Hair Restoration Surgery

Hair Transplantation and Micrografting

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In the last decade or so, there has been a tremendous increase in interest in male pattern baldness (MPB) and hair transplantation surgery. This can be attributed to many factors, primarily the improvement in the results of hair transplant surgery through the utilization of micrografting techniques. In addition, medical therapy of MPB with the use of topical solutions such as minoxidil or the medication propecia (finasteride) has helped to increase public awareness and stimulated the search for other medical approaches for MPB. Finally, a vastly increased communication between surgeons performing hair transplantation and dramatic changes in medicine affecting cosmetic fields have served to organize and transmit the available knowledge about these procedures.

More than 40 years ago, Norman Orentreich authored a paper on MPB, in which his most important observation was that grafts from the hair-bearing rim of the scalp were "donor dominant," and continued to grow hair when implanted into thinning or bald areas. Thus evolved the concept of multiple scalp grafts for the treatment of baldness. This movement of hair grafts from permanently growing sites to balding areas is the foundation of hair transplantation and micrografting as we know it today. This procedure, although used primarily in androgenic alopecia (MPB), can also be used to cover scars secondary to scalp trauma, radiation and thermal burns, inactive phases of disease such as scleroderma and other cicatricial processes, and in some female alopecias. Because MPB is a genetically determined phenomenon, transplantation procedures move permanently growing scalp hair from the sides and back of the head to appropriate recipient sites in the frontal, crown, and vertex regions.

Obviously, hair transplantation requires skill and a strong aesthetic sense. Large donor plugs, or smaller mini- and micrografts must be taken from areas that have excellent prospects for not losing the ability to grow hair during that individual’s lifetime. Because hairs grow in specific directions, grafts must be placed in a precise way so that not only does hair growth look full and natural but also the pattern of growth conceals or masks the graft recipient sites, achieving proper angles for an attractive and complete result. Finally, each individual’s facial characteristics must be evaluated to create the most natural hairline and hair density while fully anticipating facial changes throughout the years.

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NORMAL HAIR GROWTH

Hair follicles initially appear in utero. No new follicles are created after birth and none are lost in adult life. The only factors that change are the density of the follicles (which spread apart as the body surface increases with growth and weight gain) and the type of hair. The first hair to be produced by the fetal hair follicles is lanugo hair, which is fine, soft, and unpigmented. This is usually shed by the eighth month of gestation.

The first postnatal hair is vellus hair, which is soft, fine, usually pigmented, and seldom more than 2 cm long. Vellus hair remains on the so-called hairless regions of the body, such as the forehead and balding scalp. The only completely hairless surfaces are the palms, soles, glans penis, and mucocutaneous junctions.

Hair growth on the human scalp is a kind of mosaic of follicular activity with alternating patterns of growth (anagen) and rest (telogen) separated by a transitional (catagen) phase. Scalp hair grows about 0.3 mm per day or 6 inches per year. Shedding 50 to 100 hairs a day is considered normal. When hair is shed, it is replaced by new hair from the same follicle located just below the skin surface. Anagen can be initiated by plucking the telogen hair from a resting follicle or by wounding. Furthermore, certain hormones such as estrogen, progesterone, testosterone, and thyroid hormone influence hair growth.

Hair is composed primarily of keratin protein, the same material found in fingernails and toenails. The most striking feature of the protein of a hair’s central cortex is the cysteine content, which is much higher than that of the outer matrix proteins. Hair color depends on the number and type of melanosomes acquired from melanocytes migrating into the hair bulb matrix. In dark hairs, melanosomes are large, ellipsoid, and rich in melanin. In red hairs, they are spheric. White, gray, and blond hairs contain few or minimally pigmented melanosomes.

MALE PATTERN BALDNESS

MPB is the change from terminal hair to vellus hair. The true dimensions and complexity of this process have been appreciated only recently. The progress of MPB is not linear; the condition develops in fits and starts. Terminal hair progresses to vellus hair far past the age at which it was thought one could delineate the extent of MPB. Surgeons performing hair transplant surgery today realize that it is not the dramatic changes in MPB that occur between the ages of 20 and 35, but what can happen from 40 to 50 and beyond.

In caucasians, normal male pattern hair loss is noticeable in about 30% of men by the age of 30 years, and in 50% of men by age 50. Certain racial groups including Japanese, Chinese, American Indians, and some tribes of Africans are relatively immune to the condition that in caucasians follows a dominant trait with incomplete penetrance. The expression of this sex-limited gene depends on the level of circulating androgen. This hereditary incidence is noticeable, not only in men but also in women who have a strong familial history of baldness.

In men, hair loss can begin as early as age 20. In normal hair loss, one to several hundred hairs fall each day and are replaced by new hair. In the evolution of MPB, the new hair is fine and thin. Eventually, nothing is left on the scalp but the almost imperceptible fuzz of vellus hair. Simultaneously, hypertrophy of the sebaceous gland and hypersecretion of the sebum usually occur provoked by androgenic stimulation of the pilosebaceous follicles, causing complete loss. MPB usually progresses in a definite pattern. First, the frontal hairline regresses, then loss of the more temporal hair becomes apparent with simultaneous thinning of the vertex. Ultimately, the most severe balding consists of total loss of the frontal and vertex hair. Norwood classified approximately seven different types of MPB. Identification of these types is key to an understanding of proper planning of hair transplantation surgery (Fig. 1).
Dihydrotestosterone (DHT) seems to be the specific hormone responsible for MPB. Genetic predisposition contributes to the topography of MPB owing to the number of testosterone receptors of the follicular cells and the activity of 5-alpha-reductase enzyme in different areas of the scalp. This enzyme reduces testosterone and inhibits protein synthesis by shortening the anagen phase, thereby producing finer and finer hair until it is eventually lost.¹²
CYLINDRIC, MICRO-, AND MINIGRAFTS

The success of hair transplantation and micrografting results from the fact that hair follicles that are moved from one location on the scalp to another will behave as they did in their original site. For example, even in cases of advanced MPB, hair continues to grow in the horseshoe pattern above the ears and neck, and it can be moved to the bald or balding areas. The usual method of implanting grafts involves three basic types of donor grafts taken from the hair-bearing posterior scalp.

Until recently, the most common type of graft was the cylindric plug (punch graft) of approximately 4 mm, containing 10 to 20 hairs removed from the hair-bearing area and placed in a somewhat smaller cylindric hole in the balding region of the scalp. In cutting the donor plug, care must be taken to angle the punch exactly parallel with the direction of the hairs and to angle it properly in the recipient hole so that the growing hair will appear natural. Depending on the degree of baldness, one to three sessions of transplantation are required per area, with the placement of 50 to 75 grafts at each session. If previous grafts were done, the later transplants are placed between the previous grafts to create a confluent pattern. Transplantation sessions are usually scheduled 2 to 3 months apart, so that older grafts can first receive and establish an adequate blood supply.

Micrografts and minigrafts represent the newest and most recent refinement in hair replacement surgery. Minigrafts consisting of four to seven hairs and micrografts consisting of one to three hairs are implanted along the anterior hairline to eliminate the doll's hair look that cylindric plugs could cause and give the most natural appearance to the hairline. These grafts are cut from donor strips taken by multibladed knives to allow precise visualization of the hair direction and permit careful creation of the proper-sized grafts (Fig. 2).

![Figure 2. Minigrafts cut in preparation for implantation.](image)

The tiny full-thickness grafts are then implanted into wounds made by either small blade (slits) or small puncture receptor sites created by needles and punches 1 to 2 mm in diameter. In fact, hair replacement surgery is now performed utilizing large quantities of mini- and micrografts alone. Sessions of 500 to 1000 grafts are commonplace; however, the density achieved with 4-mm punch grafts will require approximately five times as many mini/micrografts for a similar result.
HAIRLINE DEVELOPMENT

The positioning of the anterior frontal hairline is the most critical factor in the successful hair transplantation procedure. Successful placement begins with one’s understanding of the concept of facial thirds. The somewhat rounded and tapered frontal hairline is placed with the apex approximately 2 cm above the perceived frontal hairline as defined by dividing the face into thirds. The lateral points of the hairline are made perpendicular to a line drawn to the outer canthus of the eyes. This somewhat posterior placement of the transplanted surgical hairline is a representation of the mature male’s hairline through the normal aging process. In anticipating future hair loss, hair transplantation should provide an aesthetic result throughout the decades of life.

A successfully placed hairline at age 30 must also retain the same aesthetically pleasing look at age 60. Hairlines placed too low will, in most cases, be aesthetically unacceptable as the patient reaches the fifth and sixth decades of life. In addition, the repositioning of the surgical transplanted hairline will limit the number of grafts required for complete fullness and, therefore, help conserve the amount of donor hair used, especially in those individuals with more advanced patterns of balding.

The anticipated hairline is drawn with an indelible fine-point marking pen. It must be symmetric and properly placed. This is followed by the placement of the anticipated recipient sites behind and confluent with the marked hairline in a staggered fashion (Fig. 3).

Figure 3. The anticipated hairline—symmetrical and rounded. It acts as a guide in this patient for the placement of mini- and micrografts in both holes and slits (slits are often used to place grafts between remaining hair to preserve it as long as possible).
In essence, the choice of donor site is taken from the hair that would typically exist in a type 6 or 7 pattern. Thus, by visualizing the patient's head from behind, an arbitrary line drawn from the top of the ears would denote an area below which all hair would be genetically programmed to grow indefinitely when transplanted. Similarly, the hair remaining just above and behind the ears would appear to have that same potential.

**PUNCHES**

The original punches consisted of a barrel beveled internally at the cutting surface of various diameters. A hole placed halfway up one side provided drainage of fluids during use and facilitated cleaning. A straight knurled handle was used to insert the punch for an easy rotational motion during use. The original material used was stainless steel; however, significant advances have been made in the so-called Australian punch, which is made of carbon steel. These edges are far superior in sharpness and will allow two to three times more punch grafts than the traditional stainless steel punches before becoming dull. Punches must be razor sharp for proper results, and although punches can be resharpened, more than one resharpening after one to two uses is not recommended.

**PREOPERATIVE EVALUATION**

As in any surgical procedure, it is important to obtain an adequate medical history and perform a careful visual and manual examination of the donor and recipient areas. In those patients undergoing procedures for cosmetic purposes or enhancement, the expectations of the patient must be successfully determined and discussed preoperatively. Careful photodocumentation is also advisable.

**DONOR SITE PREPARATION AND ANESTHESIA**

After marking the recipient sites, appropriate donor areas are chosen that will match, as closely as possible, the texture and density of the recipient area. An area that will provide the needed number of grafts is clipped to a length of approximately 2 mm with either scissors or clippers. One must be able to see the angled direction of the hair growth as it emerges from the scalp in order to also achieve proper orientation in the recipient area (Fig. 4).

**Figure 4.** Prepared donor site. Note minimal scarring and preservation of donor hair from a previous procedure.
These hair follicles must also be visualized when using a multibladed knife to take a long strip required for mini- and micrograft preparation. The area is prepared with an adequate antiseptic solution, either iodophor or alcohol-soaked sponges, to clean and remove any spicules of hair remaining on the surface. With the patient in a sitting position, the donor site is anesthetized with lidocaine 2% with 1:100,000 epinephrine. Use of a vasoconstrictor is usually necessary to aid in hemostasis. A 30-gauge needle is used in a ring block for the recipient sites and subcutaneous infiltration for the donor sites. Nitrous oxide and oxygen or intravenous sedation can also be utilized during the injection of local anesthesia, which lasts approximately 1 to 2 minutes. Approximately 10 to 15 minutes are required for full vasoconstriction to take place before the procedure is begun.

**HARVESTING DONOR STRIPS**

Complete preparation of the recipient site involves the use of recipient punches for mini- and micrografts, that is, a stab wound or small needle (punch) site at each previously marked position. These wounds are created prior to the dissection in harvesting of grafts so that bleeding will have ceased before one attempts to insert the grafts (Fig. 5A and B).

![Figure 5. A. Preparation of recipient sites to correct a receding hairline. B. Frontal recipient sites creating a natural front hairline. The vertex can be left ungrafted in patients with extensive patterns of hair loss and marginal quantities of donor hair. Scalp lifting or reduction is another option.](image-url)
Sites are generally made so that the slit or puncture wound is at a right angle to the curve of the scalp. The only requirement is that the blade or recipient punch pass deep to the skin and subcutaneous tissue. Punched-out skin from the recipient sites is removed completely and grafts are then harvested. The patient, in a sitting position with the head firmly fixed, has the donor site injected with physiologic saline until maximum turgor is obtained, so as to minimize skin distortion during the procedure.

Because hair transplantation involving mini- and micrografting has now evolved into a procedure generating and moving hundreds of much smaller grafts, the process of cutting hundreds of small grafts adds significant time and complexity to the transplant procedure. To simplify and accelerate the production of grafts, donor scalp is often harvested as long narrow strips with the aid of a multibladed knife. Grafts of single hairs, two to three hair bundles, or four to seven hairs can be visualized easily and quickly cut from narrow donor strips (Fig. 6).

![Figure 6. Combinations of micro-, mini- and larger (approximately 4 mm) grafts can also be used. Larger grafts create greater density, but can create a cornrow effect when placed in the hairline.](image)

Obtaining donor tissue as long narrow strips with a multibladed knife has become a mainstay of the transplant procedure for many surgeons, with the ideal strip defined as that which has a full complement of viable intact hairs along the entire length with a minimal number of transected hairs. The two key elements for cutting perfect strips are tumescence and proper angling of the cutting instrument. Maximal tumescence must be obtained by injecting normal saline both subcutaneously and intradermally. The multibladed knife is held by the fingers, and the angle of the knife is constantly changed, maintaining consistent alignment with the hair direction and checking for both parallel alignment of the knife blade and the donor hairs. Depths greater than 6 mm should be avoided to minimize the chance of excessive bleeding, and after a single pass with the multibladed knife, strip removal is accomplished with super sharp scissors that are used to cut along a precise plane approximately 1 to 2 mm below the level of the hair follicles. Spacers of 2 to 3 mm define the width of strips, which are best cut only into the fat layer, avoiding the galea aponeurotica (Fig. 7, A–C).
Figure 7. A–C. Note the direction of the multibladed knife with spacers to define strip width. The harvested strips can be sectioned into grafts of various sizes, usually under magnification of at least 2 to 3 times, or by use of a dissecting microscope.
When the harvesting of mini- and micrografts is complete, the donor site is generally closed in one continuous layer with 3-0 Vicryl sutures (Ethicon, Somerville, NJ), providing a thin donor line and actually enhancing the amount of donor hair available for subsequent transplant procedures.\textsuperscript{4,9}

THE RECIPIENT AREA

The recipient hole is approximately 0.25 mm smaller than the donor graft, and the graft is inserted to test for snugness of fit. Snug fit is essential because revascularization of the graft depends on growing of blood vessels from the dermis of the recipient scalp into the dermis of the graft. The recipient site must be acutely angled to match the angle at which the original hair emerged from the scalp. Usually, there is some terminal or lanugo hair to help determine this angle, but essentially all hair is placed in a forward direction (Fig. 8A and B).

Figure 8. A, Marking for micrografts to thicken and restore a partially receding hairline. B, Grafts in place with hair angled in specific directions. Adjacent hair can help determine these angles.
This angling of the recipient site improves the direction of hair growth and lengthens the recipient site, better accommodating the graft from the thicker donor skin and preventing elevation of the graft.\textsuperscript{5} Micrografts and minigrafts are implanted with a small jewelers' forceps to place the grafts into scalpel slits, needle holes, or recipient zones created by small punches (Fig. 9A and B).

\textbf{Figure 9.} \textit{A}, Frontal mini- and micrografts in holes. The remaining hair is too thin to preserve. \textit{One day post-operative. B}, Prepared micro slits. As hair is lost later in life, subsequent procedures would be indicated.
Inexperienced operators will encounter considerable difficulty at first, and it is important that the recipient sites have reached the sticky stage of coagulation before implantation is attempted, usually in 5 to 10 minutes. Remember that, for micrografts, gentle pressure is applied with a swab or a finger to adjacent grafts while grafts are inserted. Unquestionably, these procedures cannot be performed with consummate expertise and in a timely fashion without employing a well-trained transplant team consisting of (1) the surgeon who prepares and marks the operative sites and obtains the donor grafts, and (2) technicians who cut the grafts and place them just as rapidly as they are taken.

**POSTOPERATIVE CARE**

The donor and recipient sites may or may not be bandaged. If bandaging is preferred, a nonadhering Telfa (Kendall Company, Boston, MA) pad coated with vitamin E cream is placed over the operative sites. Several layers of flattened gauze sponges (4 × 3 inch) are then used to hold the Telfa in place as the scalp is wrapped with a clean bandage using two to three 4-inch gauze rolls. The dressing is removed the following morning, and the scalp and each graft are cleansed meticulously with a cotton swab and hydrogen peroxide. The hair is washed and styled to cover the operative sites. The patient is mandated to wash the hair twice a day for the first 3 days following each transplant procedure. Suture removal, when necessary, is accomplished 1 to 2 weeks after each procedure. The patient, of course, must be aware that a lag phase exists before hair growth is initiated. After approximately 3 months, the telogen phase of the implanted grafts ends and anagen begins (Fig. 10A–C).

*Figure 10. A–C, Patient showing early (3 month) growth of the initial mini-micrografting procedure (600 grafts).*
COMPLICATIONS

Bleeding, both during and after the operation, is the most common complication. It usually occurs in patients who have taken aspirin immediately prior to the surgery, so all patients are asked to abstain from aspirin or aspirin-containing products for at least 2 weeks prior to each transplant procedure. Operative bleeding is controlled by pressure, injection of additional epinephrine-containing anesthetic and saline into the bleeding site, or suturing. If adequate control takes place during the procedure, then postoperative bleeding is rare.

Edema of the forehead may occur starting on the third or fourth postoperative day. It probably results from excessive anesthetic volume or surgical trauma, and it is particularly disturbing in the frontal area, because most patients consider it to be cosmetically annoying. This swelling requires no treatment; however, it is our impression that systemic corticosteroids help eliminate this problem. Our regimen includes 12 mg of dexamethasone, intramuscularly, at the time of surgery followed by a 5-day postoperative course of decreasing dexamethasone dosage orally.

Infection is a possible complication, although the use of postoperative antibiotics and the requirement that patients wash their hair twice a day for the first 3 days prior to each surgical procedure virtually eliminates this potential. Patients are given 500 mg of tetracycline for 5 days postoperatively twice a day (Decadron 5-12 Pak, Merck, West Point, PA).

Cobblestoning or irregular elevation of the grafts is prevented by proper graft placement and by adequate cleansing postoperatively the morning after each surgical procedure (Fig. 11A–F).

Figure 11. Preoperative and postoperative results in patients with minimal hairline recession (A and B), a completely restored receding hairline (C and D), and restoration of Norwood type 6 extensive hair loss pattern (E and F).

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Hypertrophic scarring occasionally occurs in patients with a history of poor scar formation. In this case, a trial transplant is undertaken with a limited number of grafts, in an unobtrusive area, using different size donor plugs and making certain that they fit snugly in the recipient sites. If scarring and poor growth occur, further grafting on that patient should not be done.3

References


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