. A small test area can help to estimate graft survival.

MIXED PRIMARY CICATRICIAL ALOPECIAS

Acne Keloidalis Nuchae

Acne keloidalis nuchae (AKN) predominantly occurs in young black men aged fourteen to twenty five. This idiopathic primary cicatricial alopecia might be triggered by trauma (shirt collars) or infection (Demodex or bacteria). Clinically, AKN presents with skin-colored follicular papules, pustules, and plaques as well as keloid-like scarred lesions in the occipital scalp. Histologically, acne keloidalis is characterized by an acute inflammation with neutrophilic or lymphocytic infiltration and chronic granulomatous inflammation around the isthmus and the lower infundibulum. Treatment is usually difficult and protracted. Monthly intralesional triamcinolone acetonide (10–40 mg/ml) alone or combined with topical 2% clindamycin or oral (tetracyclines) antibiotics is the treatment of first choice.[5,11,21,67,68] Class I or II topical steroids alone or in combination with topical antibiotics for mild cases of AKN as well as cryotherapy and laser therapy have shown some success. Surgical excision of extensive keloidal lesions may be considered but should be reserved for therapy refractory, extensive, and symptomatic cases. Hair transplantation is not recommended for AKN because any surgical procedure on the scalp may aggravate the disease and low graft survival can be expected when transplanting into hypertrophic scars. Moreover, the lesions are usually located in the donor area (Figure 7.8).

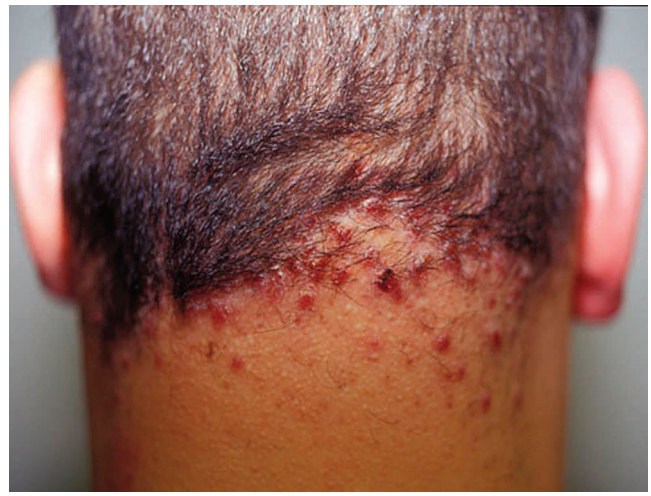


FIG. 7.8. A thirty-three-year-old male patient with acne keloidalis nuchae.

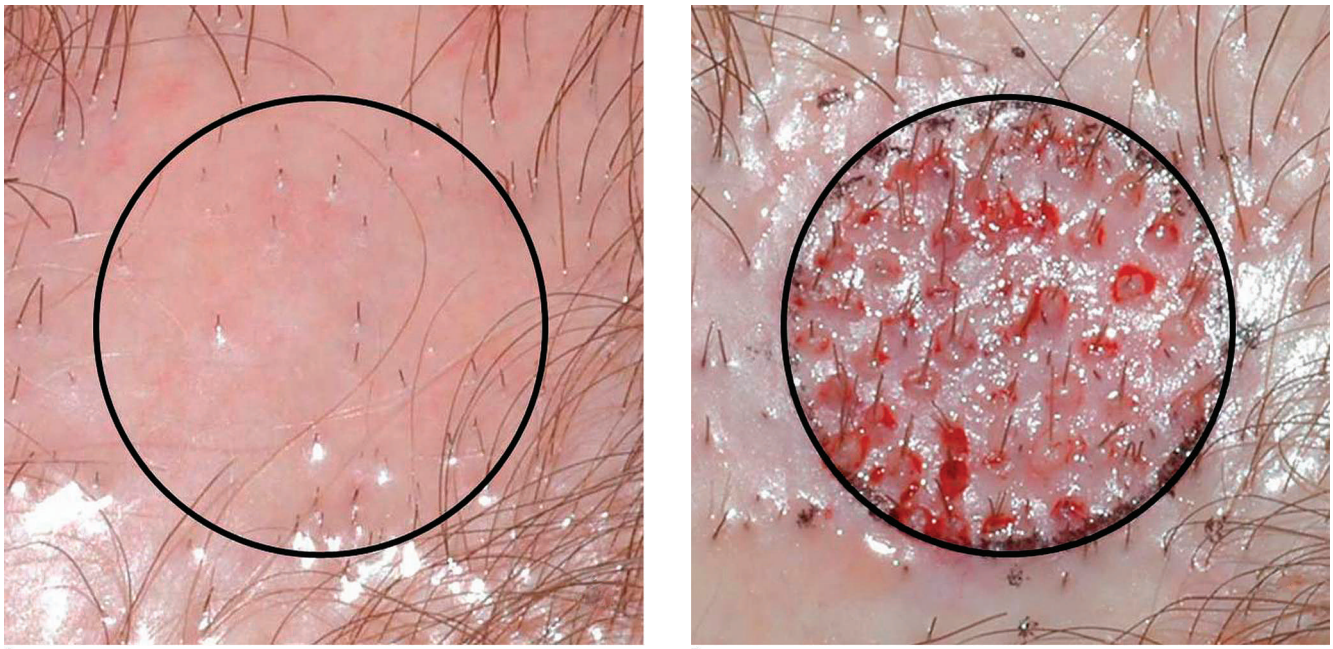
Acne Necrotica (Varioliformis)

Acne necrotica varioliformis is a very rare, chronic condition that predominantly occurs in adults. Frontal and parietal scalp, as well as seborrheic areas of the face, are most commonly affected. Acne necrotica presents with umbilicated, pruritic, or painful papules that undergo central necrosis. The condition leaves varioliform or smallpox-like scars.[69,70] Histological examination shows a suppurative, necrotic, infundibular folliculitis with lymphocytic or mixed inflammatory infiltrate.[70]

Oral antibiotics, isotretinoin, intralesional, or topical corticorsteroids have shown success.[71] Excision of larger scarred areas can be considered. Hair transplantation is not recommended.

Erosive Pustular Dermatosis

Erosive pustular dermatosis is an uncommon disorder predominantly occurring in elderly women.[72,73] The characteristic lesion is a suppurative, necrotic, erosive papule or plaque.[72,74] Histology of early lesions is nonspecific, but older lesions show an extensive, chronic, mixed inflammatory infiltrate in the dermis and later dermal fibrosis. Treatment includes class I or II topical steroids with or without topical antibiotics,



A B

FIG. 7.9. Example of the test area in primary cicatricial alopecia (1.77 cm^2, 31 FU grafts/cm^2): (A) before surgery and (B) directly after surgery.

systemic antibiotics, and oral isotretinoin.[72,74] Hair restoration surgery can be considered for burnt-out lesions.

Summary

Primary cicatricial alopecia can result from various inflammatory follicular scalp disorders that lead to the destruction of the pilosebaceous unit.

The etiology of this rare group of scalp diseases is, for the most part, unknown. Treatment can be difficult and protracted because many primary cicatricial alopecias are chronic or recurrent. Early diagnosis and aggressive treatment is crucial to prevent further hair loss. Patients should be advised about camouflage techniques including wigs and hairpieces. Hair restoration surgery is an option for burnt-out stages, especially for lymphocytic primary cicatricial alopecia. A small test area one year before a bigger session and a lower graft density is recommended. The patient has to be educated about the condition and warned about possible disease recurrence and limited graft survival.[75] Hair transplantation in neutrophilic cicatricial alopecia should be only considered in exceptional cases (Figure 7.9A,B).

SECONDARY CICATRICIAL ALOPECIA

In secondary cicatricial alopecias, permanent hair loss is caused by various other scalp conditions not related to the hair follicle. In these conditions, the primary event develops outside the follicular unit, and this leads to incidental destruction of the follicle. Possible causes are congenital defects, trauma, inflammatory conditions, infections, neoplasms, and rarely drugs (see Table 7.2). Permanent, chronic traction alopecia and scars from surgery can be considered secondary scarring alopecias as well.

Although an exact history is helpful, diagnosis in early stages can sometimes be made based on specific clinical and histologic features of the underlying disorder. Associated signs and symptoms and other diagnostic procedures may aid in the diagnosis. In their end stage, many true scarring alopecias show no specific

TABLE 7.2. Secondary Cicatricial (Permanent) Alopecias, a Classification Based on Etiology

Secondary cicatricial (permanent) alopecias

1. Genodermatoses and developmental defects with permanent alopecia
(excluding congenital Hypotrichoses and atrichias)
- -Ectodermal dysplasias
- -Aplasia cutis congenita
- -Incontinentia pigmenti
- -Porokeratosis mibelli
- -Ichthyosis
- -Hereditary epidemolysis bullosa
- -Meningocele
- -Organoid nevi (sebaceous, epidermal)
- -Vascular malformations
- -Darier's disease
- -Fibrodysplasia

2. Physical and chemical injury
True cicatricial
- -Mechanical trauma and pressure
- -Scratching
- -Burns
- -Freezing
- -Chemical injury
- -Insect bites

Pseudo-cicatricial
- -Radiation

3. Infections
True cicatricial
Bacterial
- -Carbuncle
- -Leprosy
- -Tertiary syphilis
- -Tuberculosis-lupus vulgaris

Viral
- -Zoster
- -Varicella

Tinea capitis
- -Kerion
- -Favus

Protozoic
- -Leishmania

4. Inflammatory dermatoses
Pseudo-cicatricial
- -Psoriasis (rarely)
- -Pityriasis amiantacea
- -Arteritis temporalis
- -Pyoderma gangraenosum
- -Graft-vs.-host disease

Sclerosing
- -Morphea
- -Scleroderma en coup de sabre and parry Romberg syndrome
- -Lichen sclerous et atrophicus

Bullous
- -Cicatricial permphigoid
- -Porphyria cutanea tarda
- -Acquired epidermolysis bullosa

Displacement alopecias
Granulomatous
- -Sarcoidosis
- -Granuloma anulare
- -Necrobiosis lipoidica (including miescher's granulomatosis)

5. Drugs

6. Neoplastic
Displacement alopecias
Infiltration
- -Lymphoproliferative disorders
- -Mastocytosis

Benign solid neoplasms
- -Cysts
- -Vascular tumors
- -Adnexal tumors
- -Plasmocytoma

Malignant solid tumors
- -Angiosarcoma
- -Dermatofibrosarcoma protuberans
- -Malignant fibrous histiocytoma
- -Melanoma
- -Squamous cell carcinoma
- -Basal cell carcinoma

Metastasis (alopecia neoplastica)
- -Lymphoma

Data adapted from Ref 93.

changes, and detection of the underlying disorder may be difficult. Follicular orifices are lost clinically, and histological examination shows extensive scarring with fibrosis, loss of elastic fibers, and adnexal structures.

Treatment is specific in active conditions, whereas in localized end-stage lesions, specific medical treatment is no longer efficient and hair restoration surgery techniques become the mainstay of therapy.

Developmental Defects

Aplasia Cutis Congenita

Aplasia cutis congentia (ACC) is a localized congenital absence of epidermis and dermis, often including

the subcutis. It represents a physical finding that may result from intrauterine disruption of skin development. Sixty to eighty-five percent of cases are localized on the scalp, mostly in the midline. The skull is affected in 20–30% of these cases. Larger, irregular lesions may also involve the dura and leptomeninges. Dilated scalp veins may also be present. There is a single ACC lesion in 70% of cases.

Usually, it is well delineated and measures 0.5–10 cm in diameter. Associated ectodermal dysplasias and malformations have to be ruled out. An underlying cranial defect should always be radiologically excluded. In most cases, the scarred lesion is completely excised at an older age and/or treated with hair transplantation.

Cleft Lip

In this congenital defect, moustache reconstruction can be a very rewarding procedure to cover the scar, especially in cultures where a moustache is socially highly accepted. The use of micrografts and follicular units provides the best esthetic results.[76]

Physical and Chemical Injury

Mechanical Trauma

Besides prolonged traction, the most common form of mechanically induced cicatricial alopecia results from scalp injuries, such as accidents with pulling of hair and trauma to the scalp skin.

Cicatricial alopecia has been reported as a result of birth trauma, long-lasting operations, or unconscious states without change in position. In postoperative, pressure-induced alopecia, the lesion usually presents as an oval hairless patch on the occipital scalp.

Burns

Third-degree burns can lead to scarring alopecia. Usually, other body parts are affected as well. Development of cancer in burn scars has been reported.

Chemical Injury

Acids, alkalis, and metallic salts may cause irreversible scalp damage, depending on their concentration and the duration of exposure. Once scarred areas have developed, they are usually well demarcated and irregularly shaped.

Alopecia resulting from injury can be successfully restored. For smaller areas, scalp reduction (with or without use of a scalp expander) and/or hair transplantation can be performed.[77–80] With hair transplantation, especially when micrografts (follicular units) are used, excellent results can be achieved without extensive surgery if the patient has a sufficient donor supply.[81] Pretreatment of any hypertrophic scar with carbon dioxide laser has also been used.[82]

Radiation

Radiation therapy with X-rays and ionizing rays has been used to treat intracranial and skull tumors as well as neoplasms of the scalp. Chronic radiation dermatitis with permanent alopecia can develop.

Often, hair follicles are not completely lost, but the hair appears finer and sparser. Depending on field size, the areas can be circumscribed or even mimic pattern hair loss.

Once scarring from radiation or other traumas has occurred, surgery is a therapeutic option. For small areas, surgery and flap skin transplantation can be performed.[83] Hair transplantation has been performed in selected patients with cosmetically acceptable outcome.[84] Regular follow-ups are mandatory because of the increased risk of epithelial tumor formation.

Cosmetic Surgery

Especially after face-lift surgery (rhytidoplasty), hair transplantation is an excellent option to camouflage any resulting iatrogenic scars and to reconstruct sideburns.[19] Hair transplantation has also been used

to restore eyebrow loss after inadequate chemical peeling.

Infectious and Inflammatory Disorders

Fungal Infection

A kerion is a deep, highly inflammatory fungal infection of the scalp. It can cause scarring alopecia and should therefore be aggressively treated.

It presents as a highly suppurative, boggy, nodular deep folliculitis with fistulas, and pus secretion from several openings is present. Fungal infections can also present as diffuse, dry, silvery scale mimicking psoriasis. Systemic antifungal treatment is indispensable to treat both of these presentations. Surgical intervention should only be considered in exceptional cases but can be helpful to restore scarred areas after the infection has been successfully treated.[85–87]

Morphea and Facial Hemiatrophy

Morphea is a localized form of scleroderma that can cause cicatricial alopecia. A linear form of morphea affecting the frontal scalp has been termed linear scleroderma en coup de sabre. Ocular and neurological abnormalities can be associated (Figure 7.10).

Linear scleroderma represents the most common cause of cicatricial alopecia in early childhood.

It may also be a milder presentation of the rare hemi-facial atrophy (Parry–Romberg syndrome), and overlaps have been observed. In this condition, subcutaneous fat, muscle, and bone can be affected and the skin is only secondarily affected without prominent sclerosis. Flap and expander techniques are surgical treatment options.[88–91]

Neoplastic

Various tumors can affect the scalp, either primarily or as metastases from elsewhere in the body. After treatment with excision or radiation, hair restoration surgery may not only cosmetically cover the remaining scar but can also delay detection of recurrence.

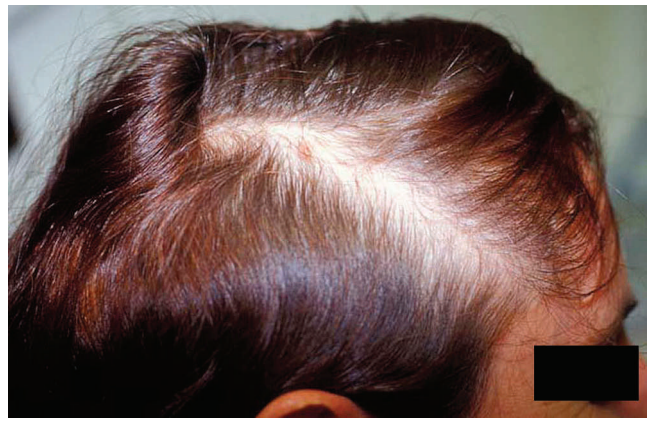


FIG. 7.10. A thirty-nine-year-old female patient with linear scleroderma en coup de sabre.

It is important to keep in mind that some sclerosing tumors, especially basal cell carcinoma, may mimic a common scar. If there is any doubt about the etiology of the scar, a biopsy should be performed.

Summary

Secondary cicatricial alopecia can result from various nonfollicular scalp conditions leading to destruction of the pilosebaceous unit.

Trauma, deep infections, or tumors can be localized only on the scalp and often lead to alopecia. Other alopecic lesions may result from an inflammatory or genetic skin condition with a variable frequency of scalp involvement and alopecia. Although some are true dermatoses, skin and scalp lesions are a marker for systemic disease in others.

If loss of follicular ostia, atrophy, sclerosis, or signs of inflammation are present; a deep biopsy, preferably at the active edge of the lesion may help to find the underlying specific cause. A thorough examination and a careful history as well as other tests may aid in the diagnosis.

In active disease, sufficient and timely treatment may prevent progression of the alopecia and possible

systemic involvement. Surgical management, especially hair transplantation, is an option in end-stage lesions, and patients are usually very satisfied.

HAIR RESTORATION SURGERY IN CICATRICIAL ALOPECIA

General rules apply to hair restoration surgery in scarring alopecia. One must make a definitive diagnosis, showing absolutely no disease activity. There should be careful preoperative evaluation of scalp thickness and blood supply. A test procedure in a small area (1.5–2 cm^2) to assess potential graft survival, eight to twelve months before a bigger session, can be performed. Hair transplantation can be combined with scalp reduction, sometimes with the use of expanders.

In the first procedure, hairs should be placed at lower densities (10–20 FU/cm^2). More hairs can be added in subsequent sessions with longer intervals (eight to twelve months minimum). The use of epinephrine should be minimized because it might decrease the anyway limited blood supply and therefore graft survival. Some surgeons even use 2–5% topical minoxidil solution one week preoperatively or pentoxyphylline 400 mg t.i.d. for two weeks before surgery to increase the blood supply and the tissue oxygenation.[92] Although some authors recommend larger grafts, others state that small follicular unit grafts have the highest chance of survival. We recommend small incisions using follicular unit grafts, transplanted at a lower density than would be performed with pattern hair loss.

Patients with cicatricial alopecia usually accept less than full growth and are very grateful for any cosmetic improvement. Every patient with cicatricial alopecia should be advised about hair restoration surgery as a possible treatment option.

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Chapter 8

EYELASH TRANSPLANTATION

by

Alan J. Bauman, MD

BACKGROUND

Throughout time, beauty has been enhanced by the outlining of one's eyes and lengthening of one's lashes. The Greeks, Romans, ancient Egyptians, and people of the Middle Ages and Elizabethan times, including Queen Elizabeth herself, have used *kohl* – a dark substance made of powdered antimony sulfide, or similar substances, "to paint" around the eyes, enhancing their appearance.

The first eyelash mascara (*it: maschera*, to mask) was formulated in 1913 by T. L. Williams, a chemist, who invented the product for his sister Mabel, so she could easily lengthen, darken, and thicken her lashes. Initially, he sold and shipped his product by mail and later set up a company called Maybelline (derived from his sister's name and Vaseline, a key ingredient). In the 1920s, actress Greta Garbo darkened her long, pale lashes with mascara, inspiring other women to do the same. Fake, glued-on strip lashes also became popular around this time. In 1957, cosmetic giant Helena Rubenstein promoted mascara in a slender tube with a convenient brush applicator. Soon after, she created the first waterproof version. Mascara has no substitute and is now used by three of four American women. At $5–$35 per tube, this makes up an annual $500 million in US retail sales.

Recently, individual false eyelash "extensions," a process performed by cosmetologists, has seen a surge in popularity. New cosmetic "eyelash conditioners," promising eyelash enhancement, have also become available. Although eyelash transplantation has been described in the medical literature in the early 1900s, it makes up a small but increasing percentage of all procedures performed by hair restoration physicians. More recently, cosmetic and reconstructive eyelash transplants have been demonstrated in Live Surgery Workshop settings (Figure 8.1). In 2006, approximately 1.4% of all hair transplant procedures were performed on eyelashes versus 0.35% in 2004.[1–3] Recent trends in patient inquiries in the author's practice also support a growing demand for this cosmetic procedure.

HISTORY OF EYELASH TRANSPLANTATION[4]

A basic understanding of eyelid anatomy is essential for performing this procedure (Figure 8.2). The documented history of eyelash transplantation begins about ninety years ago. In 1914, Dr. Franz

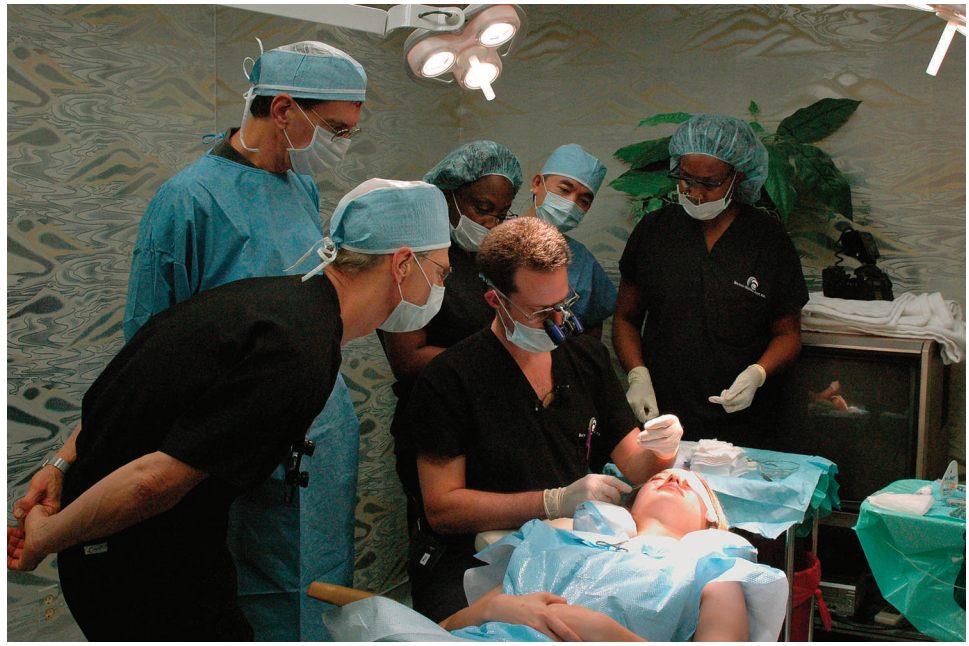

FIG. 8.1. A thirty-year-old Asian female receiving an eyelash transplant at the First Regional ISHRS Live Surgery Workshop on Eyelash Transplantation by Alan J. Bauman, MD, held in Los Angeles in October 2006. The patient is comfortably reclined and the surgeon is using 3.3× Zeiss surgical loupes.

Krusius, a German physician, published his technique for reconstruction of lost eyelashes by harvesting scalp hair with a small punch and transplanting donor hair into the eyelid with a needle that he designed.[5] A version of the Krusius needle is still used today. Also still in use today is a version of a technique published by German physician Dr. P. Knapp in 1917; in this method, one inserts into the eyelid border a composite free graft strip from the eyebrow.[6]

Sasagawa reported a hair shaft insertion method in 1930.[7] Fujita described reconstruction of the eyebrows via grafting methods using an injection needle.[8] In 1980, Marritt published his technique for transplantation of single donor hairs from the scalp into the eyelid for eyelash reconstruction.[9] In that same year, Flowers presented a "pluck and sew" technique of eyelash reconstruction at the American Society of Aesthetic Plastic Surgeons in Orlando, FL, that was eventually published in the literature.[10]

A revised version was described by Gandelman.[11] Leaving the hair as long as possible, donor follicles are separated from an elliptical donor strip or a circular punch harvest using a "pluck" method from below. Under high-powered magnification, downward tension is applied from just below the bulb of the follicle while sharp upward dissection is used to separate the follicle from its superficial attachments to the surrounding tissue. Once the follicle is released from the underside of the epidermis, continued downward tension pulls the follicle with the long hair attached completely through the skin. The resulting long hair (with follicle attached) is threaded through a French eye needle that is used to position the follicle in the eyelid in a one-step "sewing" motion. The follicle is kept well hydrated throughout the entire process.

A variety of eyelash harvest/transplantation techniques have been described in the literature. They are listed in Table 8.1.

PATIENT SELECTION

Eyelash transplantation can be used for cosmetic enhancement as well as for reconstruction. Appropriate candidates should display a good understanding of the risks, benefits, alternatives, and common

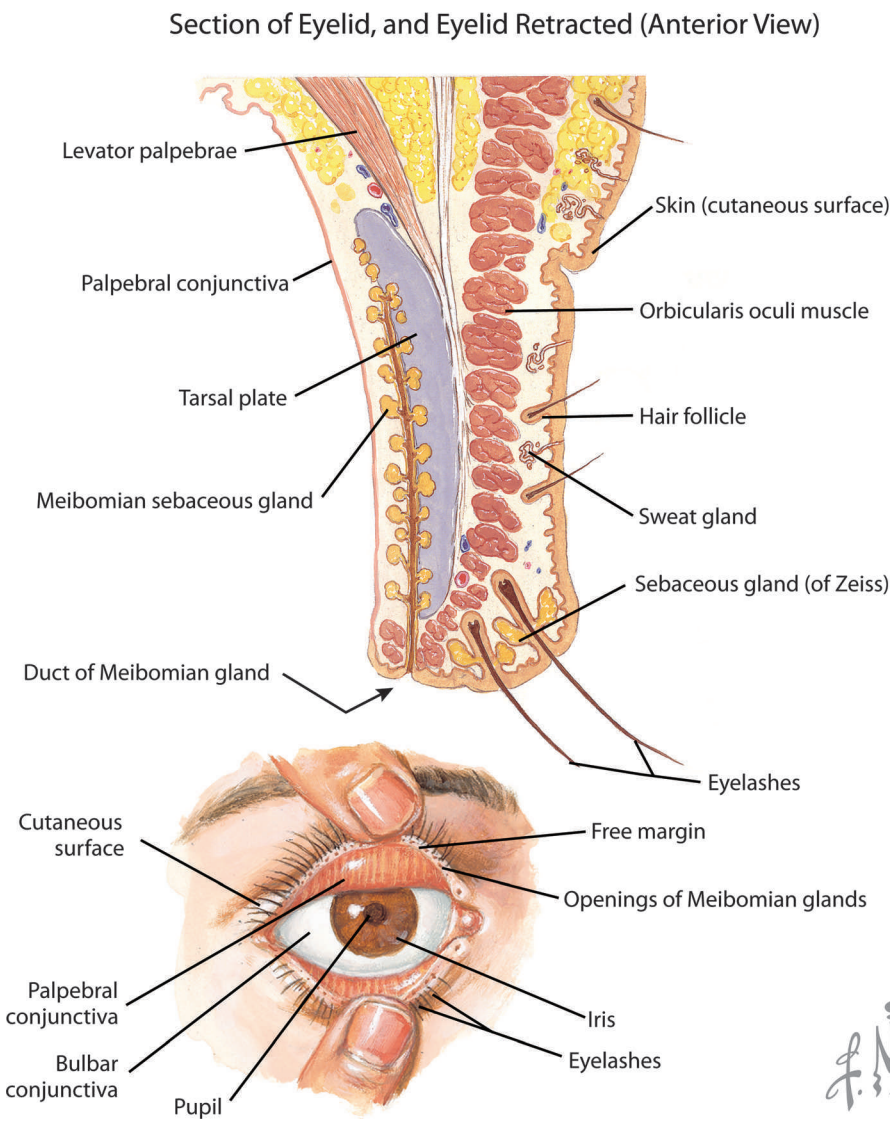

FIG. 8.2. Section of eyelid and eyelid retracted (lateral view).

sequelae, and have realistic expectations of the outcome of the procedure. As with all cosmetic procedures, candidates for eyelash transplantation should also be carefully screened for body dysmorphic disorder. Patients with a history of trichotillomania or obsessive pulling of eyebrows or eyelashes can benefit (Figure 8.3).

Since donor hair follicles are being harvested from the scalp, the patient must be made aware that the color, curl, and caliber of the harvested scalp follicles will produce the same characteristics in the lid. Exceptionally coarse, straight hair and exceptionally kinky–curly hair may be less suitable for eyelash transplantation due to the necessary management of the resulting hair growth. Patients should be well informed regarding the long-term need for routine trimming and curling (as well as perhaps perming and tinting) of the transplanted lashes. Patients unwilling to commit to the necessary maintenance of transplanted lashes should be excluded from undergoing the procedure. Several successful before and after results are shown in Figures 8.4–8.7.

The eyelids should be free from any visible inflammation and anatomical abnormalities, especially in

TABLE 8.1. Eyelash Transplantation Techniques

- Strip grafts from eyebrows
- Strip composite sideburn grafts[12]
- Donor strips from scalp, from which donor follicles are obtained
- Pedicled flaps from eyebrows
- Single follicles harvested from donor area and inserted in the eyelid with a French eye needle
- Single follicles harvested from donor area and inserted through a curved 18-g needle placed into the lid[13]
- Use of automated needles[14]
- Reverse follicular extraction of long hair[15]
- Direct placement of grafts into overlapping coronal slits in the eyelid[16,17]

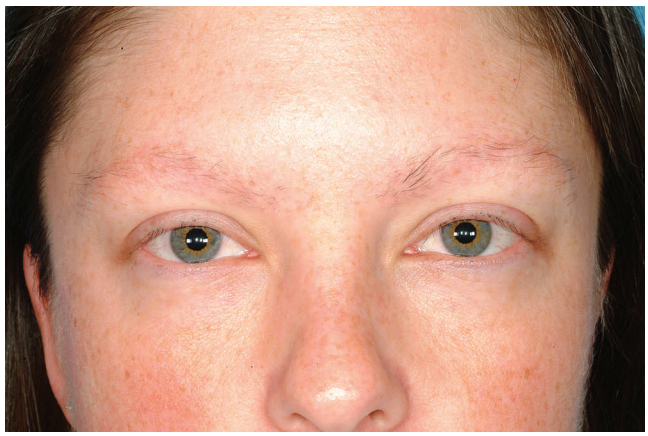

FIG. 8.3. A thirty-two-year-old female recovered from years of trichotillomania with near-complete obliteration of eyelashes and eyebrows.

trauma patients. Recovered trichotillomania patients should be "pull free" for at least one year and be made aware that recurrence of eyelash pulling will put the transplanted lashes at risk. Patients should be questioned regarding the use of glued-on eyelash extensions and strip lashes, which can damage existing lashes as well as transplanted ones. Absolute and relative contraindications are listed in Table 8.2.

METHODS

After a complete discussion of the known risks and benefits of eyelash transplantation, informed consent is obtained, and the patient is escorted to the procedure room. The technique described requires the operating surgeon to have two assistants proficient in microscopic dissection of single hair follicle grafts.

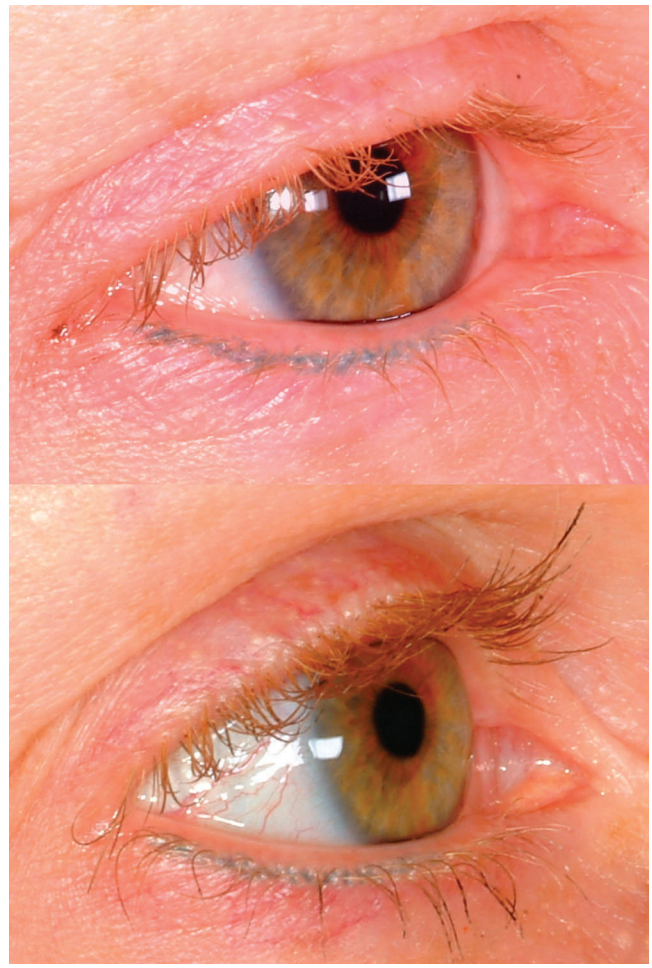

FIG. 8.4. A thirty-six-year-old female before and twelve months after eyelash transplantation (side view).

PRE-OP

Preoperative preparations include the following: Diazepam 10 mg p.o., scalp wash performed; alcohol swab prep of lid, topical 4% lidocaine cream is applied to the lid and donor area.

Donor Area

- Leaving the hair long, local anesthesia is applied to an area of untrimmed occipital scalp (2% lidocaine w/1:100,000 epinephrine) using CompuMed/Wand™ (Milestone Scientific) computerized injection (see below). Bupivicaine (0.5%) is also applied.
- Small linear harvest (e.g., 5 cm × 0.5 cm), with trichophytic closure is performed using a single

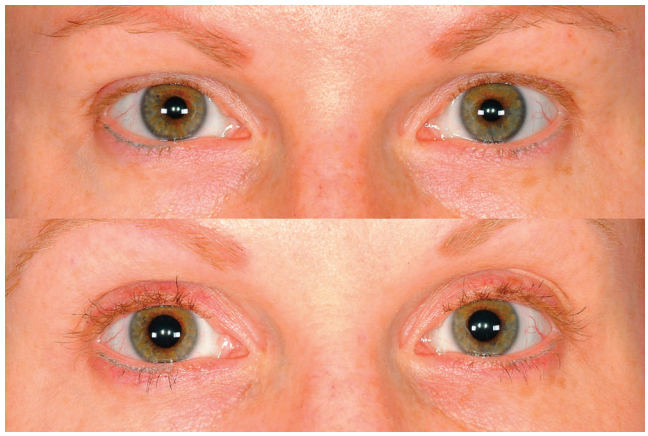

FIG. 8.5. A thirty-six-year-old female before and twelve months after eyelash transplantation (frontal view).

layer, running 5–0 Monocryl. Excising an area of this size allows us to carefully choose the best quality (mainly two-haired follicular unit) grafts.

Dissection

- Surgical Tech #1: Extremely trim, single-follicle grafts are carefully dissected under high-powered magnification, leaving the hair length ~10 cm. This length allows the hairs to be threaded through the French needle for the "sew" technique. Either "reverse follicular extraction" or careful trimming can be used to minimize the amount of epithelium on the grafts. Reverse follicular extraction is a modification of Flowers' "pluck and sew" technique. Instead of removing a segment of tissue from the donor scalp, a flap is raised and follicles are "plucked" from the underside while the long hair is pulled through. After harvesting (plucking) is completed, the flap is sutured back into position. Follicles producing "split" hairs are discarded.
- Surgical Tech #2: threads the hair shafts into French eye needles (single or paired, as desired), keeps grafts moist with normal saline on a cold surface (Figure 8.8).

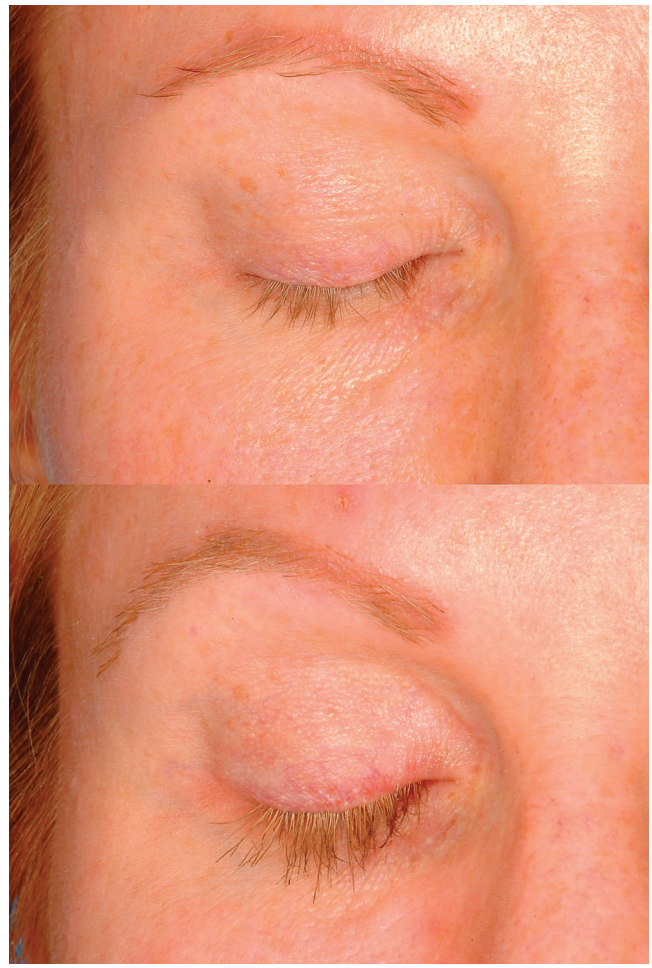

FIG. 8.6. Improved cosmetic appearance is due to the increase in the number and length of lashes.

Recipient Area/Eyelid

- There is evidence that computerized injection of anesthesia is safer (fingertip control of the needle using the hand piece directing the needle away from sensitive structures), more comfortable (slow, computer processor–controlled infiltration means the injection is barely perceptible to the patient), and more efficient (little wasted anesthesia and minimal trauma to the lid, since only one to two injections are needed per lid) for patients than manual injection.[18] We use the computerized (CompuMed/The Wand) injection (2% lidocaine

FIG. 8.7. A fifty-three-year-old female before and twelve months after eyelash transplantation of twenty-five lashes per eyelid.

TABLE 8.2. Contraindications

Absolute contraindications (poor candidates)	-Trichotillomania (active or within 1 year) -Inflammation of the lid/lid margin (active or within 1 year) -Bleeding disorders -Body dysmorphic disorder -Alopecia totalis/alopecia universalis
Relative contraindications (may make the procedure more difficult or outcome less predictable)	-Blood thinners -Hypertension -Difficulty with wound healing -Alopecia areata of the lid -Autoimmune diseases that affect the eye, eyelid, or lacrimal glands -Scalp hair length <4 cm -Abnormal lid anatomy (2° to trauma) -Patient has poor understanding of routine eyelash maintenance -Very "kinky–curly" donor hair or very coarse, straight hair

w/1:100,000 epinephrine), starting with a wheal at the lateral edge of the lid, and then working superficially and medially across the lid parallel to the lid margin while visualizing the needle tip at all times. The local anesthetic is dispersed across the lid by slow and gentle massage.

- Surgeon: Using loupe magnification, and a small specialized French eye needle, implantation is started. Care is taken to ensure proper orientation, position, and curl. A staggered entry pattern is recommended, exiting between existing eyelashes at the lid margin.

1) Needle entry (~6–9 mm from lid margin), working superficially toward the lid margin
2) Needle exit at lid margin (Figure 8.9)
3) Disengage the hair from the eye needle and pass the empty needle off field (to be rethreaded by Tech #2)
4) Pull hair through upward/vertical motion, orienting the hair curl and base of the follicle appropriately
5) The follicle base should be positioned under the skin, just beyond the needle entry point.
6) Trim hair to ~2.0 cm length
7) Repeat.

After the last lash is implanted, a cold compress is applied to the lid. Local anesthesia and implantation then commences on the contralateral eye. Transplanted follicles and lashes are examined for appropriate orientation and positioning – adjustments or removals can be made at this time. Trimming lashes to normal eyelash length or less is recommended at

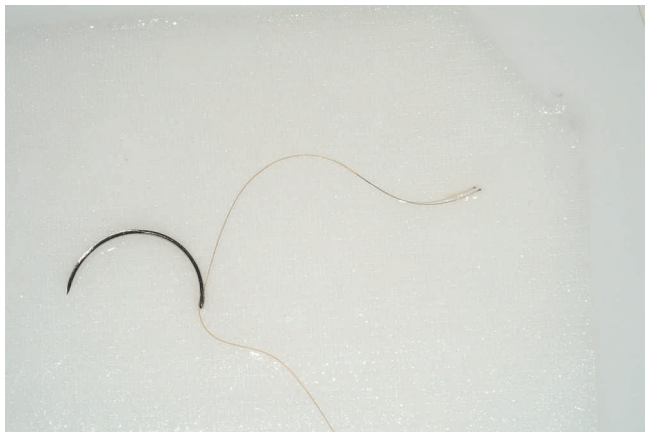

FIG. 8.8. Typically, single follicles are implanted into the lid. Although it is more technically challenging, the author has also used pairs of follicles to increase lash density. A pair of follicles (seen here) can be implanted with a single stroke of the French eye needle.

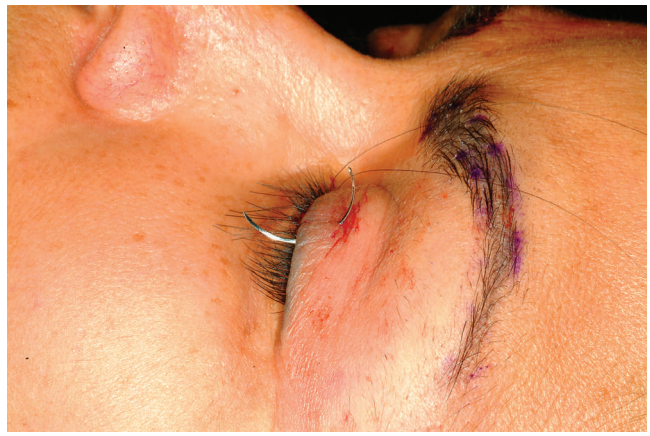

FIG. 8.9. Accurate placement of the French eye needle using high-powered magnification allows accurate orientation and positioning of the transplanted lash.

this time to minimize trauma to the transplanted lashes.

POSTOP

Postoperative instructions for patient are to keep the donor area dry overnight, while wearing safety goggles and sleeping in a semi-elevated position (i.e., at a 45 degree angle) using a neck pillow. Use mild analgesics for pain management if necessary. No rubbing or eye makeup for one week to avoid dislodging the grafts. Ophthalmic ointment or squalane can be used gently to moisturize the operative area starting immediately following the procedure as needed for several days.

Postop/24-hour visit: The surgeon will check for appropriate orientation and positioning of implanted lashes. Removal of an aesthetically "unsatisfactory" lash (or lashes) is possible at this time and/or trimming may be performed. Because the lids are no longer anesthetized, reimplantation is usually not possible. Fortunately, only about 1/100 cases require lash removal. Swelling may be present in the lids, which tends to slightly angle the implanted lashes downward (Figure 8.10).

Washing and examination of donor area are performed. A moisturizing ointment is applied to the lid and donor areas as needed for several days.

Bruising/swelling: The degree and duration of postoperative periorbital edema or ecchymosis can be quite variable. Patients should expect some degree of bruising and swelling with eyelash transplantation. Typically, lid edema gradually decreases over the course of several days, during which time the implanted lashes will "lift" upward, angling more superiorly. Minor bruising of the lower portion of

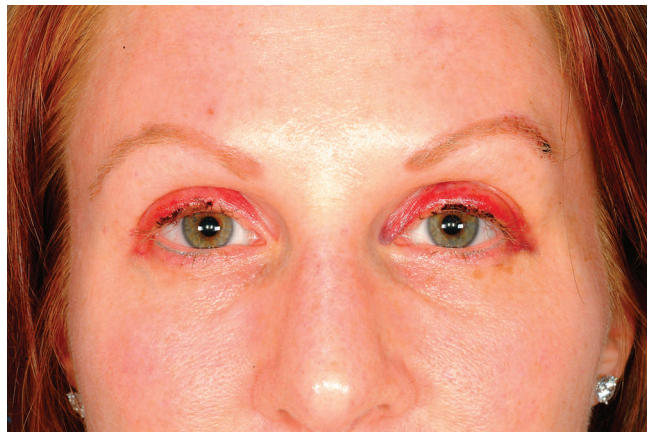

FIG. 8.10. A thirty-six-year-old female 24 hours postoperatively. The implanted lashes are checked once again for appropriate position, angle, and orientation. Adjustments can still be made at this time.

the lid margin, which may extend laterally beyond the lateral canthal area, typically takes about a week to completely resolve. Arnica, bromelain, and prednisone can all be helpful in preventing bruising. The best prevention is an atraumatic technique and close adherence to the preop instructions (avoiding medications and foods that cause bleeding).

Infection: Of sixty cases performed by the author last year, none have been complicated by infection in the lid or donor areas during the immediate postoperative period. Because no scalpels or sutures are used in the lid for eyelash transplantation, rates of postoperative infection are believed to be lower than those seen in other eyelid procedures, such as blepharoplasty. Nonetheless, about 20% of patients may develop an occasional stye, starting in the growth phase of six weeks to four months. This condition can occur even in patients who have not undergone transplantation and is usually self-limited (see below).

Vision: There have been no reports in the scientific literature of vision changes associated with eyelash transplantation. And, although iatrogenic trichiasis (eyelashes growing toward or abrading the cornea) is a theoretical complication of eyelash transplantation, this sequelae has not been reported in the scientific literature to date. Since spontaneous/hereditary trichiasis is a well-known and treatable condition, patients should be counseled that if they experience eye irritation or vision changes, they should visit their physician for evaluation and care.

COMPLICATIONS AND COMMON CONCERNS

Meibomian glands are sebaceous glands located in the tarsal plate of the upper and lower lids. They are responsible for secreting the lipid layer of tear film. By secreting their sebum over the ocular surface in a thin smooth film called meibum, these glands help prevent evaporation of the aqueous layer.

Hordeolum: Starting several weeks to months after eyelash transplantation, approximately one-fifth of patients may develop an occasional hordeolum or "stye." This is an acute infection within the meibomian glands at the lid margin. Inflammation at the neck of the gland and subsequent collection of sebaceous material produces a red, inflamed, and painful swelling at the lid margin. *Staphylococcus aureus* is the most common bacteria found in a hordeolum. It will generally drain spontaneously within five to seven days, or with the application of hot compresses or soaks. When drained, the sebum has a thick, cheesy consistency. Patients are instructed to contact the office if a sty develops and/or lasts longer than one week. Topical antibiotic ointments such as Neosporin or bacitracin, and rarely oral antibiotics, are helpful in these cases. Intralesional steroid injection can also help the area resolve more quickly.

Chalazion cyst: A chronic inflammation of the meibomian gland and surrounding tissue may result in a hard bump or sac at the lid margin. Treatment may rarely require surgical drainage.

Ingrown hair: As the implanted follicles begin to produce hair, an "ingrown" hair may occur at the lid. Initially appearing as a temporary hordeolum or stye, it may contain a hair that needs to be mechanically released.

Trichiasis: Trichiasis is the development of an eyelash that rubs against the ocular surface. Symptoms are a foreign body sensation and irritation, including excessive tearing and erythema. Trichiasis may occur spontaneously, congenitally, or iatrogenically. If left untreated, trichiasis may result in corneal ulceration (infection). The treatment for trichiasis is epilation (lash removal). Lash epilation can be performed with forceps, electrocautery/hyfrecation, or cryotherapy. Trichiasis is considered an extremely rare, theoretical complication of eyelash transplantation (Table 8.3).

One unconfirmed case of trichiasis after an eyelash transplant (a procedure performed in Vietnam over

TABLE 8.3. Possible Complications of Eyelash Transplantation

Condition	Risk/Frequency	Postop Timing	Treatment
Eccymosis	Common	Days 1–10	Supportive
Edema	Common	Days 1–5	Supportive
Soreness (donor + recipient)	Common	Days 1–5	Pain meds
Hordeolum	Infrequent	Months 2–6	Soaks, evaluation
Donor area infection	Very rare	Days 5–10	Abx, wound care
Recipient area infection	Very rare	Days 5–10	Abx, soaks
Chalazion cyst	Very rare	>6 Months	Excision
Epiphora	Very rare		
Trichiasis	Theoretical		
Vision changes	Theoretical		

ten years ago) has been reported anecdotally to the author at the time of this writing from an ophthalmologist. In that particular case, treatment was recommended, but the patient was lost to follow-up. Treatment of trichiasis might involve electrolysis, cryotherapy, or surgical excision.

MEDICAL/NONSURGICAL EYELASH ENHANCEMENT ALTERNATIVES

For several years, ophthalmologists have noted that topical ophthalmic treatments for open-angle glaucoma or ocular hypertension that contain prostaglandin F2-alpha analogs (e.g., latanoprost/Xalatan®, bimatoprost/Lumigan®, travoprost/Travatan®, and similar molecules) "significantly" increased eyelash length within weeks (Figure 8.11).[19,20] In general, this class of medications has an excellent safety profile with no major systemic side effects.[21]

In December 2008, Allergan obtained the first FDA approval of its product Latisse™ for the treatment of inadequate eyelash growth. It contains ophthalmic solution bimatoprost 0.03%, which is placed along the lash line daily, using a sterile applicator. Prior to its approval, compounds were sold off label or were available over the counter (in the form of

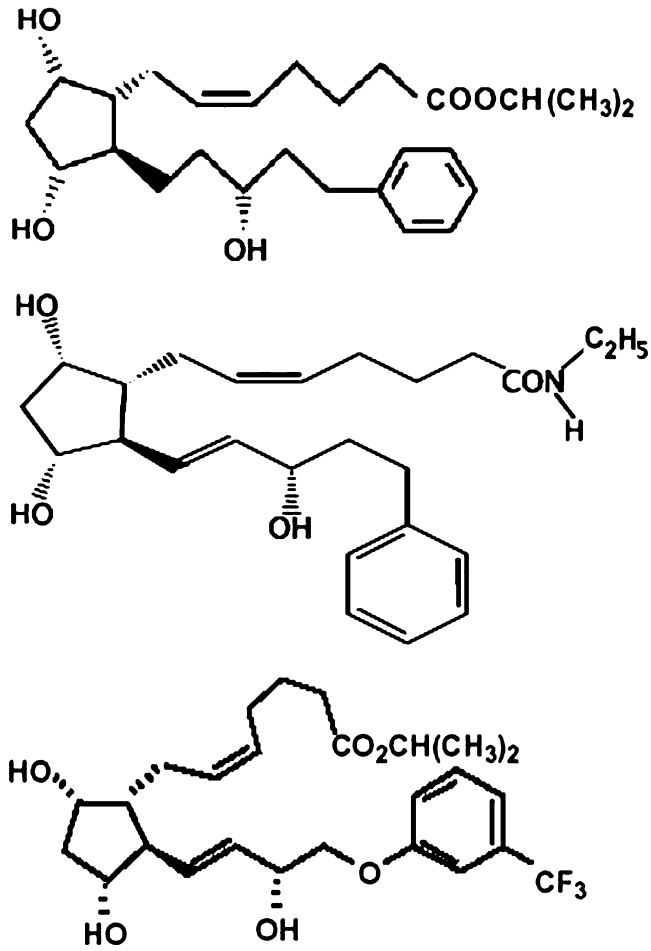

FIG. 8.11. Examples of prostaglandin analogs: Latanoprost (Xalatan®) Pfizer–prostanoid selective prostaglandin receptor agonist; Bimatoprost, (Lumigan®) Allergan prostaglandin receptor agonist; Travoprost, and (Travatan®) Alcon–prostaglandin receptor agonist.

"eyelash conditioners" that reportedly contained low concentrations of prostaglandin analogs or similar compounds). The FDA has embargoed and seized such eyelash conditions that have not undergone regulatory approval but were known to contain prescription strength prostaglandins. Although these cosmetic treatments are available from many salons and spas, it is recommended that anyone starting these treatments do so under the supervision of a physician.

Increases in the density, length, pigmentation, and caliber of eyelashes have been noted from use of these compounds within weeks and continued improvement over months (Figure 8.12). The treatments are

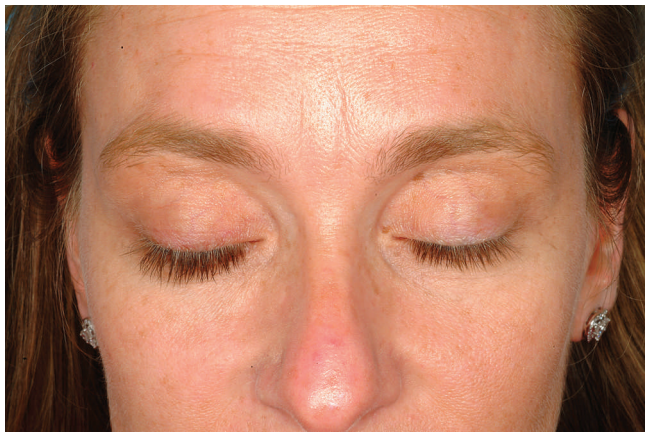

FIG. 8.12. At ten weeks, increases in lash density, caliber, and pigmentation were noticed in this patient using a topical preparation containing prostaglandin F2-alpha analog directly on the lash line of the eyelid.

typically well tolerated, with very few reported adverse side effects. Known side effects of intraocularly applied prostaglandin analogs include darkening of the eyelid skin and iris, which may be permanent as well as irritating to the eye.[22] Discontinuation of the treatment will result in a reversal of the eyelash growth effects over time.

Typical treatment with eyelash growth enhancers can be costly: Patients may spend $140–$175 per tube, which lasts several months. Table 8.4 provides an overview of nonsurgical alternatives for eyelash enhancement.

TABLE 8.4. Nonsurgical Alternatives to Eyelash Transplantation

Latisse (Allergan Inc.): The first and only FDA-approved product for treatment of eyelash hypotrichosis contains bimatoprost ophthalmic solution .03%. Trials demonstrate thicker, longer lashes at 8 weeks and full effects by 16 weeks. Continuous use is required for long-term results.
Marini Lash – (Jan Marini Skin Research, Inc): Initial formula contained bimatoprost, embargoed, and seized by the FDA. The newest formula is called a "nonprostaglandin eyelash formulation containing a proprietary peptide and other essential factors".
Revitalash (Athena Cosmetics Corp): Voluntarily removed from the market temporarily and reformulated.
MD Lash Factor™ eyelash conditioner (Procyte/PhotoMedex): This has been independently tested in studies documenting its safety. A clinical study has also been performed confirming patient reports that their eyelashes appear fuller and longer. MD Lash Factor contains a proprietary prostaglandin analog that is not bimatoprost.
Eyelash extensions: This is typically performed in a salon, cost = $300–$500 for approximately thirty to forty glued-on "lashes," which last several weeks. Compare to eyelash transplantation (~$6,000+), which is considered permanent.

CONCLUSION

Long, dense lashes have been a sign of beauty through the ages, and enhancing one's lashes has been part of beauty regimens since the dawn of recorded history. It is the author's opinion that eyelash transplantation (despite reports in the literature dating back to the early 1900s) is still in its infancy. In the experience of this author, cosmetic and reconstructive eyelash transplantation has been a rewarding procedure to perform. Careful and conservative patient selection has been critical to achieving excellent patient satisfaction. As long as patients are made aware of the routine upkeep needed and provided with the adjunctive services (e.g., trimming, tinting, and perming), satisfaction with the procedure is extremely high. Due to the delicate nature of the procedure and the potential for permanent complications, it is recommended that physicians and their technicians should not attempt eyelash transplantation before receiving appropriate educational training. The author also encourages all physicians to obtain full informed consent from all patients who request eyelash transplantation, which includes the risks, benefits, alternatives, as well as the experience of the surgeon performing the procedure.

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Chapter 9

EMERGENCY PREPAREDNESS IN HAIR RESTORATION SURGERY

by

Carlos J. Puig, DO

One of the most comforting things about hair restoration surgery, to both the patient and the surgeon, is the very low risk of complications. Although there is no registry that tracks hair restoration surgery complication data, most surgeons describe their complication rates as being less than 1%. There is an even lower incidence of life-threatening emergencies during hair restoration surgery. In the last thirty-five years, the author has been informed through personal communications of five cardiac arrests, resulting in three deaths, one severe neurological deficit, a "lock-in" syndrome, and three myocardial infarctions occurring during hair restoration surgery procedures.

The International Society of Hair Restoration Surgery (ISHRS) membership survey indicated that approximately 225,800 procedures were done in 2006. If all six of these life-threatening complications had occurred in that year, the incidence would only be one in 37,633 procedures. Since these problems were reported over thirty-five years, the incidence of life-threatening complications is indeed extremely low. The fact remains, however, that if such an event should occur in one's office, the incidence suddenly becomes 100%. Therefore, we owe it to our patients and ourselves, to be prepared for these unlikely events.

It is the intent of this chapter to help the hair restoration surgeon to be prepared for such catastrophic events. The low incidence of life-threatening situations often creates a false sense of security on the part of the physician and staff. The only way to optimize the probability of a positive outcome after such an event is by being prepared. One must have a planned response, with the trained staff and equipment to carry out that plan. One of the more difficult tasks for the hair restoration surgeon is to stay alert to the recognition of these rare situations and motivated to stay prepared to handle whatever situations may occur.

The learning objectives for this chapter are the following:

1. Describe the incidence of medical emergencies and relative risk of their occurrence in a hair restoration surgery (HRS) practice.
2. Outline the type of emergencies for which an HRS practice should be prepared.

3. Describe the current HRS definition of emergency preparedness.
4. List the equipment needed for an appropriate response to a life-threatening emergency.
5. Outline the learning objectives used for staff training to create a coordinated response to an unstable patient.
6. List and prioritize the physician's responsibilities when confronted with an unstable patient.
7. Define the priorities of the staff's interventions in an unstable patient.
8. List the two critical interventions that affect a cardiac arrest patient's survival to hospital discharge.
9. Identify the most common medical disorders that could make HRS a high-risk activity.

There are two types of emergencies that a hair restoration surgeon should prepare for: medical and environmental (Table 9.1). When making plans for dealing with these emergencies, one must consider not only protecting and treating the patient but also the patient's donor tissue, and in the case of environmental emergencies, the staff.

BASIC LIFE SUPPORT (BLS) VERSUS ADVANCED CARDIAC LIFE SUPPORT (ACLS)

For many years, there has been a debate within the field of hair restoration concerning what constitutes an appropriate level of emergency response plan.

TABLE 9.1. Emergencies for which to Prepare

Medical	Environmental
Myocardial infarction	Fire
Arrhythmias (ventricular tachycardia or fibrillation, supraventricular tachycardia, bradycardia)	Earthquake
Seizure	Tornado
Hypovolemia (dehydration, hemorrhage)	Toxic spill
Allergic Rx	Power failure
Drug interactions	Hurricane
Hypo/hyperglycemia	Flood
Hyperventilation	
Vasovagal reactions	

Some, including the author, have argued that the physician should maintain ACLS skills. Others have argued that it is very difficult for a physician who does not frequently use the ACLS skills to maintain their competency. In most communities, the response time of the local Emergency Medical Services (EMS) provider is only four or five minutes; therefore, it is better to rely on the EMS to provide ACLS skills.

It appears that this debate has been resolved with the introduction of new insights about sudden death and the resultant new technologies. Prospective studies have shown that only two treatment interventions have an impact on a cardiac arrest patient's survival to hospital discharge. These are 1) early administration of cardiopulmonary resuscitation (CPR) and 2) early defibrillation.[1–3] Every minute that passes between a patient's collapse, whether from ventricular fibrillation (VF) or sudden cardiac death (SCD) and defibrillation decreases the chance of survival to hospital discharge by 7–10% in the absence of bystander CPR. If the patient is given bystander CPR, the decline in this survival rate is only 3–4%.[4] The relationship between collapse and the time to start CPR and defibrillation can be seen very clearly in Figure 9.1.[5,6]

Because of these data, the automatic external defibrillator (AED) has been developed, so that

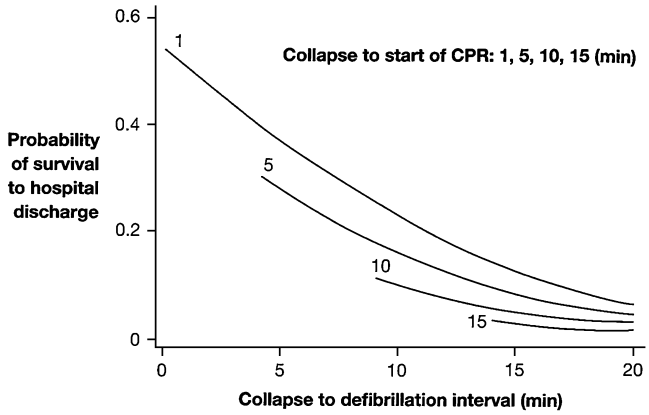

FIG. 9.1. Effect of collapse-to-CPR interval and collapse-to-defibrillation interval on survival to hospital discharge.

bystanders with no formal medical training, but trained at the BLS level can defibrillate a patient as early in the resuscitation as possible.[7–10] The AED is a device that talks the operator through the process of attaching the electrode pads, reads and interprets the cardiac rhythm, and advises about the need to defibrillate the patient. The device then advises the operator to clear all contact with the patient by everyone involved in the resuscitation and to press the shock button.

No longer is it necessary for the physician to maintain rhythm strip interpretation skills because the AED does that for him. Since they can be operated by lay bystanders, AEDs have become commonplace in hotels, airports, schools, court houses, shopping malls, hospitals, and physician's offices.[11] Since early defibrillation is one of the only two things in ACLS that correlates with survival to hospital discharge, it seems reasonable that hair restoration surgeons be able to provide BLS with defibrillation, at a minimum.[12]

The third variable essential to the development of an appropriate emergency response plan for a hair restoration facility is the response time of the EMS providers. The longer it takes for EMS providers to get to the facility, the more important it is for the physician to be able to provide a more sophisticated response. Most metropolitan areas in the United States have EMS response times of five or eight minutes. When the EMS response time stretches beyond ten minutes, the hair transplant surgeon is advised to provide an ALCS level of response to the emergency.

STAFF PREPARATION

The most difficult aspect of implementing an emergency preparedness plan is preparing the staff for dealing with a life-threatening emergency. It is the hair restoration surgeon's responsibility to see that his or her staff is trained to respond appropriately. Most offices are staffed by one physician and several technicians. Often, these technicians are very specialized, having little emergency medical experience or even medical training outside of their cutting and placing hair grafts.

Everyone, including the front office staff, should be formally trained in BLS and be able to perform high-quality CPR. At times when the physician is out of the room, the staff must be able to recognize the early signs of an evolving problem so that they can notify the physician and respond appropriately. Early intervention is essential to a positive outcome. These emergency events are so rare in hair restoration surgery that it is often difficult to motivate staff to appreciate the importance of the study.

Preparing a staff for an emergency response involves more than just BLS training. Cross-training is essential so that as additional help arrives, individuals can slip into the resuscitation procedure comfortably and efficiently. Table 9.2 lists the prioritized tasks assigned to individuals in the emergency response team.

Training of a functional Emergency Response Team requires planning and practice. This training should include both a didactic component and an organized practice sessions or drills that will allow the staff to visualize the functioning processes and procedures. Table 9.3 outlines proposed learning objectives for an Emergency Response Team Training Program.

Time should be set aside at least two to four times a year for the staff to participate in a practice drill. These drills are very important rehearsals, as the staff does not deal with BLS/ACLS every day.

TABLE 9.2. Prioritized Task Assignment to Individuals on the Emergency Response Team

Call 911, Get AED
Airway management
Breathing management (assisted ventilations)
Circulation (chest compressions)
AED management
Manage donor tissue

TABLE 9.3. Learning Objectives of Emergency Response Team Training Program

Demonstrate the performance of effective BLS, including airway management, CPR, and use of the AED.
Properly respond to and care for an unconscious patient.
List the members of a cardiac arrest response team and explain the assigned tasks of each member.
Know where the emergency response cart is kept, and exactly where on the cart the specific items for emergency interventions are kept.
Explain why it is important to keep the emergency cart log up to date.
Explain why emergency response practice drills are essential in a hair restoration surgery practice.
Describe the office evacuation plan, where the mobile emergency transplant packs are, and to where the patients are to be evacuated.
Describe how a patient's donor tissue is to be handled when the surgery is interrupted with an emergency.

In addition to caring for the critically ill patient, the staff must also know how to care for the patient's donor tissue, as the out-of-body time clock is still running during these emergencies. The remaining donor tissue is best protected by keeping it moist with a physiological solution. The constituents of the ideal storage solution and the storage temperature are dependent upon the length of the anticipated out-of-body time. Generally, if the tissue is going to be out of the body for more than six to eight hours, the use of a true tissue-holding solution such as Hyperthermosol™ or Custodial™ and chilling is advised. If the anticipated out-of-body time is less than six hours, then a balance electrolyte solution or tissue culture medium is sufficient without cooling.[13–15] Reimplantation should take place as soon as possible.

The physician assumes the role of team leader in any emergency situation. This means that he should be prepared to meet the responsibilities of both trainer and leader. Table 9.4 is a list of the responsibilities of the physician/emergency response team leader. Many feel that the easiest way for the physician to prepare him or herself for this role is to seek American Heart Association ACLS training.

TABLE 9.4. Responsibilities of the Physician Team Leader

Organize the group
Monitor individual performance
Backup team members for tasks
Model excellence of team behavior (calm, focused, collected)
Train and coach the team
Facilitate understanding of process
Focus on comprehensive patient care (diagnostics)

EMERGENCY RESPONSE PROTOCOLS

Optimizing outcome is dependent on a coordinated, well-planned response. It is important that the physicians develop written protocols for managing their Emergency Response Team's function. These protocols should include specific plans concerning identification of first responders and their activities, patient evacuation from the office, and the management of the remaining donor tissue.

Evacuation protocols can help determine the team's actions when either a medical or an environmental emergency occurs. To where will the patient be evacuated: the hospital? A colleague's office? Who will accomplish the transfer: EMS, private ambulance, car? Who will accompany the patient? Who is responsible for protecting the patient's donor tissue? Who will initiate the transfer protocol?

The EMS provider and/or ambulance company should be contacted prior to an emergency, and invited to the office, so they can plan the best routes to and from the building and document the specifics about location of and access to the office. Alternative surgery sites should be contacted and may require written transfer agreements to be executed prior to allowing patients to be brought to their institution. The specifics of the Evacuation Plan should be presented to the staff during the training program, so everyone is familiar with the plan and their role in its implementation.

The Evacuation Plan should also include instructions as to what to do when the facility has to be

evacuated because of an environmental emergency. The response may be different for various kinds of environmental emergencies. It should describe the location and routes of emergency exit, maintenance and location of emergency lighting, and the Emergency Evacuation Box that can be taken upon exiting the office. The Emergency Evacuation Box (Table 9.5) is designed to provide the instruments, soft supplies, and medications you need to complete an interrupted surgery in an off-site location. It is advised to keep skin staples in the office for rapid closure of donor wounds, facilitating rapid evacuation.

OFFICE PREPARATION

Preparation of the hair transplant office for emergency situations begins during the design of the facility. Room sizes must be large enough to accommodate not only the routine surgery but also the emergency cart, Emergency Response Team, and EMS personnel and evacuation stretchers. The hallways and doors must be large enough to accommodate stretcher access and a loaded stretcher patient egress.

The operating rooms and evacuation hallways should be equipped with emergency lighting and electrical power that will function when the building goes off the neighborhood power grid. Many buildings provide this service with generator backup. Battery powered floodlights with a trickle charger are an inexpensive alternative generator backup. In the event of power failure, things such as electrocautery, OR chairs, and OR tables may not be functional.

In the United States, hair restoration surgery offices must be built to comply with many sets of governmental regulatory codes, including Occupational Safety and Health Administration (OSHA), American Disabilities Act (ADA), and local community building, fire and health department codes. All of these are designed to assure the safety of both patients and employees in the office and will facilitate emergency access and response protocols.

All the equipment and drugs needed to respond to a life-threatening emergency should be stored on a mobile cart, so that it can be rolled into any room in the facility. This emergency cart should contain all the equipment needed to provide the level of care defined in the Emergency Response Protocols. If the protocols are designed to deliver a BLS level of care, then BLS airway equipment and an AED should be on the cart. If the protocols are designed for an ACLS response, then the cart should contain an ACLS airway, IVs, medications, and a defibrillator/monitor. Table 9.6 contains the suggested minimal equipment and drugs for an ACLS response.

Because the Emergency Cart will seldom be used, it is important that it be checked frequently to verify that the equipment is functional and the pharmaceuticals are not expired. This should be done at least monthly, and the results of the inventory should be kept in a logbook that not only documents the functionality of the cart but also dates when restocking orders were placed, so verification of the status of the restocking process can be made.

Storage equipment for the donor tissue should be kept either in the Emergency Cart or in the

TABLE 9.5. Emergency Evacuation Box Contents

Placing forceps	Suture, absorbable and nonabsorbable
Needle holders, hemostats	4 × 4's, kling, chucks, and drapes
Addsons forceps	Postop dressings, tape
Sterile cups	Local anesthesia
Sterile bowls	Tumescence solution, (RL, NS, etc.)
Selection recipient site blades and punches	Needles and syringes
Scalpel and blades	Skin pencils
Skin staples	Gloves[a], all sizes
Bowls, medicine cups,	Surgeons[a] cap[a], mask[a], gowns[a], booties[a]
Comb	Dressing ointments
Placing loupes	Biohazard bags, and sharps containers

[a] Number and sizes customized to the anticipated staffing.

TABLE 9.6. ACLS Emergency Cart Inventory for an Emergency Response Consistent with American Heart Association 2007 ACLS Training Program

Airway equipment	Oral pharyngeal airway	Nasopharyngeal airway
	Laryngeal mask airway	CombiTube
	Endotracheal tubes	Laryngoscope, stylet, and ET tube Magill forceps
	End tidal CO_2 monitor	Suction machine, suction tubing, and Yankauer suction tube
	Ambu bag – valve – mask	Oxygen tank
Defibrillator/ monitor or AED	Electrodes/ preferably self-adhesive shock/read	Electrode paste
	Stethoscope	Sphygmomanometer
IV/IO equipment	IV Catheters	IV Tubing, micro and macro drip
	Interosseous infusion needles	IO access kit
	Tourniquets	IV fluids
Pharmaceuticals	Nitroglycerin tabs or paste	Aspirin
Vasopressors	Epinephrine	Vasopressin
Antiarrhythymics	Amiodarone	Lidocaine
	Atropine	Magnesium sulfate
	Adenosine	Diltazem
	Digoxin	
Support equipment	Backup batteries	Biohazard bags and sharps box
	Safety eye shields	Gloves

Emergency Evacuation Box. These would include covered sterile bowls and storage solutions necessary for the proper protection of the patient's donor tissue. The containers should make provision for the indirect icing or the tissue, as an extended out-of-body time is anticipated.

PRIORITIES OF LIFE-THREATENING EMERGENCY INTERVENTIONS

The order in which emergency interventions are carried out is critical to a positive outcome. Dealing with a rapidly deteriorating patient is very intimidating to the average hair restoration surgeon. Preventing brain anoxia is the paramount goal of BLS and ACLS strategic interventions. The central nervous system does not tolerate anoxia. The most common cause of permanent brain damage in unconscious patients is cerebral anoxia, not the primary disease that caused the loss of consciousness.

All emergencies should be approached with the same methodical examination and treatment priorities. These are the priorities of the ABCDs of emergency medicine, outlined in the American Heart Association's BLS course: **A**irway, **B**reathing, **C**irculation, and **D**efibrillation. The rules for use of the algorithm are simple: Find it, Fix It, Check It . . . and if the patient does not improve start over and do it all again.

Immediately after assessing the victim's level of consciousness and calling for help, and the defibrillator or AED, the first responder who finds the patient should direct their attention to the patient's **A**irway. Open the airway with a head tilt-jaw thrust maneuver (Figure 9.2). After this maneuver, one should *look* for the chest to rise, *listen* for air escaping in exhalation, and *feel* for airflow against their cheek.

In the absence of respirations, the first responder *gives two **B**reaths*, and each should cause the chest to rise. The preferred method of ventilation is mouth to mouth, and the second preferred method is bag-valve mask. If the chest does not rise while breathing, the airway must be checked for obstructions.

After giving the first breath, the first responder should check for **C**irculation by checking for a carotid pulse. If there is no pulse, the first responder should proceed directly to **D**efibrillation by attaching the AED or defibrillator and following prompts or ECG, shocking the patient if indicated. *If the patient has no pulse and a defibrillator or AED is available, chest compressions are not indicated.*

If there is only one responder, CPR is deferred until after the AED is connected and the first shock is given. In a team response, CPR will begin immediately upon finding the patient pulseless and continue until the patient is connected to the AED. A

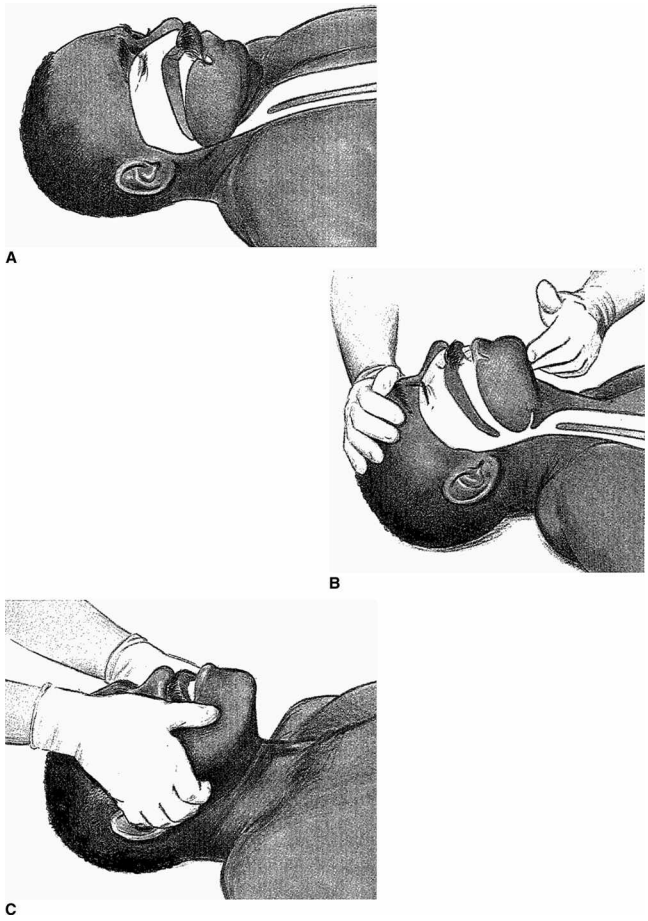

FIG. 9.2. Obstruction of the airway by the tongue and epiglottis.

well-organized emergency response team should be able to go through the algorithm and defibrillate a patient in two to three minutes. Figure 9.1 demonstrates how the ability to do so will significantly improve the probability of survival.

After the shock, CPR should resume at a compression/breathing ratio of 30/2, without checking for a pulse. Minimize interruptions in chest compressions. After two minutes (four cycles of 30/2 CPR), stop and repeat the AED examination of the cardiac rhythm and repeat the shock if indicated.

An important advantage to responding with an Emergency Response Team is that the physician is not tied to any one intervention. The physician can make diagnostic observations and fine-tune the team's activities to the needs of the patient. This structured approach also allows the physician to participate where needed to provide "backup" assistance in difficult interventions.

In most metropolitan areas, by the time the Emergency Response Team has completed the first two shock/CPR cycles, the EMS provided should be on site. In many jurisdictions, it is inappropriate to transfer a critically ill patient to a healthcare provider possessing a lower skill level, so the physician may have to attend to the patient during transport to the hospital.

It is not the intent of this chapter to substitute for or reiterate BLS or ACLS training, but rather to reaffirm the crucial steps and help prepare the physician, staff, and facility for such an emergency. There have been several changes in the ACLS guidelines as of 2006, regarding the energy delivered during defibrillation, medication usage, and delivery priorities. The new ACLS algorithms have been revised into only three protocols: pulseless arrest, bradycardia, and tachycardia. The reader is encouraged to review the most current standards offered by the American Heart Association on ACLS.

SPECIFIC EMERGENCY SITUATIONS

Not all medical emergencies present as a pulseless patient. Although cardiac arrest is a final common pathway to the demise of the critically ill, an astute physician and sensitive surgical team can identify the "at risk" patients and move them on to an appropriate critical care provider.

A carefully reviewed, thorough medical history is the physician's first defense against operating room catastrophes. Careful attention should be given to the list of medications the patient is currently taking, as these are a clue to their past medical problems and the severity of their illness.

MEDICATIONS

Care must be taken to verify that the patient's medications will not cross-react, potentiate, or interfere with the medications used during the transplant surgery; especially the lidocaine and epinephrine, as they may be needed in relatively high doses.

Patients with hypertension definitely need to have their medication history reviewed: if the patient is on a noncardioselective beta blocker, there is a small but very real risk of hypertensive crisis, resulting from the interaction of the noncardioselective beta blocker and epinephrine or another sympathomimetic.[16,17] All beta blockers have been shown to reduce the plasma clearance of lidocaine by 15–45%, thereby elevating the risk of lidocaine toxicity.[18]

Caution must be exercised with patients taking monoamine oxidase inhibitors (MAOIs), as they prolong and potentiate the effects of epinephrine.

Every year, the pharmacopeia available to the practicing physician expands. Fortunately, the internet and several other web-based database applications make it possible for any physician to quickly check any medication for potential drug interactions. A familiarity with programs such as PDR.net™, Palm PDR™, and Epocrates™ are recommended. When potential conflicts are identified, the surgeon should work with the patient's primary care physician to modify the patient's medication regime to one more compatible with the hair restoration procedure medications.

MYOCARDIAL ISCHEMIA

Angina, the pain associated with transient short-term myocardial ischemia, usually presents as a dull, crushing chest pain that radiates to the neck, left arm, or back between the shoulder blades. If this occurs during a surgery, the physician should immediately consider transferring the patient to an emergency room for cardiac evaluation. The hair restoration surgeon should immediately give the patient oxygen, one aspirin (5 g), and possibly sublingual nitroglycerin for the pain, while activating the transfer protocols and preparing the patient for transfer.

HYPOVOLEMIA

Hypovolemia should never be the result of hemorrhage during a properly performed hair restoration surgery procedure; rarely will a patient experience more that 100 cc of blood loss. Patients may come in for the procedure somewhat dehydrated, especially if the physician has instructed them to be NPO (nothing per os) for six or eight hours preoperatively. The combination of these two may precipitate a hypovolemic hypotension.

Table 9.7 outlines the classification of blood loss based on the patient's clinical presentation. It is most important to realize that the blood pressure and pulse do not change until patients have lost 30% of their blood volume (1,500–2,000 ccs). The earliest sign of hypovolemia is a narrow pulse pressure, which is the difference between the systolic and diastolic pressures. When the pulse pressure is less than 15 mmHg, one must consider that the patient's circulating blood volume has gone down by 15–30%.

Critical to the early identification of hypovolemic patients is recording baseline and intraoperative vital signs. Tracking vital signs is a significant help in differentiating hypovolemia from vasovagal reactions. The treatment of hypovolemia in a hair restoration surgery procedure is IV fluid replacement. Remember, "Blood is thicker than water," so when using crystalloids (Normal Saline, Ringers, or Plasmalyte) to replace blood volume, one must infuse a volume equal to at least three times the estimated blood loss.

VASOVAGAL REACTIONS

Fainting, of vasovagal origin, is by far the most common emergency event associated with hair restoration surgery. Vasovagal reactions are mediated by the

TABLE 9.7. Example of an Emergency Response Policy

Policy	It is the policy of Dr. XXX to provide the equipment, trained staff, and operating emergency medical systems necessary to deal with emergency situations in a timely and efficient manner.
Purpose	To provide a safe environment for patients to have hair restoration surgery.
Scope	All hair restoration facilities
Responsibility	Office managers, nursing coordinators, medical techs, and staff physicians
Procedure:	1. All employees will maintain current CPR or BLS certification by either the American Heart Association or the American Red Cross. The certification must consist of training in the use of an AED. 2. All staff physicians will maintain ACLS certification by AHA 3. Every telephone in the facility will have either a button set to speed dial 911 or the local emergency medical services response unit. 4. Every facility will have an AED, and every employee will know where it is located, and how to use it. 5. Every facility where surgery is performed will maintain an emergency medicine box or cart that will contain: a. Emergency airway equipment (protective face masks and ET tube-sizes 6, 7, 8, and laryngoscopes) b. Supplemental oxygen c. Epinephrine 1 mg IV d. Atropine 1 mg IV e. Nifedipine 20 mg capsules PO f. Albuterol inhaler 17 G g. Benadryl 25 mg injectable h. Dextrose 50 G IV i. Naloxone 0.4mg/ml j. Flumazenil 0.1 mg/ml 100 vial k. 1,000 cc Normal saline for IV use l. IV Tubing and catheter m. Lidocaine for cardiac IV use n. Lidocaine 2 g in 500 D5W 6. Emergency cart log (appendix MO2000a) will be maintained, and kept on the cart, with entries made daily documenting: a. Expiration dates of medicines b. Defibrillator discharged at appropriate energy levels c. Date and time of emergency response drills 7. The nursing coordinator will maintain in sound operating order an emergency evacuation hair transplant tool kit that will contain all the instruments and soft goods necessary to complete a hair restoration surgery at an alternative location. 8. Medication nearing expiration will be restocked in a timely manner, such that the emergency box is always up to date. 9. In every facility, where surgery is performed, the staff physician and coordinator will organize Code response team drills quarterly, and document the date and time of the drills in the Emergency Cart Log. These drills are to train and verify: a. That everyone remembers how to do CPR and activate the EMS system. b. That team assignments are remembered 1. Scribe, EMS caller 2. Airway manager 3. Chest compression provider 4. Medication tech 5. Defibrillator tech c. Entire team knows where all the emergency equipment is and can retrieve it. d. Entire team knows how to find meds and use the AED. 10. In the event that an adverse situation occurs, an incident report is to be completed after the situation is resolved. Copy is to be kept in the patient's chart, and a second in the risk management file. 11. In the event that a patient needs to be evacuated to a higher level of care that transfer will be made to the nearest hospital, in accordance with the transfer agreement. a. After the physician orders to transfer the patient, the office manager will contact the hospital and i. Describe the need to move the patient. ii. Put the staff physician in contact with the accepting physician in the hospital. iii. Chart the persons contacted and the times they were contacted. b. If the rescue service has not yet been contacted, the office manager will contact the appropriate transfer service to affect the patient transport. c. The nursing coordinator will place the patient's remaining donor tissue in the physician's preferred storage solution, in a sealed zip lock bag, in an indirect contact cooling tray, properly labeled with the patient's name, date, and time of harvest. The donor tissue is to stay with the patient at all times. d. The staff physician will make arrangements with the transfer institution to complete the tissue transplant as soon as the patient is deemed stable by the admitting physician. e. The Nursing coordinator will assure that the Emergency Evacuation Transplant Tool Kit is available to the physician and the patient at the alternative location. Microscopes may also need to be evacuated to complete the procedure.

autonomic nervous system and result in vasodilatation and a bradycardia. They are commonly associated with the drop in pCO_2 associated with the hyperventilation of anxiety. Such reactions are more common in first-time surgery patients, usually during the anesthesia or donor harvesting phases of the procedure.

The early signs of a vasovagal reaction are generalized weakness, diaphoresis, nausea, and pallor. Often, the hyperventilation associated with the anxiety reaction is subtle and unrecognized unless the patient is encouraged to breathe into a rebreathing bag or mask. The cool moist patient can rapidly deteriorate into full syncope, if not recognized and treated. These full syncope patients are transiently unconscious and may experience tonic–clonic muscle contractions, which may be mistaken for a seizure.

Their altered level of consciousness demands immediate attention to their airway, so as to prevent cerebral anoxia and more serious sequelae. Dropping the patient into the Trendelenburg position, and having the patient rebreathe his or her own CO_2 by breathing into a rebreathing mask or paper bag, is also of help. A preoperative anxiolytic, such as diazepam 5–10 mg, may reduce the incidence of vasovagal/hyperventilation reactions.

It is very important that the staff be prepared and appropriately responds to vasovagal reactions. Everyone must be trained to recognize the signs of this reaction, to manage an airway, and not be intimidated by the transient seizure-like activity that may occur. Patients usually do very well once they recover from the primary episode. In thirty-five years, the author has never found it necessary to discontinue a surgery because of these reactions.

HYPOGLYCEMIA

Diabetics should be encouraged not to come off their daily routine for blood sugar management. Patients with a history of unstable blood sugar, taking either insulin or oral antidiabetic medications, should be closely monitored during surgery for vital signs and blood sugar. Keeping a glucometer in the office is recommended for using on these patients. Contemporary hair restoration surgery procedures can take six to ten hours; this coupled with the increased metabolism associated with the stress of having surgery, epinephrine, and steroid dosing can result in hypoglycemia.

When the blood sugar approaches 50 mg/dl, patients will become confused, agitated, lethargic, and sometimes lapse into seizure or coma. Personality changes and belligerence are associated with the less severe hypoglycemia, and may be an indication for immediate blood sugar evaluation. Often, hypoglycemia is difficult to distinguish from other causes of an altered level of consciousness. For the brittle diabetic, preventing hypoglycemia with frequent blood sugar monitoring and prophylactic meals is the best strategy.

SEIZURES

The most common cause of seizures is failure of the patients to take their seizure medications. Hair transplant patients with a seizure disorder must be advised to stay on their medication prior to the surgery. Many hair transplant surgeons will require preop medication levels to assure that the patient's medications are indeed in the therapeutic range. Preoperative diazepam may be helpful in preventing intraoperative seizures.

Seizures in a patient who has no history of a seizure disorder demands that the surgeon consider alternative causes, such as hypoglycemia and lidocaine toxicity. The treatment of a seizing patient includes airway management, gentle restraint to prevent the patient from injuring him or herself, intravenous diazepam, and most importantly protection of the airway during the postictal, semicomatose period. Once the seizure and airway are under control, a blood sugar and lidocaine levels should be included in the diagnostic evaluation.

Seizure is also a classic, although late, sign of lidocaine toxicity. Earlier signs of lidocaine toxicity include agitation, irritability, and copper penny taste in the mouth. The introduction of tumescent anesthesia, as an adjunct to the classical scalp ring block, has helped reduce the risk of developing a lidocaine toxic patient. In this era of recreational drugs, it is important to remember that cocaine and lidocaine have a similar structure and can be cumulative in their toxic effects, so a patient who has used cocaine before surgery is at a higher risk of developing a toxic reaction and possible seizure.

ALLERGIC REACTIONS

Hair restoration surgeons are blessed in that the principal medications that are used during the procedure rarely cause allergic reactions; in fact, steroids and epinephrine are two of the frontline treatments for an allergic reaction. Most allergic reactions are the body's response to seeing a substance after it has formed antibodies to that substance from a prior exposure. These reactions are mediated through immune globulin E (IgE), which causes the release of histamine from mast cells. The histamine causes the urticarial rash, wheezing, and bronchospasm. When the histamine reaction is rapid and more severe, the reaction is termed anaphylactic. This clinical presentation includes diffuse vasodilatation and pooling of blood in the peripheral vascular system causing the severe hypotension of a distributive shock.

A similar reaction can occur that is not IgE mediated and does not require prior sensitization to the antigen. These anaphylactic reactions can occur in response to the first-time administration of antibiotics, local anesthetics, and nonsteroidal anti-inflammatory drugs (NSAIDs).

Epinephrine, antihistamines, and steroids are the principal drugs for treating all of these allergic reactions. The epinephrine dose used for allergic reactions is very different from that used for the cardiac emergencies discussed earlier. Here, one should administer 0.3–0.5 cc of epinephrine 1:1,000 subcutaneously every ten to twenty minutes; in severe cases, an epinephrine IV drip can be started at 0.5–5 mg/minute, along with diphenhydramine 50 mg IV. In patients who have deteriorating vital signs, hypotension, massive volumes of IV fluids, and dopamine may be needed to compensate for the vasodilatation of a distributive shock.

Brochospasms usually responds well to inhaled beta-adrenergic agonist therapy and oxygen with little risk of cardiovascular complications. Large doses of IV steroids are also used in treating severe reactions, although one should not expect that they will have a significant impact on the reaction for six to eight hours.

HEREDITARY ANGIOEDEMA

Head and neck surgery has been associated with attacks of hereditary angioedema. This rare autosomal dominant disease can cause spontaneous edema of the extremities, face, gastrointestinal tract, and, most importantly, the airway. The associated laryngeal edema can be life threatening.

It appears that the disorder is mediated by either a dysfunctional or a decreased C1 inhibitor protein. Most patients will relate either a personal or a family history of the disease; however, the qualitative defect of C1 protein allows for milder forms of the disease, which are often not previously diagnosed.

Patients known to have the disease can be prophylactically treated with aminocaproic acid (Amicar) and fresh frozen plasma. Treatment of an acute episode is focused on airway management and epinephrine administration, subcutaneously, or in nebulized form. C1-INH concentrate is rapidly effective in the treatment of laryngeal edema associated with hereditary angioedema.[19] Generally, hereditary angioedema does not respond well to antihistamines or steroids.

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Chapter 10

TECHNOLOGY IN HAIR TRANSPLANTATION

by

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INTRODUCTION

The nature of hair transplantation, involving the assessment, harvest, and transfer of hundreds of individual hairs, practically mandates the use of technology at some point in the process. Also, because many different types of physicians perform hair transplantation, much creative genius is brought to the field. Techniques for documenting baseline hair growth, measuring changes in hair density and/or thickness, photographing the donor and recipient areas, and analyzing the scalp itself are very helpful. Furthermore, methods of magnification are essential for both graft and recipient site creation. In this chapter, we describe different devices that may be helpful in the medical or surgical treatment of hair loss. We have received no funding from any of these companies or their developers.

DERMATOSCOPY

Many different devices can provide simple magnification of the skin and scalp. They vary in their degrees of magnification and design in resting against the area of interest. A relatively recent development is the technique called dermatoscopy or epiluminescent microscopy (ELM). Original dermatoscope devices involved placing a flat glass plate against the skin or scalp, under oil immersion to eliminate surface reflection due to the refractive index mismatch between air and skin[1] (Figure 10.1). They were marketed under such trade names as Dermogenius (Canfield Scientific, Fairfield, NJ) and Episcope (Welch Allyn, Skaneateles Falls, NY) (Figure 10.2). Some disadvantages of these devices were the need to autoclave the glass plates between patients and the inconvenience of applying an oil or gel beforehand. It is easy to see how this would be especially cumbersome on the scalp.

The company 3Gen LLC (San Juan Capistrano, CA) has developed a technology that eliminates the need for an oil or fluid interface. Their DermLite® products contain eight to thirty-two light-emitting diodes (LEDs) that are placed in a ring around a 10× magnifying lens (Figure 10.3a,b). Together, these cross-polarizing lights cancel out any surface

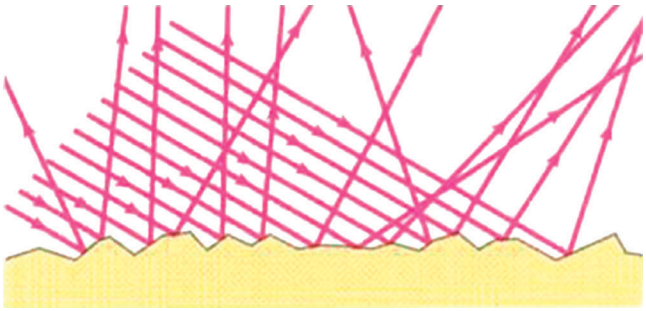


FIG. 10.1. The reflection of light by the skin surface makes examination of deeper skin structures difficult.

FIG. 10.2. Example of device by Welch Allyn used for dermoscopy (Courtesy of Welch Allyn).

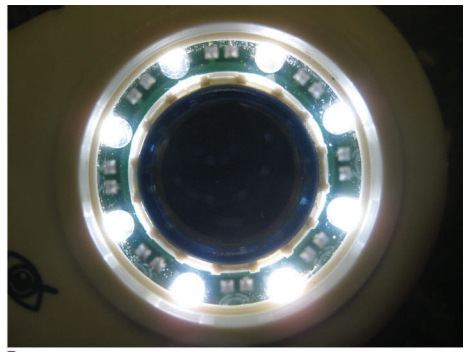
reflection created by the stratum corneum. The DermLite® II Adapters can be used either individually or may be attached to a camera such as Nikon Coolpix P5100 or Sony DSC-W170. Saving the images to a digital file allows one to accurately assess hair density or use the images for other purposes. The manufacturer also sells a set of five reticles, which may be attached to the camera. On the day of surgery, the HT surgeon may use it to photograph the donor area (Figure 10.4). Then, he or she may use the images at another time or for purposes other than planning surgery.

Another device, the Proscope HR™ (Bodelin Technologies, Lake Oswego, OR) is used in medicine as well as for investigative and forensic studies. This lightweight, handheld device is shaped like a small hair dryer and can be held up to the scalp (Figure 10.5). It also has a set of polarized LED lights that can project onto the area of the scalp to be visualized. Its built-in camera projects images through a cord and onto a computer screen, through specialized software that accompanies the program. Because it has an opening to the lens, and does not crush the hairs with a single glass plate, it photographs hairs in their natural, upright angle of growth (Figure 10.6). It also has two settings on the light switch: One setting offers bright lighting so that the operator can identify small, vellus hairs. The second more polarized setting allows for closer examination of the scalp itself. If there is any redness or flaking, it will be visible on this setting.

DIAGNOSING HAIR LOSS

Many physicians report that such magnified, polarized views of the hair follicle in vivo can provide clues to the diagnosis of hair loss.[2,3] Most patients who present for hair transplantation have straightforward androgenetic alopecia, which appears as miniaturized hair follicles. Others may have cicatricial, or scarring alopecia, which is discussed extensively in another chapter of this book. Although these conditions do not preclude hair transplantation, they should be transplanted only when patients' hair loss

A



B

FIG. 10.3. ***(A) Two examples of handheld Dermlite devices. The model on the left may be attached to a camera. (B) LED Lights around the lens help illuminate the scalp area of interest.***

is stable and nonprogressive. In these settings, it is helpful to use a magnified, polarized lens to identify any scarring of the scalp epidermis. Central centrifugal cicatricial or "hot comb" alopecia (frequently seen in African-American women) may appear as shiny skin that is devoid of follicles. Lichen planopilaris (LPP) can appear as erythematous skin with some flaking or scaling. It may also have less visible follicles depending on the degree of scarring.

Likewise, some genetic or autoimmune hair disorders can be visualized with polarized dermatoscopy. In one large study of 300 Asian patients, findings correlated with alopecia areata included black dots, tapering hairs, broken hairs, yellow dots, and clustered short vellus hairs.[4] Abnormalities in hair structure can also be seen. Monelethrix can be identified by its hair shafts with uniform elliptical nodes and intermittent constrictions.[5] Netherton syndrome, with its trichorrhexis invaginata, or bamboo hair, may also be seen.[6] Furthermore, seborrheic dermatitis, psoriasis, and trichotillomania may all be further elucidated using dermatoscopic evaluation.

ASSESSING HAIR DENSITY AND DIAMETER

Besides diagnosing hair loss, these devices are especially helpful in documenting hair growth or loss at a single point in time. This is especially useful in the anatomical scalp areas where patients complain of hair loss. Patients may undergo baseline imaging at

FIG. 10.4. ***View of donor area through a 1/4 cm reticle (image courtesy of William Parsley, MD).***

FIG. 10.5. ***The Proscope HR^{TM} device (Bodelin Technologies, Lake Oswego, OR).***

FIG. 10.6. Digital image of the scalp taken with the Proscope HR™ device.

a set point in the scalp, for instance 15 cm posteriorly from the glabella. Then, after six to twelve months on finasteride, minoxidil, or after undergoing hair transplantation, subsequent images may be taken at the same site and compared to the first images in order to assess the efficacy of different treatments. It is easy to see the difference between the thicker, transplanted hairs growing in the midst of thinner, preexisting hairs (Figure 10.7). Female patients may particularly benefit from this reassurance.

FIG. 10.7. Dermoscopy after hair transplantation reveals the difference between thin, preexisting hairs and thicker, transplanted hairs.

Other, simpler methods are available for assessing density. Some HT surgeons use a simple handheld magnifier to assess donor density. This can be done after trimming the donor area and before excising the strip. One product, the Hair Densitometer (Ellis Instruments, Madison, NJ) provides 10× magnification through a 1 cm^2 viewing area that is divided into quarters (Figure 10.8). It allows for a rapid, intraoperative assessment of hair counts when there is no need for digital or electronic analysis. It is also an affordable addition to any hair surgeon's collection of equipment.

TRICHOMETER

The Trichometer (Figure 10.9) provides a standardized way to measure density and diameter changes

FIG. 10.8. The hair densitometer (Ellis Instruments, Madison, NJ).

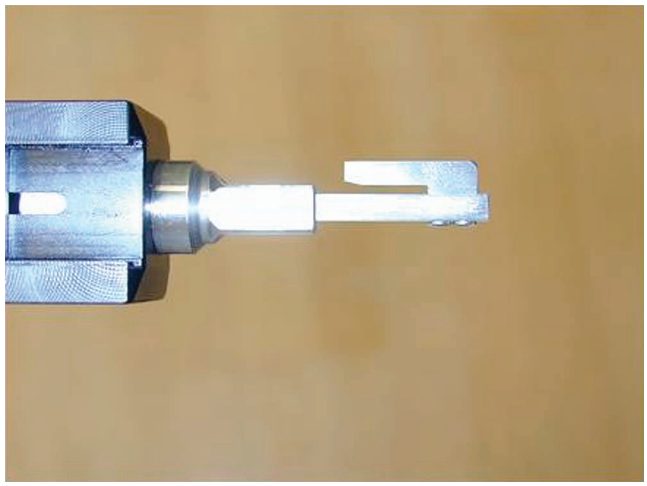
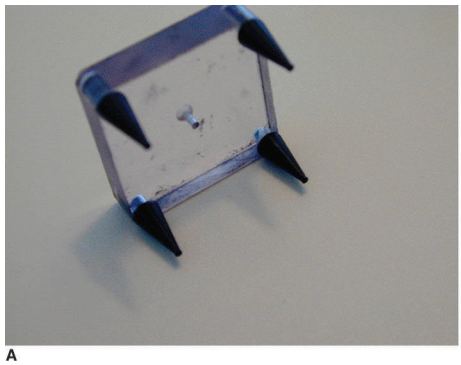


FIG. 10.9. The trichometer is a handheld device that can measure hair density and/or diameter (Image courtesy of Bernard Cohen, MD).

FIG. 10.11. The diameter of the collected hair is calculated to find the trichometric index (TI) (Image courtesy of Bernard Cohen, MD).

in the hair shaft.[7] It involves gathering hair from a 2 cm × 2 cm square area (4 cm^2) (Figure 10.10a) and measuring the cross-sectional area of the hair bundle formed (Figure 10.10b). The device uses an internal spring to compress the hair to the same predetermined load each time it is engaged (Figure 10.11). The resultant cross-sectional area is expressed as square millimeters of hair per square centimeter of skin × 100 (mm^2/cm^2 × 100) and is called the trichometric index (TI). Because the sample area is constant, any change in the number and/or diameter of hairs is reflected in this index. When the value increases, this indicates hair growth or thickening. When it decreases, it indicates hair loss.

Care must be taken to measure the hair at the same distance from the scalp. Otherwise, the values may be confounded by hair breakage at the distal ends of the hair. Hairdryers, vigorous combing, and the use of ponytail holders can all contribute to hair breakage. In fact, the Trichometer was first reported in the HT *forum* as a device for measuring hair breakage.[8] Investigators may use the device to measure cross-sectional diameter distally and divide this by the cross-sectional diameter proximally. This calculated value, hair breakage index (HBI), can indicate the percentage of hairs broken in the scalp. For instance, 2.46/3.58 × 100 = 70, meaning 30% of hairs are broken. Cohen reports that a normal HBI



A

B

FIG. 10.10. (A) Device used to mark 2 cm × 2cm area (Image courtesy of Bernard Cohen, MD). (B) Gathering hair in a 4cm^2 area provides a standardized sample area for all patients (Image courtesy of Bernard Cohen, MD).

is 90–100. Investigators should be aware that a layered haircut may artificially increase the HBI.

There is great promise for this device. Traditionally, measuring hair density and diameter has been very difficult. Investigators must use semipermanent means such as tattoos to mark the area being measured. Then they often require hair clippings to obtain indicators of hair mass. These techniques, although standardized and essential for clinical research, are not practical for everyday patients. Most of our patients are their own best judges of their hair loss or growth. However, they often need reassurance that minoxidil, finasteride, or hair transplantation is working. Likewise, less proven methods of hair growth such as biotin, low-level light therapy (LLLT), or certain shampoos could be more easily and better assessed using devices such as the Trichometer before and after their implementation.

COMPUTER SOFTWARE

In addition to the imaging lenses described above, some companies have taken the next step of creating computer software that allows the investigator to mark and calculate values for hair loss and hair growth. The Folliscope (Seoul, South Korea) is one that is already commercially available (Figure 10.12).[9] It includes both a handheld camera, which photographs the scalp under magnification, as well as software to analyze the photos. After capturing images of the scalp, investigators can tally the number and size of follicular units visible on the screen. They may identify hairs as terminal or vellus (Figure 10.13). They can also measure the width of the follicles to track any increase or decrease in shaft diameter (Figure 10.14). This same function can be applied to measure the length of the follicles, as well, to measure hair growth rate. One advantage of this program is that it captures the images using a standardized cross-sectional area, which then corresponds to other measured areas, such as hair shaft length or diameter. No calculation or conversion is required because the field area is incorporated in the software.

FIG. 10.12. The Folliscope allows users to capture images of the scalp.

A similar software is called Trichoscience version 1.4, produced by Trichologic (Moscow, Russia).[10] Its website is in Russian, but an American version 1.5 may soon be available through Merz. It does not come with a handheld device for capturing images but is used to calculate images taken with a regular 35-mm camera or other device. We used it to analyze images taken on the Proscope HR™ device. As above, we were able to tally the vellus and terminal hair counts, as well as measure the width of individual hair shafts. It was less convenient because it required converting the field area into the corresponding actual hair shaft measurements. Further refinements are necessary before this software will be fully user friendly.

Some major drawbacks of both programs are that they ultimately are operator dependent to count and identify hair follicles as vellus or terminal, as well as to measure the widths of hair shafts. Different operators may be more or less meticulous about marking the follicles. Another drawback is that the counts are less accurate when hair is longer than a few millimeters. Unfortunately, most patients, and especially women, do not allow hair clipping when it is already thinning considerably. Finally, the hair shaft diameters differ at

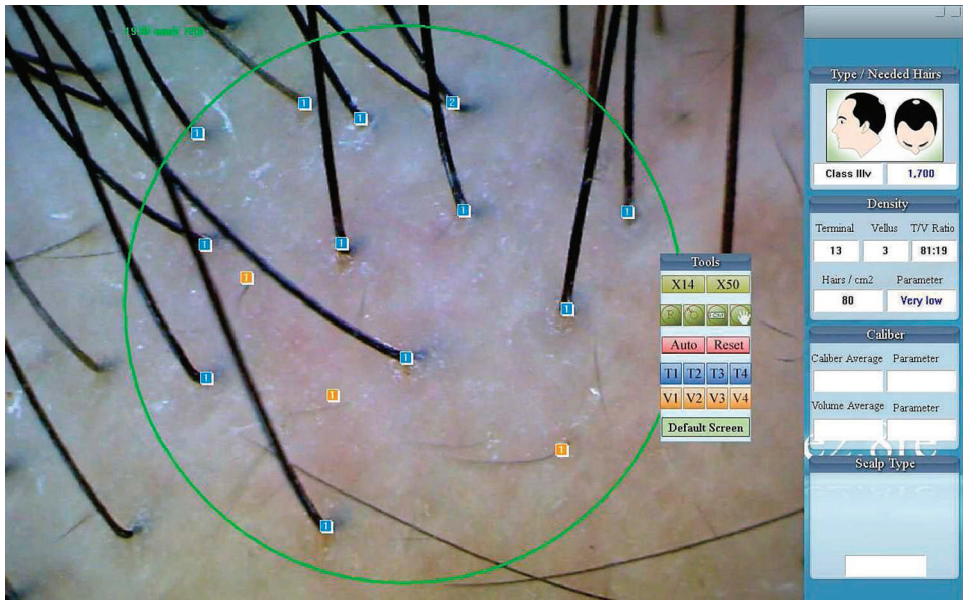


FIG. 10.13. Folliscope software used to mark and tally vellus and terminal hairs.

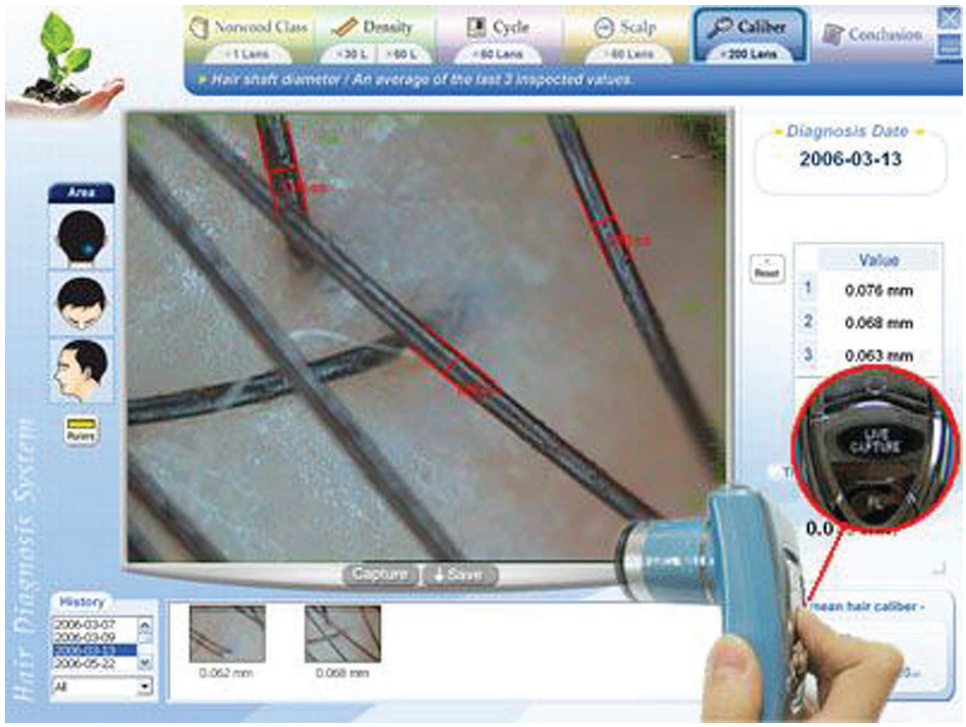


FIG. 10.14. Folliscope software used to measure hair shaft diameter.

different distances from the scalp. Thus, interstudy hair measurements may also vary based on how proximally or distally investigators measure the hair width. Even standardizing this is difficult unless all hair shaft diameters are measured at a set distance from the scalp.

The software that is described most in the literature is called Trichoscan.[11–13] It requires trimming the hair and then dyeing these hairs (Figure 10.15). A tattoo is used to mark the spot on the scalp. Magnified digital images are taken at baseline for the measurement of hair densities or diameter or two

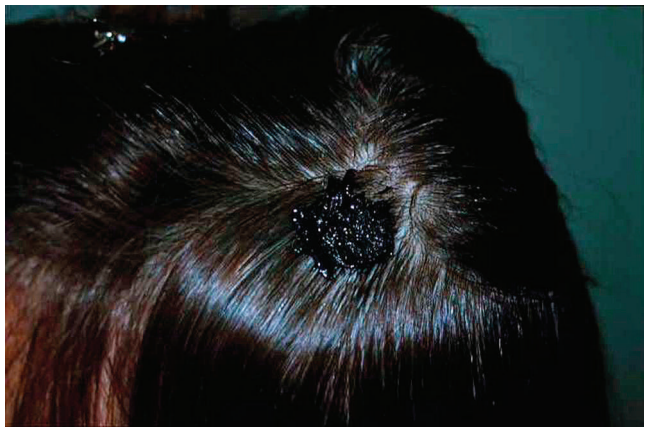


FIG. 10.15. Trichoscan system involves trimming and dyeing the scalp hair.

to three days after clipping in order to define anagen hairs as growing and telogen hairs as nongrowing (Figure 10.16). More photographs are taken at three and six months after clipping. This way, investigators can measure not only the hair density and diameter, as above, but also the hair growth rate (mm/day) and anagen/telogen ratio. The software is reported to have up to 99% accuracy and repeatability, even among different operators. Investigators have implemented the device to measure the efficacy of treatments for hair loss as well as for hypertrichosis and hirsutism.[14] A rather new device called Trichoscan Smart is able to count follicular units manually.

FIG. 10.16. Image being taken with the Trichoscan software.

An ideal software is one that has a standardized cross-sectional area, which corresponds to hair shaft diameter. It would automatically tabulate the number of follicular groupings. It would have an internal cutoff value to identify hairs as either vellus or terminal. Likewise, it would automatically calculate hair shaft diameter at a set distance from the base and calculate an average for all the hairs. Perhaps most importantly, it would not require trimming or tattooing of the scalp. Designing such a device may be impossible or just around the corner.

LIGHTING AND MAGNIFICATION

It is common for hair transplant surgeons to use various accessories to create and place recipient sites. This is especially difficult when placing the grafts among existing hairs. The Avram Stand uses a ring of polarized lighting around a large magnifier for better visualization. It is hands-free and can be used either for cutting grafts (Figure 10.17) or for creating recipient sites on the scalp. Other lighting devices such as the Magni-Focuser provide both lighting and magnification but are worn on the head.

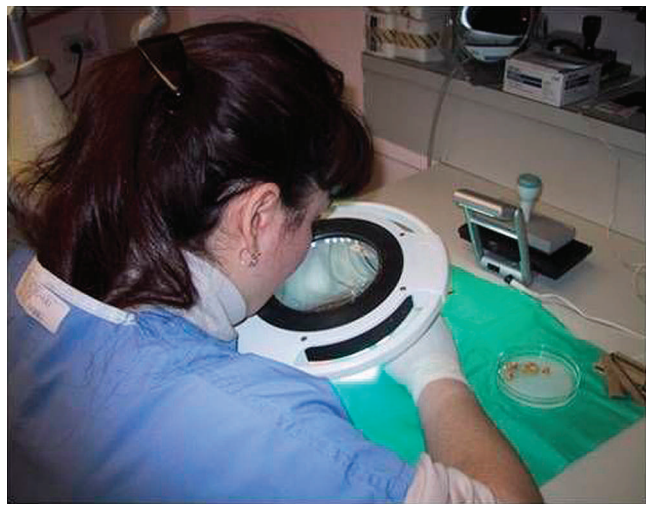


FIG. 10.17. The Avram stand can be used to cut grafts or create recipient sites.

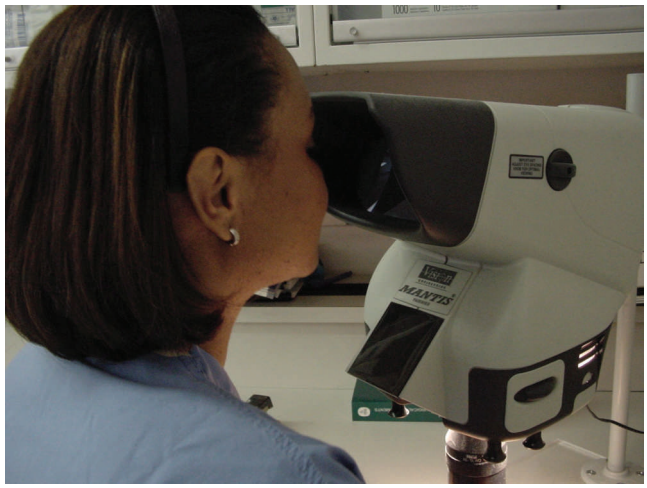


FIG. 10.18. Microscopes can be helpful in the graft dissection process.

MICROSCOPES AND TELEVISION

Many hair transplant surgeons find microscopes to be useful in the graft dissection process. They report better graft visibility and reduced transection rates.[15] Numerous models are available, which provide varying options of eyepieces and ergonomics. As with the imaging devices listed above, cameras may be attached to allow trainees or visitors to see the microscope field. Manufacturers such as Meiji Techno (Santa Clara, CA) offer useful microscopes for hair transplantation (Figure 10.18).

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Hair Transplant Before-and-After Photos

Hair transplantation results in consistently natural-appearing transplanted hair for men and women. This is the result of an evolution in surgical technique over the past ten years. The following photos are examples of patients who have undergone one to four hair graft transplantation and the consistently natural appearing results they can achieve.

While helpful, a photograph will not determine the expected density for each individual patient. Factors such as donor density, the type of hair loss, and the rate of ongoing hair loss will all influence the net perceived density from each individual procedure.

In addition to transplantation for male and female pattern hair loss, we have some examples of corrective hair transplantation. Unfortunately, from the 1960's through the 1990's, many patients received unnatural-appearing, "pluggy" transplanted hair over the frontal scalp. This, for many patients, has resulted in creating a new cosmetic emotional concern. Through contemporary surgical techniques, we can substantially improve natural-appearing pluggy transplanted hairs and there are some examples of this in the glossary as well.

In addition, transplantation is done to correct hair loss due to chronic inflammatory skin diseases, trauma, and surgical scars. The growth of transplanted hair in scar tissue, while not quite the same as normal skin, does grow and can make a substantial cosmetic impact for patients.

If you have any specific questions regarding the photos, don't hesitate to e-mail us at mavram@dravram.com.

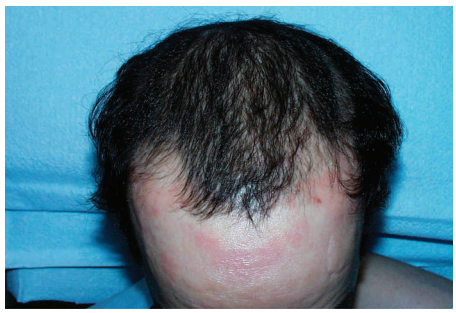

FIG. 1A. Before hair transplant.

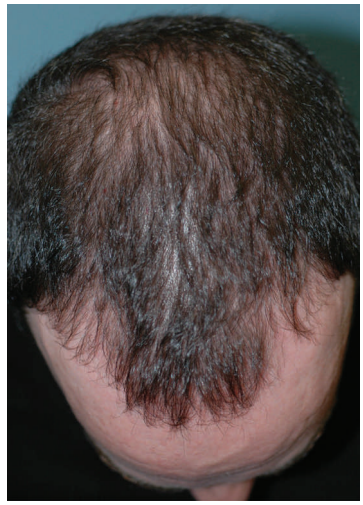

FIG. 1B. After 600 one to three hair grafts.

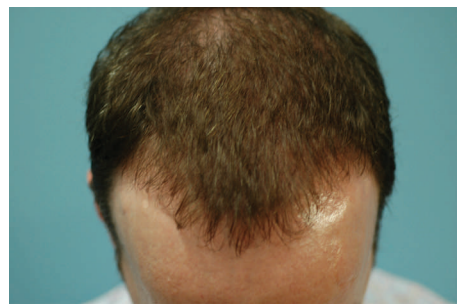

FIG. 1C. After 700 one to three hair grafts (second surgery).

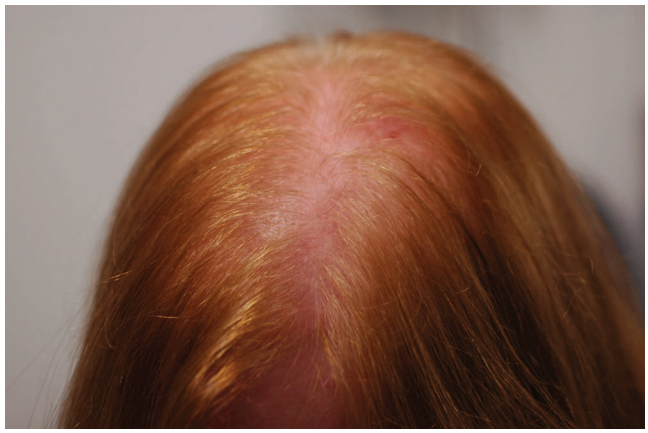

FIG. 2A. Before hair transplant.

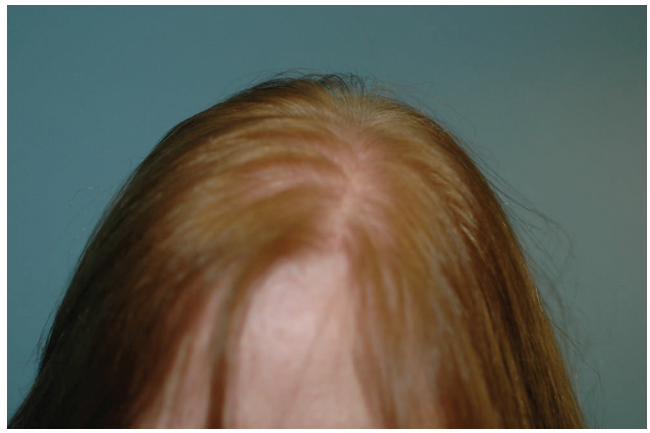

FIG. 2B. After 550 one to three hair grafts.

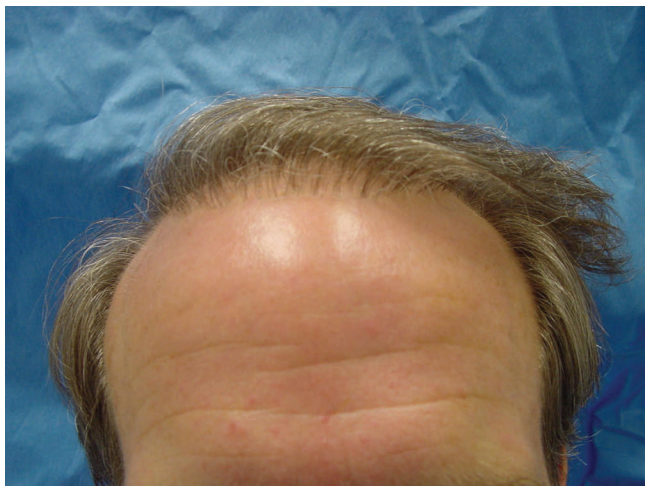

FIG. 3A. Before hair transplant.

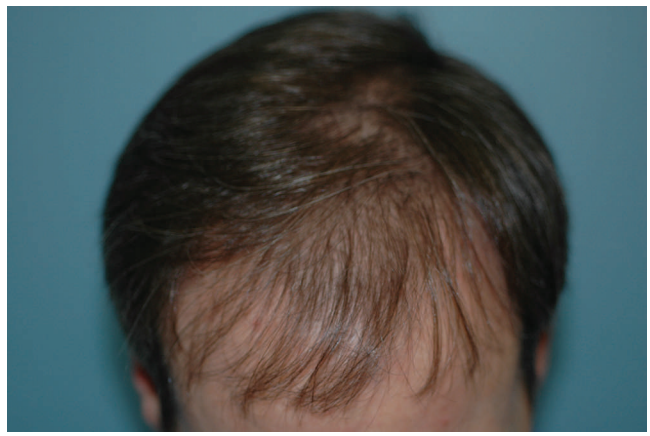

FIG. 3B. After 500 one to three hair grafts.

FIG. 3C. After two surgeries 1,300 grafts total.

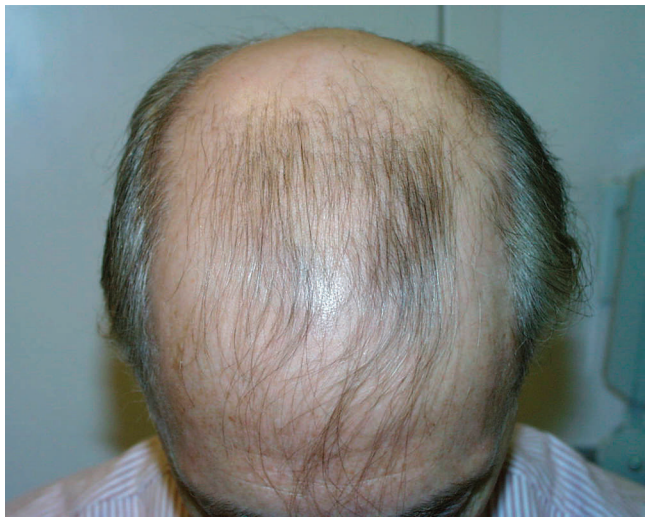

FIG. 4A. Before hair transplant.

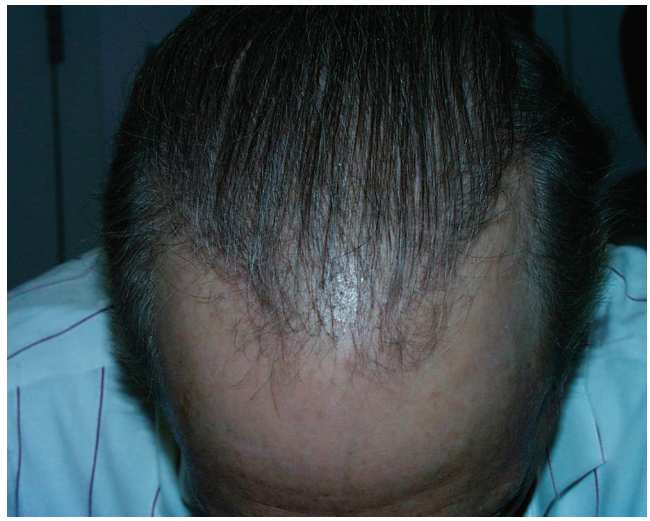

FIG. 4B. After 800 one to three hair grafts.

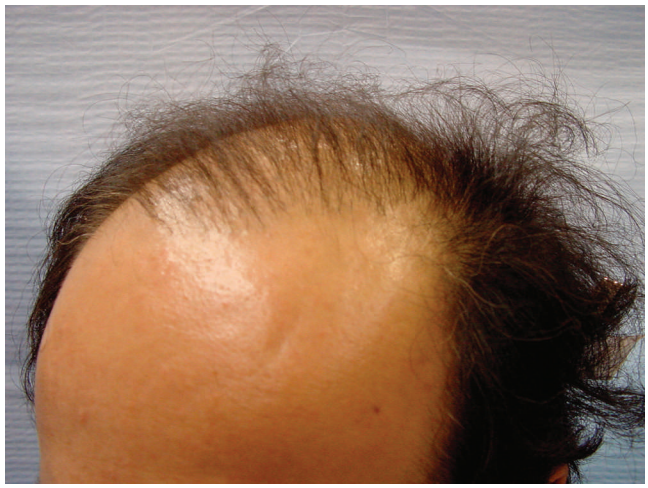

FIG. 5A. Before hair transplant.

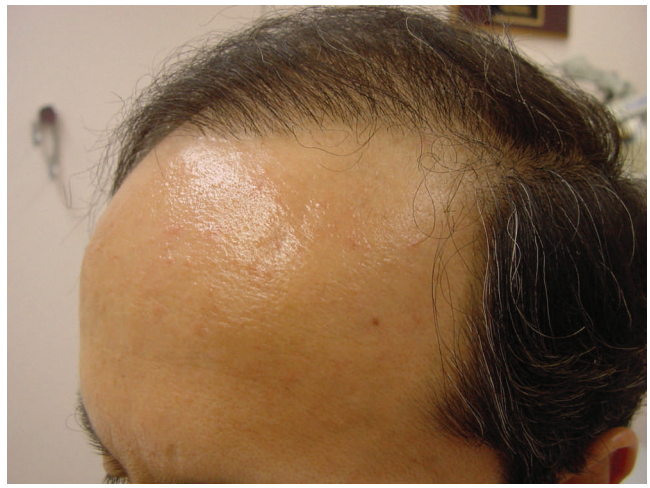

FIG. 5B. After 500 one to three hair grafts.

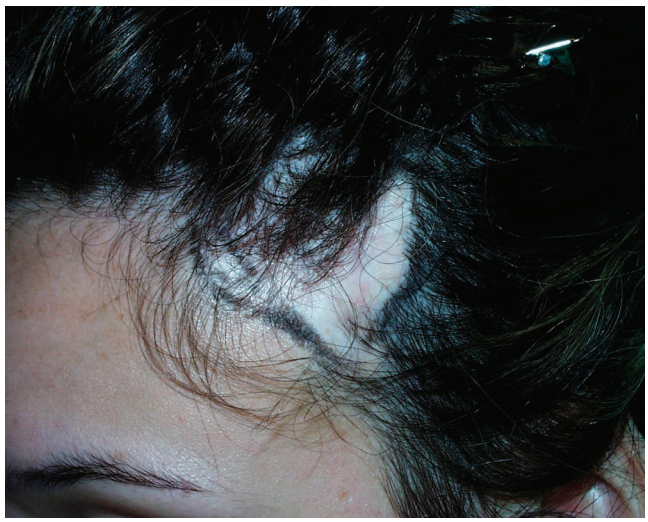

FIG. 6A. Before hair transplant.

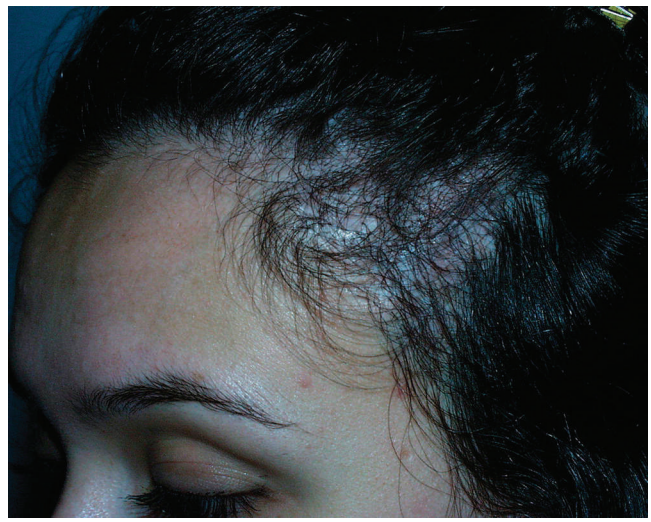

FIG. 6B. After 600 one to three hair grafts.

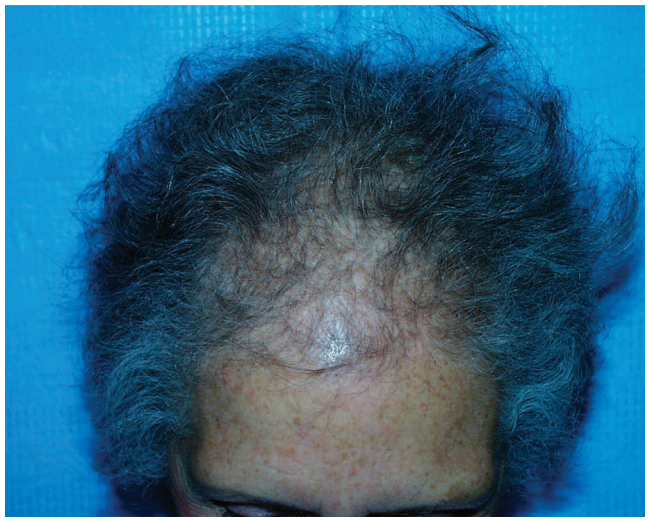

FIG. 7A. Before hair transplant.

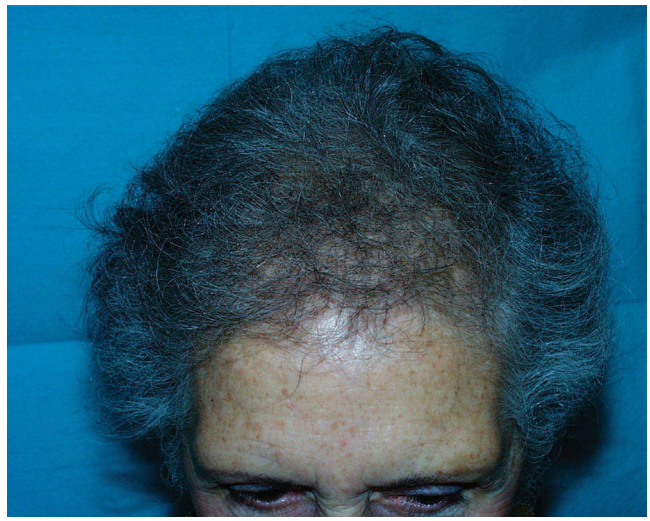

FIG. 7B. After 750 one to three hair grafts.

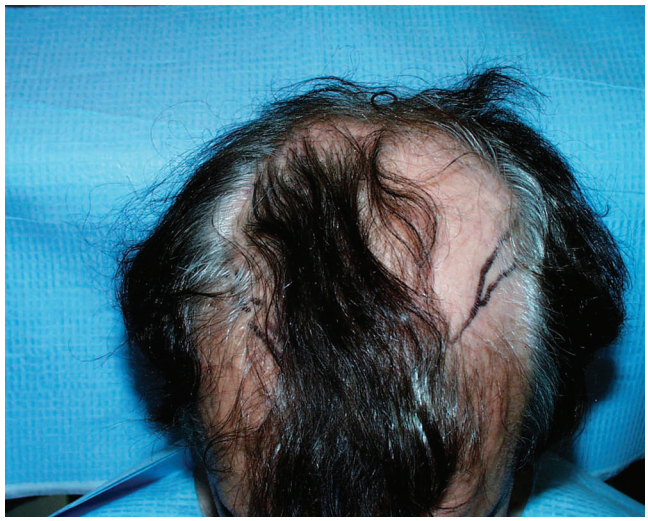

FIG. 8A. Before hair transplant.

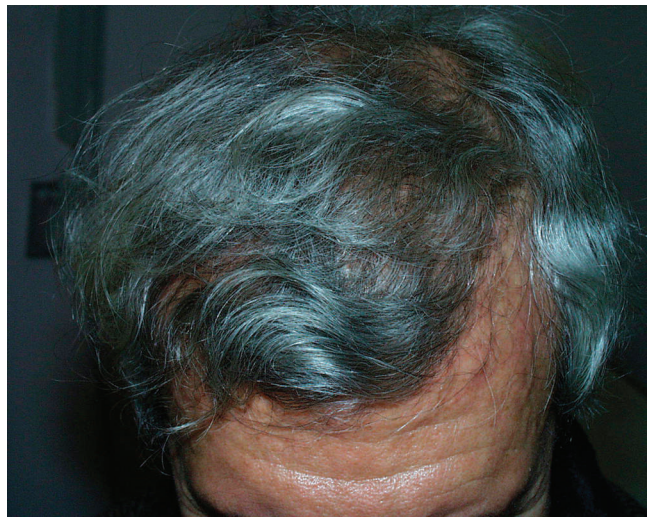

FIG. 8B. After 650 one to three hair grafts.

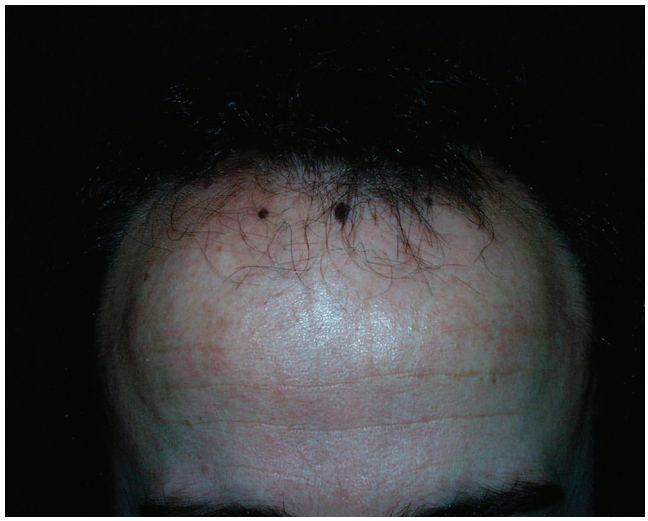

FIG. 9A. Before hair transplant.

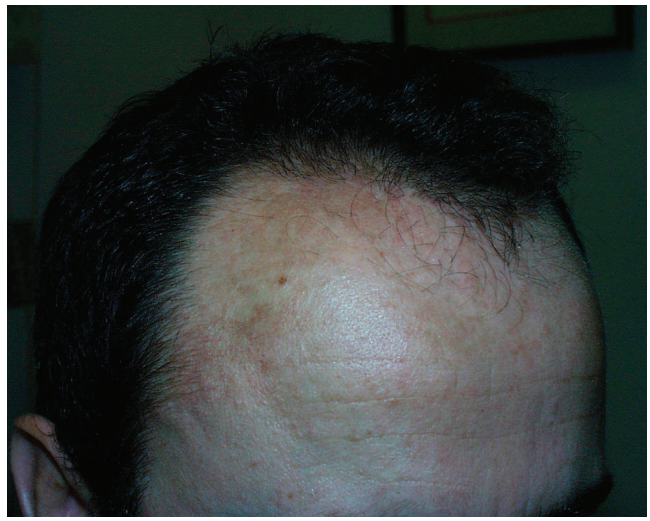

FIG. 9B. After 450 one to three hair grafts.

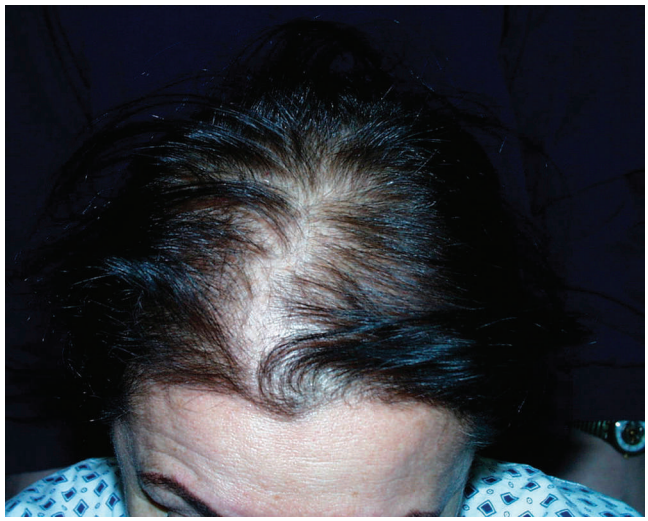

FIG. 10A. Before hair transplant.

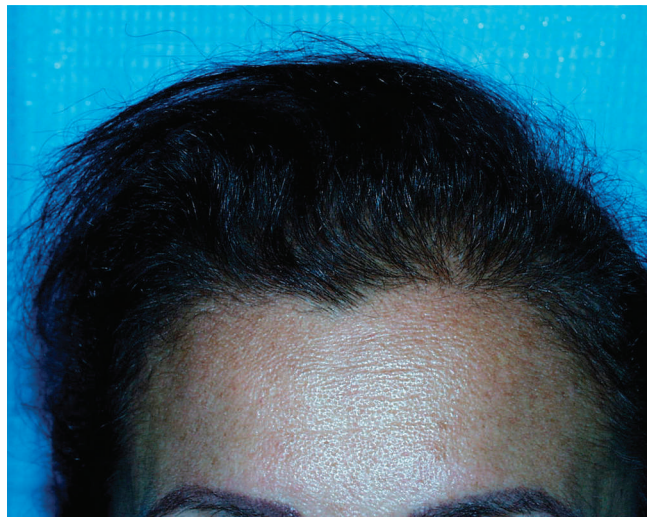

FIG. 10B. After 725 one to three hair grafts.

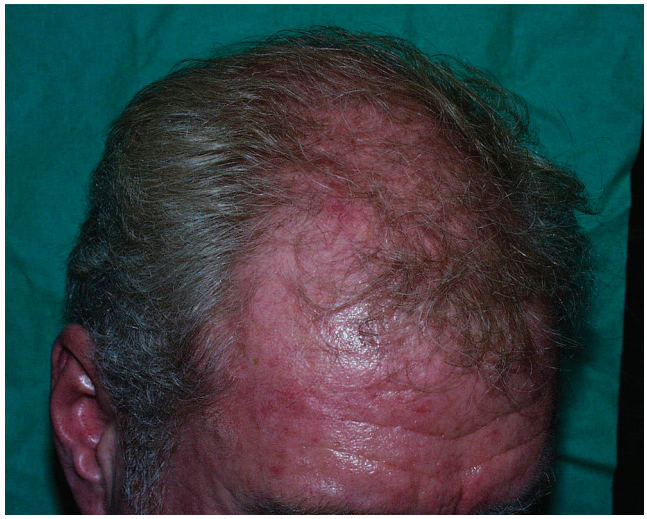

FIG. 11A. Before hair transplant.

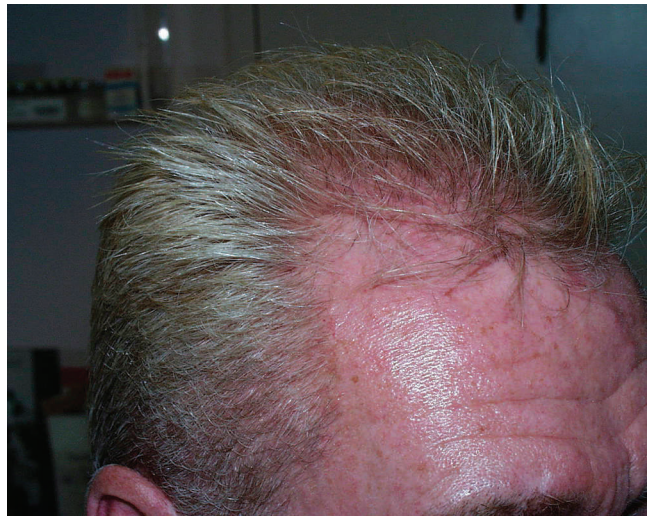

FIG. 11B. After 700 one to three hair grafts.

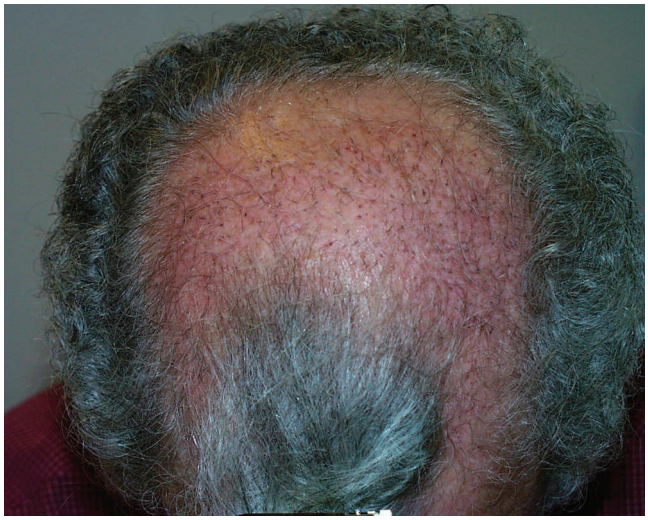

FIG. 12A. Before hair transplant.

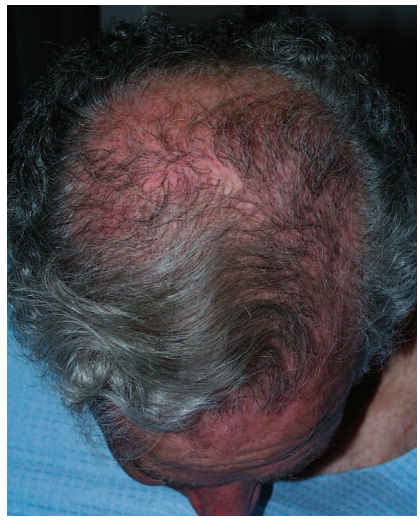

FIG. 12B. After 540 one to three hair grafts.

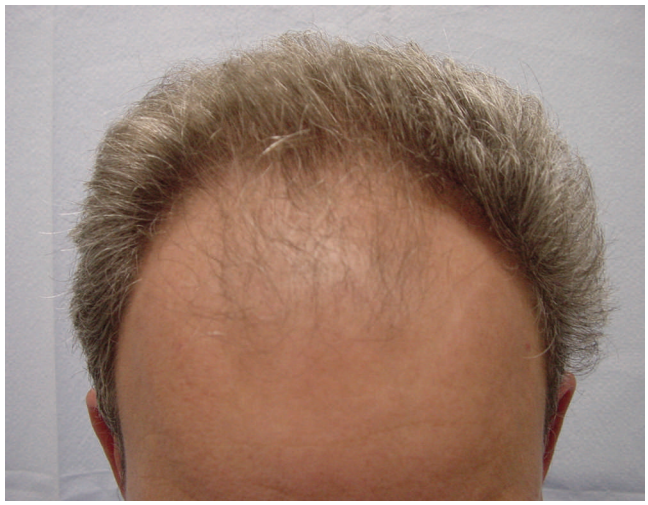

FIG. 13A. Before hair transplant.

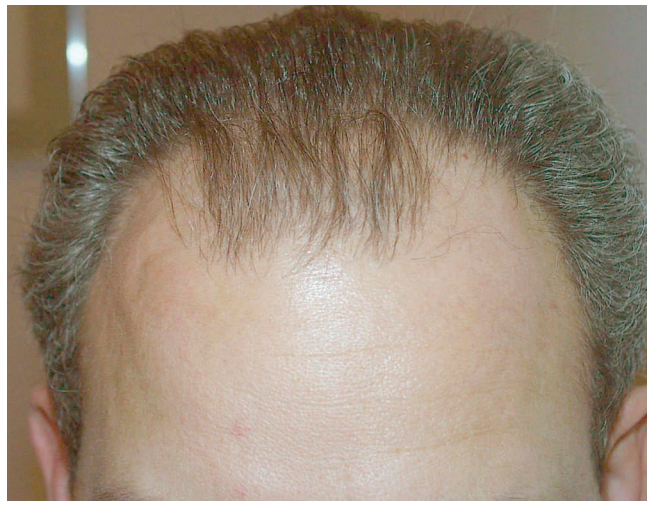

FIG. 13B. After 600 one to three hair grafts.

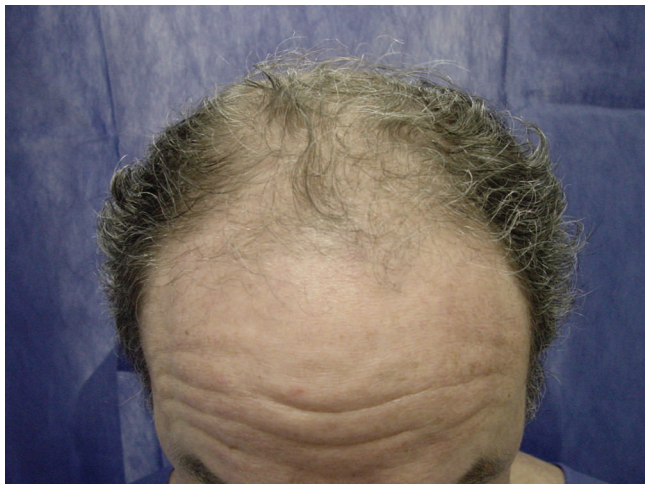

FIG. 14A. Before hair transplant.

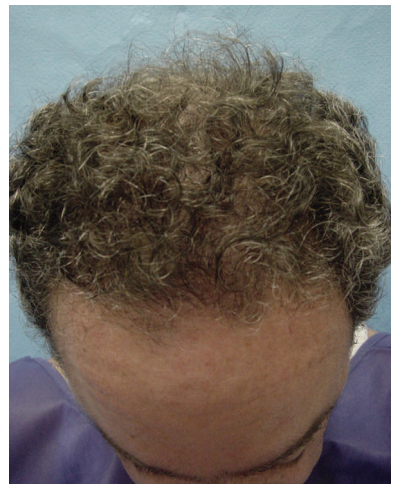

FIG. 14B. After 950 one to three hair grafts.

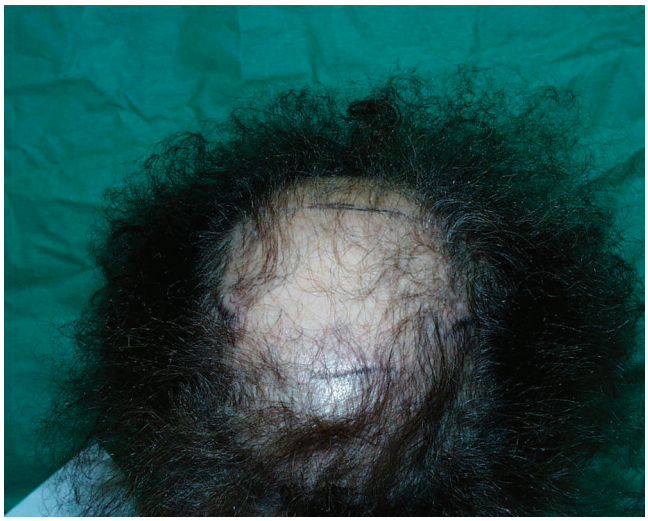

FIG. 15A. Before hair transplant.

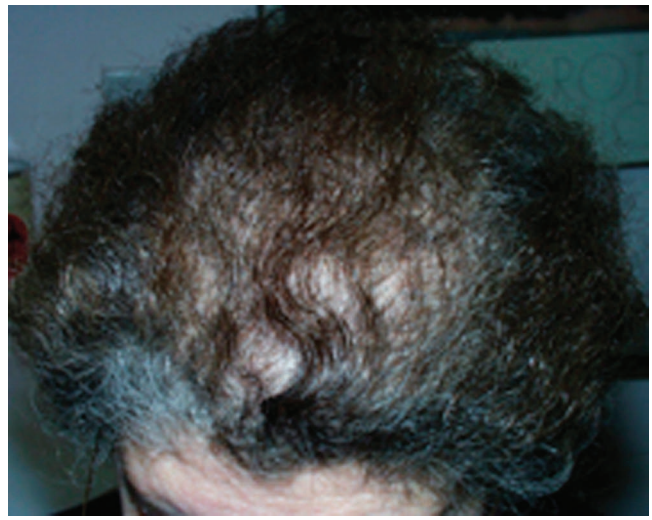

FIG. 15B. After 600 one to three hair grafts.

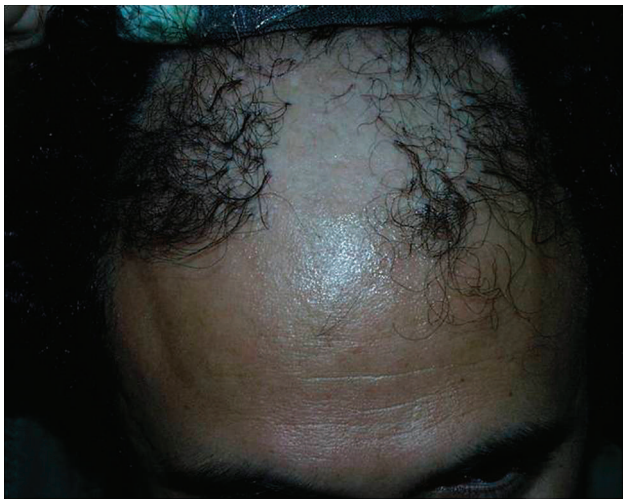

FIG. 16A. Before hair transplant surgery with hairpiece.

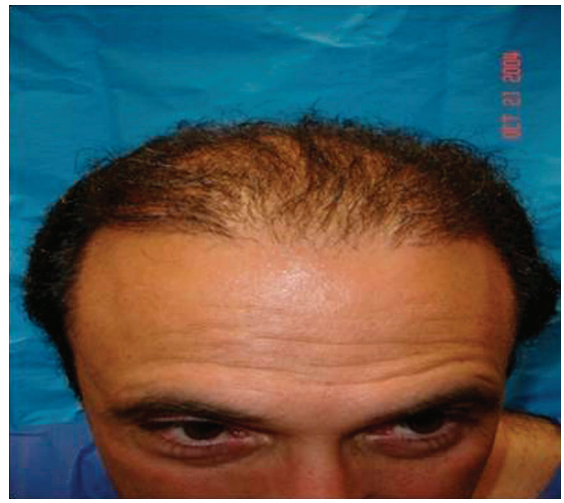

FIG. 16B. After hair transplant surgery.

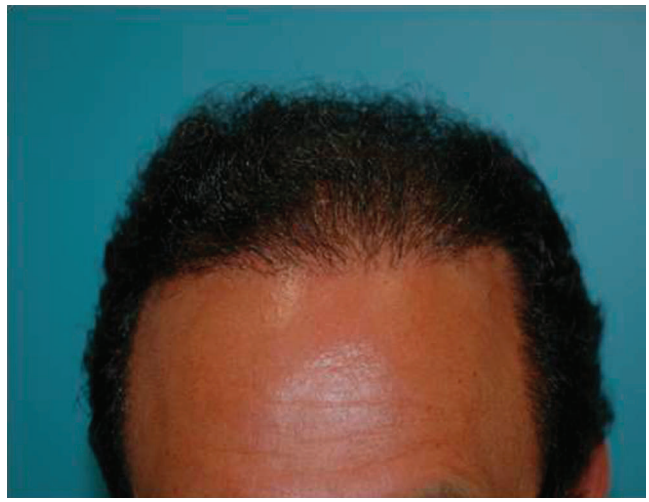

FIG. 16C. After hair transplant surgery with no hairpiece.

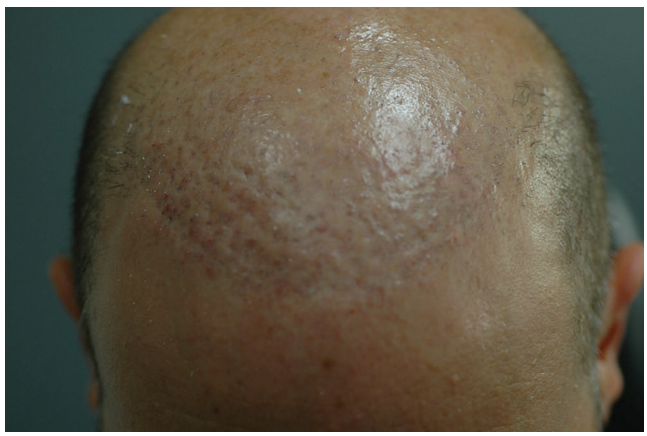

FIG. 17A. Before smooth beam procedure.

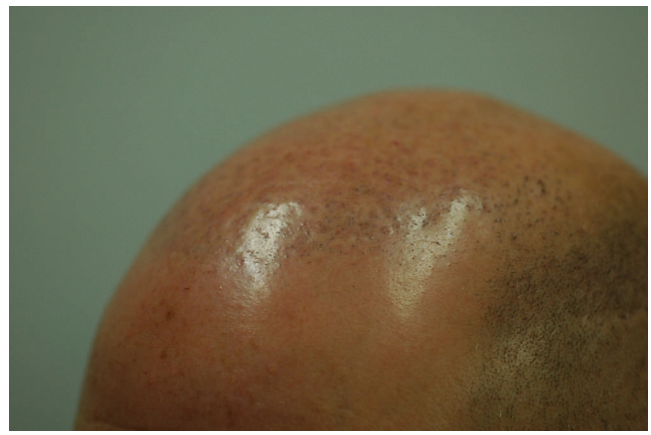

FIG. 17B. After three smooth beam procedures.

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