Hair Restoration
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The use of micrografts (one or two hair follicular unit grafts) and minigrafts (three or four hair follicular unit grafts) in large numbers has revolutionized hair restoration in aesthetic and reconstructive cases and has rapidly become the technique of choice in most cases. The use of single-hair grafts is not a new concept. Tumura [1] in 1943 was the first to report the use of single-hair grafts to restore pubic hair. Fujita [2] in 1953 reconstructed eyebrows with single-hair grafts.

The first reports on the use of single-hair grafts on the scalp were by Nordstrom [3] in 1980 and Marritt [4] in 1981 who introduced the use of single-hair grafts to the front hairline to camouflage plugs and scars from previous hair restoration procedures. This provided natural-looking hairlines by providing a transition zone in the front. It was, however, time-consuming and at that time it did not seem to be a viable alternative to restore hair for larger areas of hair loss.

In 1991, Uebel [5] introduced the use of micrografts (1–2 hair grafts) and minigrafts (3–4 hair grafts) in large numbers (1000–1200 grafts) to cover large areas of hair loss, such as the entire top of the head in cases of male pattern baldness (MPB). The author has subsequently further increased the number of grafts transplanted in a single session up to 2500 and has described multiple other applications for micrografts and minigrafts, such as restoring natural-looking hair in the face and scalp (eg, restoring natural-looking sideburns, eyebrows, mustaches, beard) and, more recently, other body areas including lower legs [6–12].

In 1984, Headington [13] described an important concept in hair anatomy—the follicular unit. When we study the histology of skin (scalp), traditionally we see vertical sections. Headington studied transverse microscopic sections of the human scalp and noticed that hair grows in follicular units of one, two, three, or four hair follicles with their independent neurovascular boundless, sebaceous glands, sweat glands, and pilo-erectile muscle surrounded by a sheath of collagen (Fig. 1). These follicular units seem to be true physiologic units. Maintaining them as intact as possible seems to increase the survival and ultimate hair growth of the grafts.

The life-cycle phases of a hair follicle

Anagen is the actively growing phase. In this phase, the follicular cells are actively multiplying and keratinizing. In a nonbalding scalp, normally about 90% of the hairs are in this phase, which lasts about 3 years. During the catagen phase, the base of the hair becomes keratinized, forming a club, and separates itself from the dermal papilla. It then moves toward the surface and is eventually connected to the dermal papilla only by a connective tissue strand. This phase lasts 2 to 3 weeks. During the telogen phase, also called the “resting phase,” the attachment at the base of the follicle becomes weaker until the hair finally sheds. During this period, the follicle is inactive, and hair growth ceases. This phase lasts 3 to 4 months and commonly occurs after hair transplantation. For this reason, significant growth of the hair grafts is not seen until this phase is over. Some of the native hair often goes into the catagen and then into the telogen phase from the insult of the surgery; this is called telogen effluvium.
I use one- and two-hair follicular units as micrografts and three- and four-hair follicular units as minigrafts (Fig. 2). When dissecting grafts I keep two, three, or four hair follicles together as a unit and preserve the tissue around the hair shaft of single hair grafts to make sure I preserve all the vital components.

The appearance of fullness has to do with hair mass, which is related to the number of hairs, the thickness of the individual hair shafts, the texture and color of the hair, and the curliness of the hair. The contrast of colors between the scalp and the hair has a significant influence on the optical illusion of fullness. The average healthy nonbalding patient has a density of about 200 hairs/cm² (range 130–280); only 50% of this number is needed to give an appearance of normal density, which is about 100 hairs/cm² (range 65–140). This number can be transplanted in two sessions of micrografting and minigrafting.

**Patient selection**

We have no method to create new hair. All current techniques for hair restoration involve redistributing the patient’s existing hair. Therefore, candidates for hair transplantation are limited to those who have a favorable donor site surface area and density relative to the size of the area to be transplanted. Several centers worldwide are working on tissue engineering in an attempt to clone hair follicles or culture and multiply hair follicles in the laboratory setting. When successful, we will be able to treat patients with limited donor hair and need only harvest a sample of hair follicles. This would eliminate donor site morbidity and discomfort almost completely.

MPB is a progressive condition. The rate of hair loss may slow down after 40 years of age, but it never stops completely. Therefore, the preoperative plan must ensure a natural-looking long-term result. Good communication with patients is essential to establish realistic expectations.
Reconstructive applications of micrografts and minigrafts

Micrografts and minigrafts grow anywhere on the face and thus are useful for restoring sideburns, temporal hairline, eyebrows, mustache, beard, etc. The most common reasons for using micrografts and minigrafts in reconstructive cases include (1) revision of unfavorable results from previous hair transplantation procedures (eg, the plug look, corn field rows, and hairline scars); (2) post-surgical conditions, such as the lost sideburn and temporal hairline after facelift and other facial rejuvenating procedures; (3) post-traumatic injuries; (4) correction of hair loss burn injuries; and (5) certain congenital conditions, such as the absence of hair on the prolabium in cases of bilateral cleft lips, hair loss due to excision of congenital hairy nevus, arterio-venous malformations, or after involution of strawberry hemangiomas.

Technique

For cases of MPB I normally do between 1000 and 2500 grafts per session (megasessions) depending on the degree of hair loss. This labor-intensive procedure requires an organized and efficient surgical team. My surgical team consists of three surgical assistants and myself. I remain in the operating room for the duration of the procedure and insert all grafts personally. Efficiency is the key when transplanting a large number of grafts in a single session.

The patient is placed in the supine position and mildly sedated with midazolam (2–10 mg) and fentanyl (25–50 μg), which are titrated for each patient. I usually treat pediatric patients under general anesthesia. The patient’s vital signs, EKG, and O₂ saturation are monitored throughout the procedure.

Supraorbital and occipital nerve blocks are established with 0.5% bupivacaine with 1:200,000 epinephrine (~30 mL). This includes a ring block just below the proposed hairline. A tumescent solution of 0.5% lidocaine with 1:200,000 epinephrine is infiltrated in the donor site. The patient’s head is turned to the left, and harvesting of the right half of the donor ellipse is begun immediately.

Under 3.5× loupe magnification with Personna Prep Blades, thin slices (1.5–2.0 mm) are dissected from the donor ellipse over a sterile wooden board and handed to the assistants. The assistants prepare the final grafts from these slices while the surgeon closes the right half of the donor strip. Careful dissection of the thin slices into micrographs and minigrafts is the most tedious part of the procedure and one of the most important steps. The incisions must be made precisely parallel to the hair shafts at all times to minimize the loss of hair follicles.

Graft dissection

To dissect the slices into micrografts and minigrafts, the assistants use 3.5× loupe magnification,
no. 10 Bard Parker blades, and jewelers forceps. They generally work over a wooden board that has been autoclaved. The darker and thicker the individual hair shafts, the easier it is to dissect the grafts. The ideal grafts have intact hair shafts all the way from the subcutaneous fatty tissue to the scalp surface, are somewhat thick, and contain from one to four hairs. They must be handled as atraumatically as possible. The grafts are held by the fatty tissue under the hair bulbs or by the tissue around them, not by the hair bulb or dermal hair papilla.

In cases of very-light-colored or white hair, we use microscopes (10×) for a safe dissection of the grafts (I prefer the Mantis Microscope). The surgeon turns the patient’s head to the right for harvesting the left half of the donor ellipse. The surgeon closes the left side donor site and finishes slicing the remaining segment of the donor ellipse into slides. Several

![Figures A to F](image_url)
hundred grafts have been dissected at this point. They are lined up in rows on a wet green or blue towel and are ready for insertion. The process of graft dissection and insertion continues until all the grafts are transplanted.

It is imperative to keep the grafts wet in normal saline solution and chilled to approximately 4°C until they are lined up for insertion. If the graft becomes desiccated, no hair growth will occur.

Key points to remember in graft dissection are:

- Maintain the follicular units as intact as feasible.
- In patients with dark hair, 3.5× loupe magnification is sufficient to dissect most grafts as follicular units.
- In patients with light hair or gray hair, surgical microscopes and background lighting may be needed for more accurate dissection.

Fig. 5. A 58-year-old woman who lost her sideburns due to a facelift procedure. (A) Before. (B) Planning the hairline to be restored. (C) At the end of surgery, she received 400 micrografts and minigrafts (200 per side); side view. (D) One year after, side view. (E) One year after, oblique view. Notice the direction of the hair growth and the absence of detectable scarring.
Graft insertion

Infiltration of tumescent solution into the recipient area is important for several reasons, the most important of which are to promote hemostasis and to produce temporary edema of the scalp, which facilitates graft insertion. I inject 150 mL of 0.5% lidocaine with 1:200,000 epinephrine when transplanting 2000 or more. If good hemostasis is not obtained with this amount of solution, I increase the epinephrine strength to 1:100,000. Optimal hemostasis is often achieved if the tumescent solution is infiltrated in thirds. I first inject the anterior region once a large number of grafts have been inserted. I proceed posteriorly, doing the same for the middle third and the posterior third. Doing this allows us to take advantage of the peak times of epinephrine effect.

As fibrinogen turns into fibrin, the grafts adhere better to the recipient slits. We repetitively return anteriorly to insert more grafts, packing them densely to minimize popping out of neighboring grafts. The epinephrine effect is often still adequate when returning to the anterior region to place additional grafts; otherwise, we re-inject.

I use a slit-and-insert technique, so there is no need for punch removal of scalp or dilators. A slit is created, and immediately a graft is inserted (Fig. 3). I use 22.5 sharp point blades at and 1 cm in front of the hairline to create a nice transition zone, intentionally making a slight irregularity to mimic nature. With these blades, the scars are undetectable. Posterior to that I prefer to use no. 11 Feather Personna blades.

Fig. 4 shows an example of a 28-year-old man with MPB V before and a year after a single megasession of 1783 micrografts and minigrafts.

On the face, the technique of graft insertion is similar but more difficult because there is much more tendency for grafts to pop out as others are inserted. My experience in restoring the eyebrows, mustache, or beard has shown that it is best to make most or all of the slits initially and insert the grafts later to minimize this problem.

Fig. 6. A 39-year-old male third-degree burn victim. (A) Before. (B) Surgical planning of the hair to be restored outlined by marking pen. (C) One year after a single session of 180 micrografts and minigrafts. (D) Close up, after.
On small cases, the grafts are harvested from a small donor ellipse from the occipital area posterior to the mastoid prominence and dissected as for scalp transplantation. The size of the donor strip varies from very small to a large depending on the number of grafts needed and the donor site hair density.

The slits on the face are made with a no. 22.5 Sharpoint blade. You can also use a NoKor 18-gauge needle, always inserting the blade at the angle of the desired direction of hair growth, laterally and upward following the direction of the natural eyebrows. In the case of sideburns or temporal hair line, mustache, or beard, we angle the blade with which we are making the slits so it orients the hair growth in the proper direction.

Fig. 5 shows a 58-year-old woman who lost her sideburns secondary to a facelift procedure. She underwent 400 micrografts and minigrafts (200 per side). Fig. 6 shows an example of a 39-year-old male third-degree burn victim with loss of moustache hair before and 1 year after a single session of 180 micrografts.

For dressings I generally use one or two layers of adaptic, Kurlex, and a 3-in elastic Ace bandage for the scalp. I use adaptic, gauze, and 0.5-in SteriStrips or hypoallergenic paper tape (Micropore) on the face.

The hair transplanted to the face is usually harvested from the scalp, so it has the characteristics of scalp hair and thus needs to be trimmed frequently. Axillary or pubic hair can be used but require a larger donor ellipse because these areas normally have less hair density.

When revising previous hair transplantation if the plugs are large, I usually combine plug reduction (partial removal of the plugs) and recycle the plugs as micrografts and minigrafts and use additional grafts (if available) in front and between the plugs to obtain optimal improvement [14,15]. The plug reduction is done by coring out hair follicles with a 2- to 4-mm Punch biopsy forceps. The insertion of the grafts is done as described previously.

### Problems and complications

As with a face-lift procedure, patients are told to expect dysesthesia and hypesthesia cephalad to the horizontal donor site closure. This resolves within a few weeks to months.

I have encountered few complications. In 9 years I have treated over 500 patients without a single incidence of infection or hematoma. In one patient who had undergone four hair plug procedures elsewhere, a minor dehiscence occurred at the donor site closure (<1 in), but this granulated and healed spontaneously. In two patients, one who was African American and the other of Mediterranean origin, keloid scars developed at the donor site only.

Initially, many patients had ingrown hairs and small inclusion cysts because I inserted the grafts too deep. I learned to prevent this by leaving the epidermis of the grafts slightly superficial to the epidermis of the recipient scalp, which also prevents small-diameter pitting.

### Summary

For aesthetic and reconstructive hair restoration cases I prefer the use of micrografts and minigrafts for several reasons:

- There is a natural short-term and long-term result.
- There is minimal (usually undetectable) scarring.
- Minimal down time can often be accomplished in just one session or two sessions. There is quick healing and recovery.
- The direction of the hair can usually be controlled by angling the surgical blade (the most difficult areas include eyelashes and eyebrows).
- The desired hairline design can be controlled with precision.
- There are no worries about flap ischemia, tip necrosis, or expander exposures and extrusion.

In my experience, micrografting and minigrafting provide a high level of patient satisfaction.

### References


