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# CME article Part II. Hair transplantation: Surgical technique



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## Learning objectives

After completing this learning objective, the reader will be able to describe different methods to achieve effective and durable anesthesia in hair transplantation; to describe the harvesting technique method of follicular unit excision (FUE); to compare the differences between FUE and the strip harvesting techniques, and their indications; to classify and discuss the variety of punches and devices available for FUE harvesting; to describe the different methods of graft implantation; and to list and discuss the most common complications in hair transplantation.

## Disclosures

### Editors

The editors involved with this CME activity and all content validation/peer reviewers of the journal-based CME activity have reported no relevant financial relationships with commercial interest(s).

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The authors involved with this journal-based CME activity have reported no relevant financial relationships with commercial interest(s).

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The second part of this hair transplantation review concentrates on the technical aspects of the surgery. First, we review the 2 main local anesthetics used in hair transplantation, lidocaine and bupivacaine, how to achieve long-lasting local anesthesia, and what techniques can be used to minimize the pain associated with anesthetic infiltrations. Second, we review the 2 donor harvesting techniques currently used: strip harvesting follicular unit transplantation and follicular unit excision. The technical aspects of each technique are described in detail, along with their advantages and disadvantages. Third, the different methods of graft implantation currently used by the majority of hair surgeons are discussed, including premade sites and stick-and-place and the use of tools such as implanters. Fourth, postoperative care, expected results, and the main complications involved in hair transplant surgery are reviewed. (J Am Acad Dermatol 2021;85:818-29.)

## ANESTHESIA

### Keypoints

- Hair transplantation is performed under local anesthesia, commonly using lidocaine and bupivacaine.

- Small-caliber syringes and needles, vibration anesthesia, and blunt microcannulas minimize pain during infiltration.

Hair transplantation is performed under local anesthesia. An oral anxiolytic may be given

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*Abbreviations used:*

FU: follicular unit  
FUE: follicular unit excision  
FUT: follicular unit transplantation

30 minutes before surgery (2-10 mg of diazepam, 7.5 mg of midazolam, or 0.5-1 mg of alprazolam). The 2 most commonly used local anesthetics are lidocaine 1% with epinephrine 1:200,000 and bupivacaine 0.25% with epinephrine 1:200,000.<sup>1</sup> Pain during infiltration can be minimized by injecting the anesthetic with small-caliber syringes (1-3 mL Luer lock) using 30-gauge needles and blunt microcannulas, and applying vibration anesthesia.<sup>2,3</sup>

The first author recommends using 25-gauge microcannulas with a modified tumescent anesthetic solution, prepared by mixing 30 mL of lidocaine 1%, 70 mL of saline, and 0.4 mL of adrenaline 1:1000, giving a 100-mL solution of lidocaine 0.3% with adrenaline 1:250,000.<sup>4</sup> The anesthetic is injected first as a ring block in the lower occipital donor area margin to anesthetize the occipital nerves that run upward (Video 1). If required, local infiltration touch ups can be given during the harvesting procedure. In the recipient area, the anesthetic solution is injected as a ring block 1-2 cm below the proposed frontal and/or temporal hairline. Administering the anesthetic at different time intervals and not all at once, plus the dilution of lidocaine in the tumescent solution, decreases the peak plasma lidocaine concentrations, providing a greater measure of safety.<sup>5,6</sup> Although not essential, some surgeons like to perform a bilateral supraorbital nerve block.<sup>1</sup>

Because lidocaine has a very rapid onset effect but lasts only 2-3 hours, bupivacaine 0.25% containing epinephrine 1:200,000 is injected in the frontal hairline as a ring block around 2 hours into the procedure. The use of bupivacaine achieves a longer-lasting anesthesia (3-8 hours) for the rest of the procedure.

The accepted maximum dose for lidocaine 1% with epinephrine is 7 mg/kg and for bupivacaine 0.25% with epinephrine, 3 mg/kg.<sup>7</sup> The first symptoms of local anesthetic toxicity include dizziness, light-headedness, perioral paresthesia, and taste disturbances. A major disadvantage of bupivacaine is that it is arrhythmogenic and can precipitate ventricular tachycardia or fibrillation.<sup>7</sup> This is a particular concern with inadvertent intravascular injection or high overall dosages. Blunt microcannulas are not exempt from inadvertent intravascular arterial injection, especially when smaller sized cannulas (27 g) are used.<sup>8</sup> Steps to avoid intravascular injection include aspirating prior to injection or

constant needle/microcannula withdrawal while injecting.

## DONOR HARVESTING TECHNIQUES

### Keypoints

- In strip harvesting follicular unit transplantation, the follicular unit grafts are obtained through the microscopic dissection of a long strip excised from the donor scalp. A linear scar is left in the donor area.
- In follicular unit excision, the follicular unit grafts are directly and individually harvested using a micropunch to incise the surrounding skin and forceps to extract the graft. Barely visible pinpoint scars are left in the donor area.

There are 2 types of donor harvesting technique: strip harvesting follicular unit transplantation (FUT) and follicular unit excision (FUE). FUE has lately surpassed FUT strip harvesting as the most commonly used technique because the former is perceived as less invasive and does not leave a permanent linear scar (Table I).<sup>9,10</sup> Hair surgeons should master both FUT and FUE. In experienced hands, excellent results can be achieved with both techniques.<sup>11,12</sup>

### Strip harvesting FUT

When preparing for strip harvesting, most surgeons trim donor hair to 4-5 mm to facilitate graft handling.<sup>1</sup> However, some prefer to leave donor hair at a normal or only slightly shortened length, allowing patients a temporary impression after the procedure of how the transplanted hair might appear once fully grown; this is known as preview long hair FUT.<sup>13</sup>

The strip should be harvested from a horseshoe-shaped area of the mid-occipital scalp, known as the “safe donor area.” This safe zone comprises a horizontal band that is approximately 5-6 cm wide (Fig 1).<sup>14</sup> Most follicles in this area are less influenced by the androgen-dependent involution that occurs in androgenetic alopecia. The strip’s dimensions should be calculated based on donor area follicular unit (FU) density and the number of grafts required for the surgical plan according to the formula: donor strip area (cm<sup>2</sup>) = number of FUs desired to harvest/FU density (FU/cm<sup>2</sup>; Table II).<sup>15</sup> The width of the donor strip excision may vary according to the laxity of the scalp (the greater the laxity, the wider the strip that can be harvested); however, in most patients, it measures 10-15 mm at the widest central point.

An objective way to determine the maximum width is the Mayer-Paul formula,<sup>14,16</sup> which defines scalp elasticity as the percentage of the original

**Table I.** Summary of the main differences between strip harvesting (follicular unit transplantation) and follicular unit excision

	Strip harvest (FUT)	FUE
Shaving the donor hair	Trimming of a limited donor area Extensive trimming not needed	Most surgeons trim the donor scalp
Discomfort in the donor area	More postoperative discomfort Sutures needed	Less postoperative discomfort No sutures needed
Surgical skills	More surgical skills required by the doctor	Long learning curve required to avoid follicular transection
Patient suitability (in general all patients can be accepted for both FUT or FUE, but some are more suitable for a specific technique)	Unwillingness to trim occipital scalp hair to harvest individual follicular units	Patient with tight scalp Patients with multiple donor scars from previous FUT sessions Young patients with uncertain hair loss future (FUE allows a patient to trim hair short in the future without visible linear scar)
Risk of FU transection	Less risk of transection due to microscopic dissection of FU grafts	Highly dependent on the physician's punch incision skills: high risk (>30%) in inexperienced and low risk (<5%-10%) in experienced hands
Staff needed	More staff needed for microscopic dissection	Fewer staff needed
Donor morbidity (scar, wound healing problems, etc), excessive harvesting, harvesting in areas not considered a "safe donor area"	Linear scar, usually more difficult to camouflage with short hairstyles than with FUE	Small pinpoint hypopigmented scars easy to camouflage with short hairstyles Higher risk of excessive harvesting
Duration of surgery	Average operating time is 3-6 hours	Average operating time is 4-8 hours
Duration of recovery of the donor area	10-12 days until sutures can be removed from donor wound	3-7 days
Possibility of harvesting body sites	No	Yes (beard most commonly)

FU, Follicular unit; FUE, follicular unit excision; FUT, follicular unit transplantation.

**Fig 1.** Safe donor area. The shadow area in the center indicates where the strip should be harvested.**Table II.** Length of donor strip according to the number of follicular units desired to harvest\*

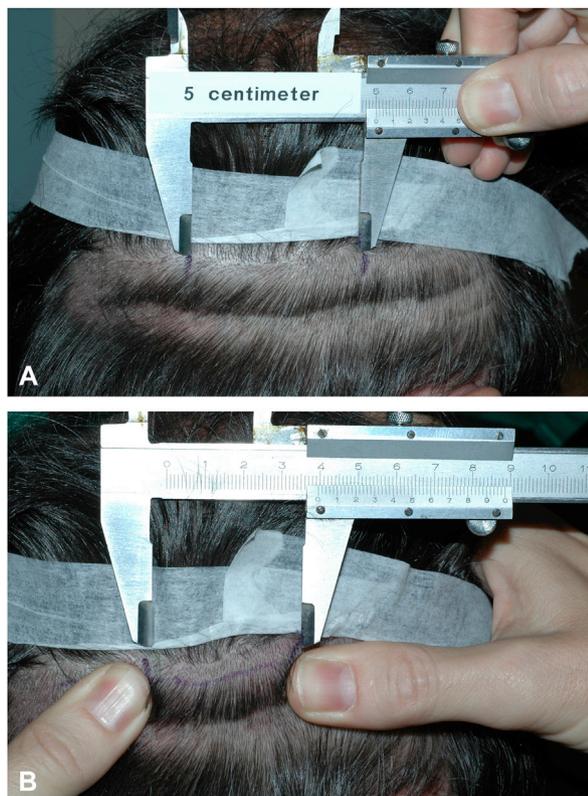
Follicular units (number)	Length of strip (cm) (width fixed at 1 cm)	Length of strip (cm) (width fixed at 1.5 cm)
500	6.2	
1000	12.5	
1500	18.7	
2000	25	16.6 <sup>‡</sup>
2500	31.2 <sup>†</sup>	21
3000	37.5 <sup>†</sup>	25

\*These numbers are calculated using the formula: Area of strip = follicular unit harvested/follicular unit density, and considering an average follicular unit density of 80 FU/cm<sup>2</sup>.

<sup>†</sup>Given that the maximum length of a strip that can be excised from ear to ear is generally 30-35 cm, to harvest ≥2500 follicular units it is preferable to excise a strip wider than 1 cm.

<sup>‡</sup>To harvest ≤2000 follicular units, it is preferable to excise a 1 cm wide strip.

length that vertical lines placed 50 mm apart move toward each other when compressed by the surgeon's thumbs: % scalp elasticity = (50 mm – distance after compression)/50 mm × 100 (Fig 2; Table III).



**Fig 2.** Scalp elasticity assessment. **A**, Initial measurement of 50 mm. **B**, Compressed scalp distance of 39.5 mm. According to the Mayer-Paul formula, % scalp elasticity =  $(50 - \text{scalp distance})/50 \times 100$ , this patient has 21% scalp elasticity  $(50 - 39.5)/50 \times 100 = 21\%$ .

**Table III.** Maximum strip width to be excised according to scalp elasticity\*

Scalp elasticity (%)	Strip width (cm) <sup>†‡</sup>
10	1
15	1.5
20	2
25	2.2

\*Scalp elasticity was calculated according to the Mayer-Paul formula; see Fig 2.

<sup>†</sup>Strip width measured at the central point of the strip. For strips of  $\geq 1.5$  cm, it is recommended to reduce the width by 5 mm in the lateral quarters (mastoid protuberance), where the elasticity is reduced.

<sup>‡</sup>Strip width measurements are recommended for first surgeries. Decreasing these width measurements by 20% is recommended for subsequent surgeries.

Strip incision should extend down to the subcutaneous fat, deep enough to remove the entire FU but not so deep that there is a danger of sectioning the neurovascular bundles (Fig 3 A). Tumescence infiltration with physiologic saline in conjunction with precise scalpel incisional angulation parallel to the hair shafts reduces follicle transection.

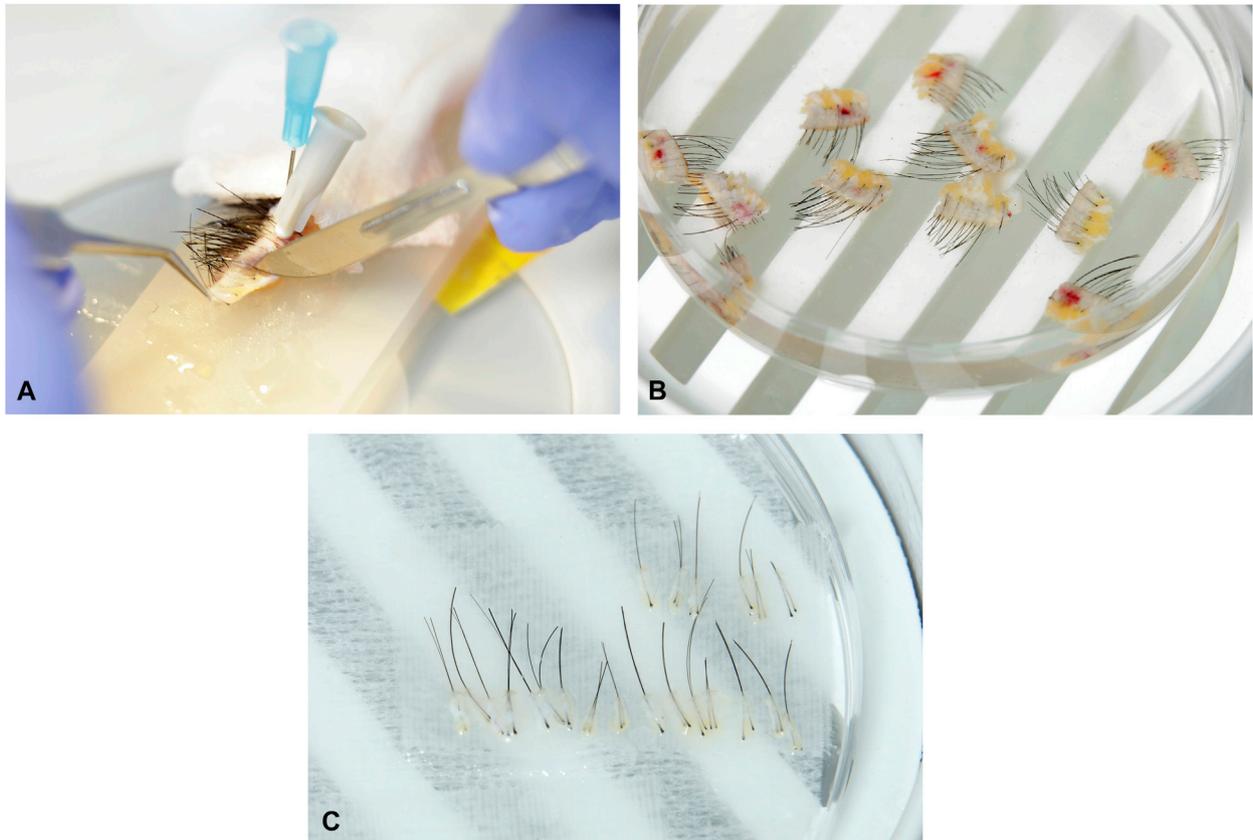


**Fig 3.** Strip harvesting technique. **A**, Excision of a long, thin strip from the donor area. **B**, Immediately after closing the surgical wound with running suture.

After strip excision, the wound can be closed in 1 or 2 layers with minimal or no undermining (Fig 3 B). A double layer closure distributes wound tension more evenly.<sup>1</sup> Any preferred absorbable suture in the deep layer and a nonabsorbable suture at skin level can be used, which is removed 10-12 days after the procedure. Staples can also be used for epidermal closure with similar results.

With strip harvesting, a long but thin linear scar is left, which normally can be hidden by the hair. A trichophytic closure makes the scar less visible.<sup>17,18</sup> This involves excising a narrow rim of epidermis and dermis (<1-mm deep) along the inferior and/or superior border of the incision so that the underlying hairs grow directly into the resulting donor scar. Subsequent surgeries should include the previous scar, when possible, to avoid adding unnecessary scars.

Initially, the donor strip is subsectioned under a stereomicroscope into slivers approximately 1 FU in width (Fig 4 A).<sup>19</sup> Each sliver is then dissected into FU grafts (Fig 4 B), which are immediately placed in a holding solution (normally physiologic saline and lactated Ringer) to keep the grafts hydrated (Fig 4 C). There is still some debate as to whether the hair grafts should be kept at room temperature or chilled (1°-



**Fig 4.** **A**, The scalp donor strip is microscopically dissected into slivers. **B**, The slivers are immediately immersed in the holding solution. **C**, Following immersion, they are dissected into follicular units.

4°C).<sup>20</sup> The current perception is that if the grafts are out of the body <6 hours, they can be left at room temperature without affecting their survival rate (80%-95%).<sup>21,22</sup>

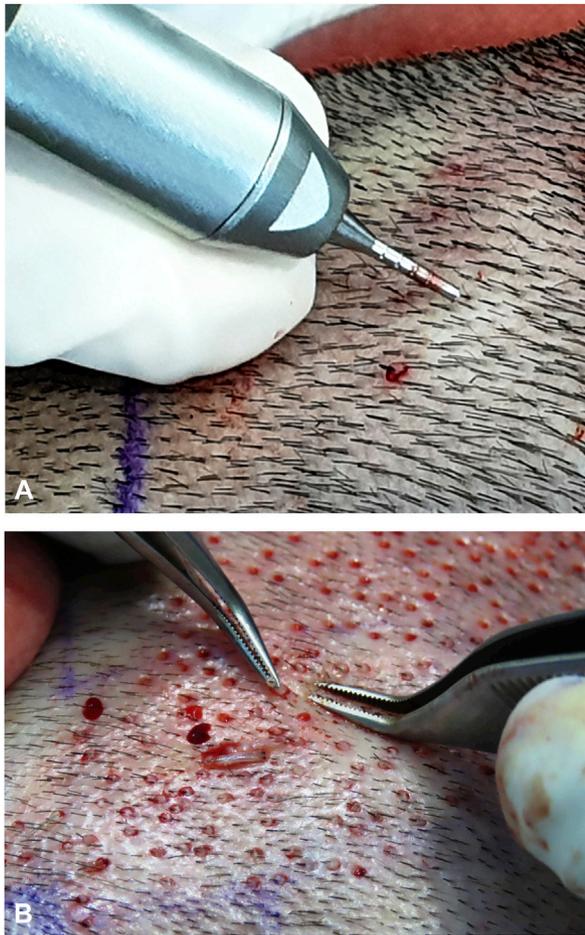
## FUE

FUE is similar to the old punch-grafting technique, with the main difference being that the punch used in FUE is no bigger than 1 mm in diameter.<sup>23-25</sup> The FUE procedure is summarized below.

**Donor hair.** Most surgeons shave the hair in the donor area to approximately 1 mm to facilitate punch incisions. An unshaven FUE is more appealing for the patient but more challenging for the surgeon. One time-consuming option is to trim only the hairs that will be harvested. Another possibility is to simultaneously cut the hair shaft and isolate the FU using a rotating sharp punch.<sup>26</sup> True "long hair FUE" occurs when the FUs are excised with the hairs left long. Specialized asymmetric or slotted punches can allow intact full-length hair shafts to be retained, although more efficient instrumentation to harvest long hair FUs is needed.<sup>27</sup>

**Punch incisions in shaved FUE.** A hollow metal punch that is 0.8-1 mm diameter cores out an intact FU. The punch must be perfectly centered on the exiting of the hairs (Fig 5 A, B; Video 2). High-quality 4×-8× loupes are recommended for this step. The punch is then advanced to an approximate depth of 3 mm. Hair follicles tend to splay apart below this level, and so advancing the punch any farther increases the risk of hair follicle transection.<sup>27</sup> The experience and "feeling" of the surgeon is vital to avoid significant transection. A complete FU transection rate (all hairs of a transected FU) in FUE should be below 3% in experienced hands and a partial follicular transection rate (FUs containing at least 1 transected follicle) of 10%-15% can be considered acceptable using current instrumentation.<sup>28-30</sup>

Various punch types are available, differing mainly in tip design (sharp, blunt, or hybrid; Fig 6).<sup>31,32</sup> Sharp punches cut the skin with minimal force and depth control is essential to minimize graft transection. Due to their greater dissecting effect, blunt and hybrid punches can be more easily introduced deeper in the tissue with less risk of transection. However, in inexperienced hands, blunt



**Fig 5.** **A**, Alignment of the punch with the exit angle of the hair shaft. **B**, Extraction of the follicular units with curved serrated forceps. Note the wounds left by the multiple punch extractions.

punches can result in greater downward pressure, introducing the graft into the dermis or subcutaneous tissue (buried grafts).

If a buried graft is noted, pressure can be applied to the surrounding area to try to force the graft to the surface or fine-tip forceps can be used to try to locate and remove the buried graft. If the buried graft is not located, it can potentially result in cyst formation.<sup>27</sup> Sharp punches can be handled manually or adapted to a motorized device. Blunt and hybrid punches can only be used with motorized devices that differ mainly in the type of movement exerted on the punch tip: rotation, oscillation, roto-oscillation, vibration, or a sequenced combination of such motions (Table IV).<sup>33,34</sup> A robotic system (ARTAS, Venus Concept) is also commercially available.<sup>35,36</sup>

**Extraction of the follicular units and healing.** The extraction of the FUs is manually done with forceps (Fig 5 B; Video 3). The grafts are then immediately placed in holding solution until

implantation. The FUE wounds in the donor area re-epithelialize rapidly in 3-4 days, although erythema and crusting may persist for up to a week (Fig 7). These FUE wounds leave residual pinpoint donor scars. Although not clinically evident in some patients, these scars may be observable as hypopigmented or white dots if the patient's head is shaved (Fig 8). Their prominence varies, depending on hair/skin color contrast (the greater the contrast between hair and skin color, the higher the likelihood of scar visibility), punch size (the bigger the punch, the more visible the scars), and number of extractions. A recommended safety measure to avoid overharvesting is to harvest around 10%-20% of the original FU density per session.<sup>37</sup> For instance, for a patient with an FU density of 80 FUs/cm<sup>2</sup>, around 8-16 FUs can be harvested per cm<sup>2</sup>.

Depending on each surgeon's skills, the instrumentation used, and the harvesting difficulty inherent to each patient, harvesting 1000 grafts with FUE takes 1-2 hours. For patients with large balding areas (Norwood types 5 and 6) that need over 2000-2500 grafts per session, many surgeons prefer to carry out these sessions over 2 consecutive days to reduce operating time and the interval that the grafts are outside the body.<sup>32,38</sup>

Although body hair transplantation is beyond the scope of this review, FUE can be used to harvest hair from other body regions in patients with insufficient hair available for scalp donor harvesting.<sup>39</sup> The beard is considered the most reliable area, as the thick terminal hair is similar to scalp hair and graft survival rates are similar.<sup>40</sup>

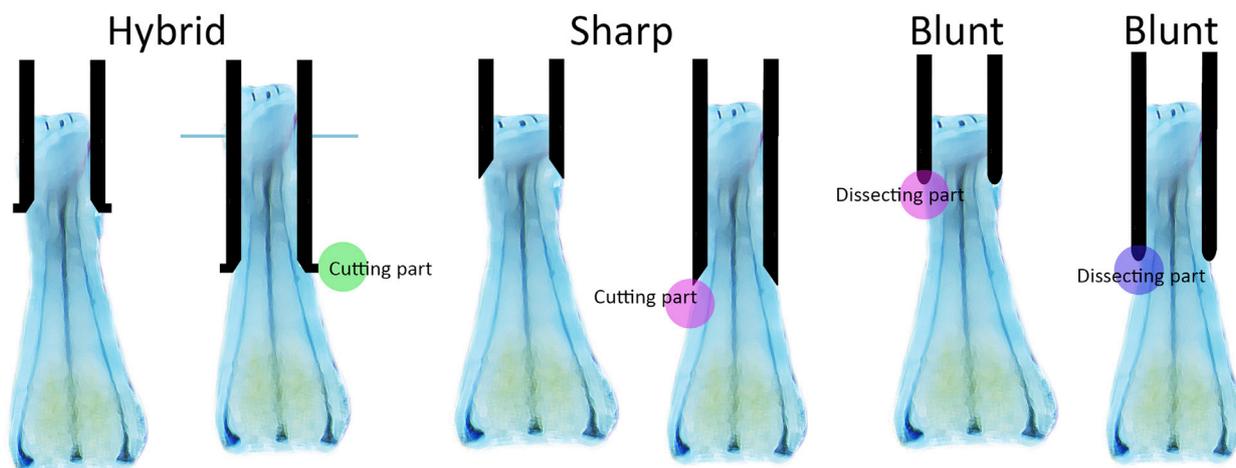
## THE RECIPIENT AREA

### Keypoints

- For a natural look, a hairline requires a transition zone and many irregularities. Male hairlines should maintain frontotemporal recessions while female hairlines should be lower and flat.
- The ideal recipient site density for good aesthetic coverage is 25-45 FUs/cm<sup>2</sup>.
- Implanters and forceps are used for graft implantation.

### Hairline design

The anterior hairline design is an important component of the natural look desired in a hair transplant. Although called a "line," it is in fact a transition zone 5- to 10-mm wide that merges the bald forehead to a zone of increasing gradient of density. It should be created with numerous irregularities to mimic a natural hairline. In most males, the midfrontal point should be positioned 7-9 cm above the glabella and the hairline should maintain the



**Fig 6.** Tip designs of punches used for follicular unit excision: sharp, blunt, and hybrid. (courtesy of Dr Jean Devroye, Brussels, Belgium).

**Table IV.** Basic differences between types of follicular unit excision punches

Criterion	Sharp punches	Blunt punches	Hybrid punches
Edge	Sharp cutting edge	Round cutting edge	Flat end. Some have a flared cutting edge
Effect	Cutting effect	Dissection effect	Combination of cutting and dissection effect
Depth	Control of depth to 2.5-3.0 mm deep is essential	Less need for depth control	Less need for depth control
Transection	Longer learning curve to avoid transection	Less transection but more risk of buried grafts	Less transection than sharp and more transection than blunt punches
Device	Can be used with manual follicular unit excision or motorized devices	Only used with motorized devices	Only used with motorized devices

frontotemporal recessions. In females, the hairlines are lower (6-7 cm above the glabella) and flatter with a concave shape.<sup>1,41</sup>

### Recipient site creation

For good aesthetic coverage, the goal is to transplant 25-45 FU grafts per cm<sup>2</sup> in the recipient area.<sup>1,42</sup> A useful tip to better visualize and calculate the distribution of the desired graft density is to draw squares (eg, 2-cm squares) in the recipient area. For example, to achieve a graft density of 30 FUs/cm<sup>2</sup> the surgeon needs to implant 120 grafts in each 2 × 2 cm square (Video 4).

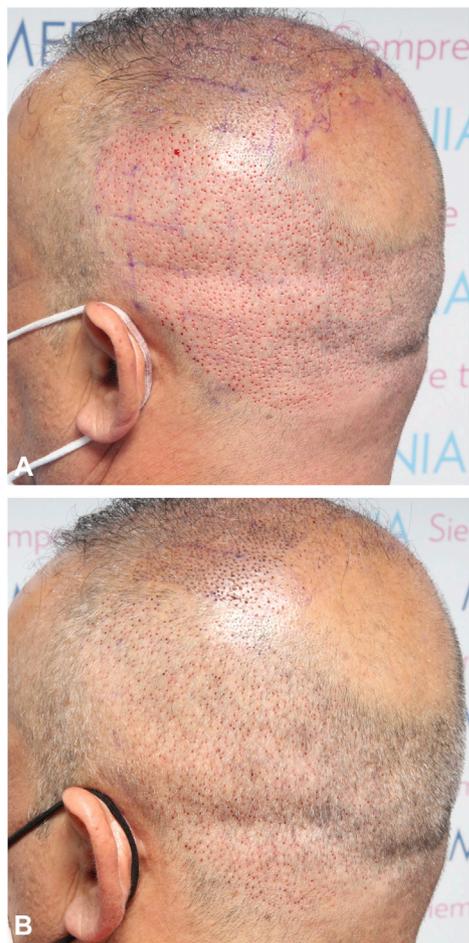
When making the recipient sites, certain rules are always applicable. First, the grafts must be implanted at the same angle and in the same direction as the existing nontransplanted hair.<sup>43</sup> Second, single-hair FUs should be positioned in the anteriormost part of the hairline, while 2-, 3-, and 4-hair FUs should be situated just behind with the idea of creating a

transition zone.<sup>41</sup> In women, given the normally more diffuse hair loss pattern and more limited donor area, it is better to focus the limited number of available grafts in the most cosmetically sensitive areas, especially the midfrontal and midcentral scalp.<sup>44</sup>

### Implantation methods and instruments

In the premade sites method, the recipient sites are made first and then the grafts are inserted. Twenty-two- to 23-gauge hypodermic needles or 0.6- or 0.7-mm blades can be used for single-hair FU grafts and 19- to 20-gauge needles or 0.8- to 1-mm blades for 2- to 4-hair FU grafts.<sup>41</sup> Incision depth should be approximately 4 mm. In the stick-and-place method, the grafts are inserted at the same time the sites are made.

Fine-tip forceps and implanters are used to insert the grafts into the recipient sites. When using forceps, gently grasping the FU graft by the



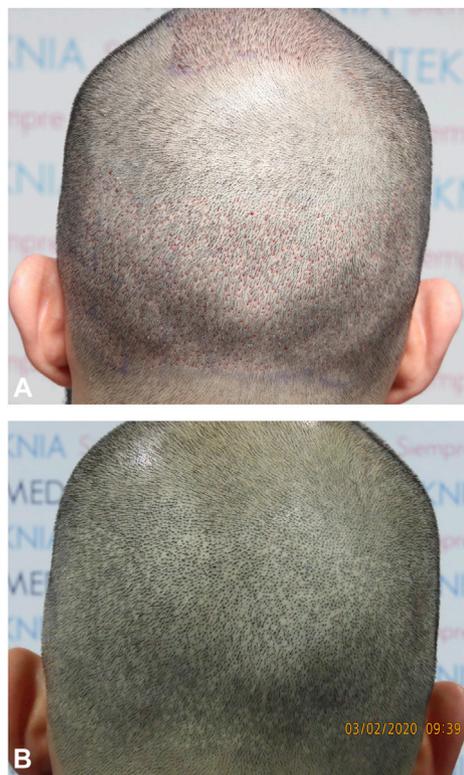
**Fig 7.** Follicular unit excision wounds in the donor area. **A**, Immediate postoperative appearance. **B**, At day 3 after surgery.

perifollicular tissue and not the follicle itself is critical to avoid damaging the follicle. The implanter comprises a hollow needle, in which the grafts are placed, and a piston, which propels the hair graft out of the needle and into the recipient area (Fig 9 A).<sup>45,46</sup> Implanters are gaining in popularity because they are relatively easy to learn to use and there is less graft handling and so less potential follicle damage. One drawback to implanters is that the additional presence of 1 or 2 technicians is required to load the grafts (Fig 9 B). A surgeon assisted by 2 technicians loading implanters can perform approximately 700-1000 grafts/hour (Fig 9 C; Video 4).

## POSTOPERATIVE CARE AND FOLLOW-UP

### Keypoints

- Transplanted hairs start growing 2-3 months after implantation and final results can be observed after 6-12 months.



**Fig 8.** Follicular unit excision hypopigmented scars in the donor area. **A**, Donor wound 24 hours after 1528 follicular unit excision extractions. **B**, One year later, small pinpoint scars can be seen in the donor area when the hair is shaved.

Some surgeons protect the donor area for 24 hours with an emollient-coated Telfa pad secured to the forehead with tape. The recipient area is typically not bandaged. Patients are advised to sleep with head elevation, and a short course of oral prednisone (40 mg once daily for 3 days) may be prescribed to help reduce frontal edema.<sup>1,38</sup> An antibiotic ointment can be applied to donor FUE wounds or to the suture line for 3-4 days. Patients are instructed to keep the recipient area clean by spraying it with physiologic saline every 2-3 hours for the first 2-3 days. Patients can shampoo their hair the day after the procedure.

Most transplanted grafts form a superficial scab that falls off by day 7-10. Patients should be informed that there is the possibility that hair shafts of the transplanted grafts shed in variable proportions 3-4 weeks after the procedure and that transplanted FUs will begin growing in approximately 2-3 months. Proper evaluations cannot be made until 9-12 months following the procedure, when the transplanted hairs will have fully grown (Figs 10 and 11). For the same reason, it is advisable to wait 9-12 months if a second session is required.



**Fig 9.** Graft implantation. **A**, Implanters. **B**, Loading the follicular unit into the implanter. **C**, Insertion of the graft into the recipient site.



**Fig 10.** **A**, A 35-year-old man with androgenetic alopecia. **B**, Photo taken 24 hours after the transplantation of 1627 follicular unit grafts in the frontal and parietal region using the follicular unit excision technique. **C**, Outcome 1 year later.

## COMPLICATIONS OF HAIR TRANSPLANTATION

### Keypoints

- There are complications inherent in hair transplant surgery and complications due to poor technique.
- Complications include folliculitis, cysts, wide donor scars, donor area thinning, telogen effluvium, and poor growth.

### Complications inherent in hair transplant surgery

The incidence of complications in hair surgery is estimated to be around 5%.<sup>47</sup> Inherent risks include folliculitis, broad donor strip scars, prolonged paresthesia, cysts from buried grafts, telogen effluvium, infection, skin necrosis in the donor or recipient

region, arteriovenous fistula, and keloidal scarring in donor scalp (Table V).<sup>48-51</sup> The greater the tension on the strip wound, the higher the risk of a wider scar, infection, or necrosis. Women have a higher risk of postoperative telogen effluvium in the recipient area.<sup>44</sup>

### Complications due to poor technique

Technique-related complications include donor area scarring and/or depletion with evident areas of thinning due to FUE overharvesting (Fig 12 A), hairline designs that are too low or unnaturally straight, transplanted hairs that are misdirected (Fig 12 B), and lack of planning for future androgenetic alopecia long-term progression.<sup>52</sup> Patients with unnatural hairlines due to excessively low hairline



**Fig 11.** **A**, A 63-year-old woman with female pattern hair loss. **B**, The follicular unit excision technique was used to transplant 2046 follicular units. **C**, Outcome 1 year later.

**Table V.** Common and rare complications of hair transplant surgery

	Common complications	Rare complications
Inherent to hair surgery	<ul style="list-style-type: none"> <li>• Folliculitis</li> <li>• Pruritus</li> <li>• Cyst formation</li> <li>• Numbness/paresthesia</li> <li>• Telogen effluvium (more common in FPHL)</li> <li>• Broad scars (strip harvesting follicular unit transplantation)</li> </ul>	<ul style="list-style-type: none"> <li>• Infection</li> <li>• Necrosis of donor or recipient region</li> <li>• AV malformation</li> <li>• Hiccups</li> <li>• Keloids in donor area</li> </ul>
Due to poor technique	<ul style="list-style-type: none"> <li>• Poor growth</li> <li>• Unnatural distribution of hair on the scalp</li> <li>• Unnatural hairline design</li> <li>• Inappropriate angle of growth of transplanted hair</li> <li>• Donor depletion and donor scars due to excessive follicular unit excision overharvesting</li> </ul>	

AV, Arterio-venous; FPHL, female pattern hair loss.



**Fig 12.** Physician-induced complications. **A**, Thinning of donor area due to follicular unit excision overharvesting. **B**, Poor growth and bad design of the frontal hairline with erroneous directions of the follicular unit grafts.

designs or the use of large grafts containing several FUs placed in the anterior hairline often require the removal or punch reduction of the offending grafts,

hair graft recycling, and/or the transplantation of smaller 1- and 2-hair FU grafts to create an artistically improved and more natural appearance.<sup>53,54</sup>

**Table VI.** Causes and possible solutions for poor growth after hair transplantation

Causes of poor graft growth	Possible solutions
Excessive hair graft transection	<ul style="list-style-type: none"> <li>• Provide long-term training for staff</li> <li>• Use appropriate instruments</li> <li>• Use an appropriate punch incision technique that includes the correct angle and depth of the punch incision</li> </ul>
Graft dehydration	<ul style="list-style-type: none"> <li>• Maintain grafts in holding solution at all times</li> </ul>
Improper graft handling in the implantation process	<ul style="list-style-type: none"> <li>• Handle gently</li> <li>• Avoid damaging and crushing the graft by grasping perifollicular tissue rather than the follicular unit itself</li> </ul>
Excessive trauma in the recipient site	<ul style="list-style-type: none"> <li>• Prepare a recipient site to be as superficial as possible (average 4 mm deep)</li> <li>• Avoid making recipient sites larger than 1 mm in diameter; normal diameter range is between 0.6 and 1.0 mm, depending on graft size Avoid making more than 50 recipient sites per cm<sup>2</sup>; normal range is between 25 and 45 follicular unit/cm<sup>2</sup></li> </ul>

Poor growth, normally due to physical trauma to the grafts as the result of improper handling (crushing, dehydration, or excessive time outside the body) is a common complaint heard at many hair transplant clinics (Table VI).<sup>55,56</sup> Even if these negative factors can be avoided, a small percentage of patients (0.5%-1%) will nevertheless be affected by poor growth.<sup>57</sup> The idiopathic cause of poor growth, known as factor X, may be due to the significant variability in scalp blood flow and/or the intrinsic hair growth rate that exist between individuals, differences that can be observed when hair follicles from different individuals are cultured in vitro.<sup>58</sup>

## REFLECTIONS

In the last decade, the hair transplant field has grown as a result of FUE, because patients perceive it as a minimally invasive procedure and doctors find it easier to enter this field using FUE. Although dermatologists are specialists trained in the diagnosis and medical treatment of hair loss disorders, only 2%-7% of them work in practices where hair transplantation is performed (Personal communication, Jeff Miller, American Academy of Dermatology, May 24, 2021). This low percentage suggests a call to action for the field. This will involve access to more educational opportunities, such as hands-on training in accredited preceptorship/fellowship programs, to learn how to properly and ethically perform the procedure.<sup>59,60</sup> Educational opportunities in hair restoration surgery recommended by the authors include the Fellowship Training Programs (<https://ishrs.org/physicians/fellowship-training-programs/>) and physician education programs (<https://ishrs.org/physicians/education/>) offered through the International Society of Hair Restoration Surgery.

## Conflicts of interest

None disclosed.

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