



Figure 15.11 The donor area is shaved for FUE harvesting.

The instrumentation used for follicular extraction is relatively brief.

Special FUE punches with diameters ranging from 0.7 to 1 mm are used with a handle and microforceps.

There are two steps involved for the FUE procedure. In the first step, a sharp punch is placed over the follicular unit and aligned according to the direction of the hair shaft. The punch rotation must be realized without any axial pressure.

During the first step two parameters must be respected: depth and obliquity.

The rotation of the punch placed around the follicular unit allows the epidermis and dermis to be penetrated until the section of the arrector muscle insertion, which is 2–3 mm in depth.

It is important to measure the depth of insertion of the punch, which tends to vary from one person to another.

In the case of insufficient depth, the follicular unit cannot be extracted. In the case of a deep penetration, there is a risk of roots transection.

The second parameter is the respect of the obliquity. The emergence of the hair shaft varies according to the different axes of the follicles when performing a penetration of punch into the dermal layer; if the punch is

oriented along the axis of the emergence of the hair, the follicle will be transected. In order to avoid this transection, the perfect angle must be found. This angle is estimated after viewing the first 10 harvested FUEs.

Usually the angle is verticalized from 5° to 10° relative to the angle of emergence of the hair.

In the second step, fine-toothed forceps are used to apply a gentle traction to the top of the follicular unit until it is extracted from the deeper dermal and subcutaneous connections.

Follicular units are extracted one by one using micro-punches of 0.7–1 mm in diameter (Figure 15.12a–c). The instrument is rotated either manually or by a motor (Figure 15.13a). Each graft is extracted with jeweller forceps (Figure 15.13b).

The grafts are checked to control their quality and maintained in ice-cold saline before being inserted (Figure 15.14).

On average 1000 follicular units are removed in 2–3 hours.

Each follicular unit contains one to three hairs, so 1000 follicular units corresponds to approximately 1000–3000 hairs.

After harvesting all the follicular units, the patient is placed in a sitting position.

Local anesthesia is done on all the recipient areas. The recipient area is perforated with ophthalmic microsurgical blades (spearpoint or chisel).

The insertion of follicular units is done with jeweler's forceps or using a Choi implanter²⁴ (Figure 15.18). The Choi implanter allows the assistant to store the graft in the microslot while it is inserted by the operator.

The procedure is done in about 3–4 hours, depending on the length of the session.

Sometimes the process is called “stick and place”: one operator does the perforation and the other operator inserts immediately each FUE.

Indications for FUE

- Patients who have male or female androgenetic alopecia (Figure 15.15a–c).
- Patients who have a habit of shaving the hair (Figure 15.16a and b).
- Patients with limited laxity of the scalp (a limiting factor for strip harvesting).
- Patients with sufficient hair density in the donor area.
- Patients who do not want a scar line after harvesting a strip, since the latter, although very thin, can be blurred by some FUE in a second session.

Advantages of FUE

- The microscars in the donor area are, usually, almost imperceptible.
- The microperforations associated with harvesting follicular units in the occipital and temporal regions heal within a few days after surgery.

hair transplantation for a esthetic surgery of the scalp and body hair

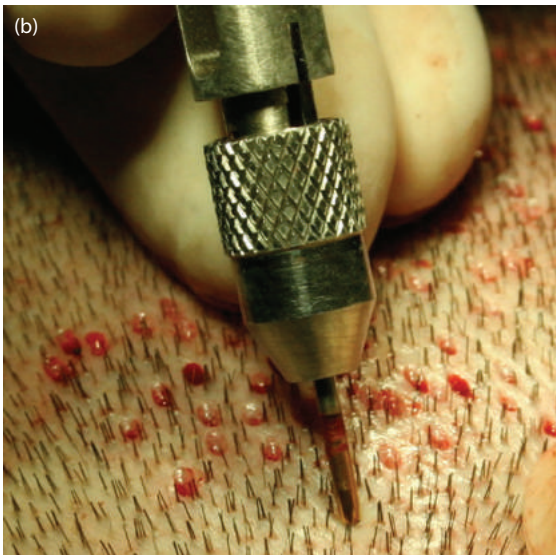
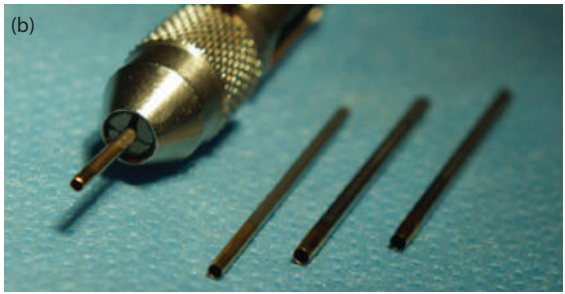
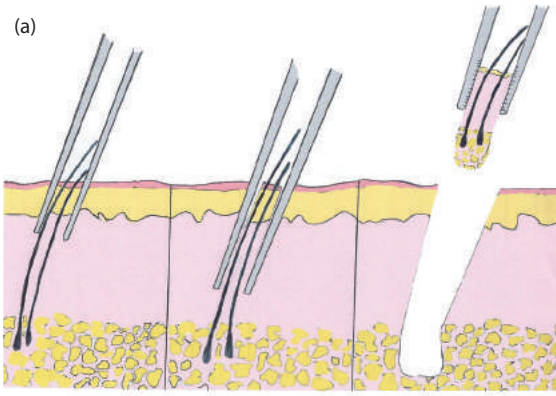


Figure 15.13 (a) Micropunch of 0.7–1 mm for FU extraction. (b) Handle for manual micropunch.



Figure 15.12 (a) Incision and extraction of FUE, (b) incision with the punch, and (c) follicular unit extraction with forceps.

Figure 15.14 (a) Aspect of follicular units immediately after extraction. (b) Recipient area incisions and FUE implantation on male frontal recession.

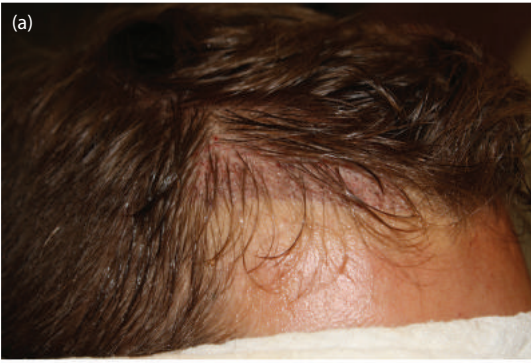


Figure 15.15 (a) Aspect immediately after insertion of FUE on a frontal hairline. (b) Frontal recession before treatment. (c) Nine months after one FUE session.

- There are no sutures and at most moderate postoperative pain.
- In some cases it is possible to harvest body hair, such as chest hair, for small FUE reconstruction.



Figure 15.16 A frontal hairline (a) before and (b) 9 months after one FUE session.

Disadvantages of FUE. Usually, FUE is selected for small and medium baldness, especially in men.

In women, a sparse donor area often contraindicates FUE, especially since women rarely agree to have a pre shave.

The FUE is more hazardous during any subsequent sessions according to the remaining donor hair capacity.

The FUE is worst for choosing the best angle and orientation during the implantation step.

In post-op FUE scabs are not hidden by the hair shaft.

The capacity of the donor area will be reduced if there is inexorable evolution of the alopecia process to greater baldness.

An essential point is that there is no regrowth of hair in the donor area for those which have been harvested.

It is possible now to do a FUE harvesting on a non-shaven scalp if a small session is indicated.

Postoperative course after follicular transplant

- A bandage is sometimes applied for one night in order to avoid bleeding after itching on the graft.
- A first cleaning with shampoo can be made the next day, and long implanted hairs can be dried with a mild air dryer.
- Swelling in the forehead may appear within 24–48 hours after surgery and will disappear 2–4 days later.
- Small crusts and implanted hair shafts will take approximately 7–10 days to fall out. Some long hair may remain implanted.
- Implanted follicles can have interrupted hair growth during the first 3 postoperative months.
- Regrowth of new hair is expected 3–4 months after surgery.
- Follicular units are extremely reliable, but we should still report the occurrence of secondary cysts due to the unfortunate inclusion of skin debris or a second hair transplant into the hole. This exceptional small complication should be treated as an outbreak of acne vulgaris with antibiotic, orally and locally, sometimes with an incision of the cyst.²²
- Twelve months are necessary to evaluate the final outcome of the surgery.

Actions stimulating hair growth on transplants

Effect of minoxidil lotion

Usually 2–4 weeks after a hair transplant, the scabs over the transplants fall out, involving the bulbs of transplanted hair.^{10,17,18} This fall-out, albeit transient with an average regrowth 3 months later, is sometimes aesthetically annoying.

An independent personal study¹⁷ has shown that the application of minoxidil 2% lotion before and after transplantation allows persistent growth of part or all of the hair on more than two-thirds of the grafts, and causes fall-out in less than half of the transplanted hair on less than one-third of the grafts.

So it seems that the pre- and postoperative use of minoxidil 2% or 5% lotions, or taking orally finasteride 1 mg,¹⁸ allows the continuation of the anagen process in a large amount of transplanted hair.

Effect of platelet growth factors (PRP)

Platelets contain “growth factors” (see Chapter 19; Figure 15.17).

The PRP process is a technique that involves isolating platelets from a blood sample, concentrating them by centrifugation, and injecting them back into the scalp.

Various evaluations show it is possible to observe an increase in the number of hairs per square centimeter due to an increase in hair diameter of vellus.

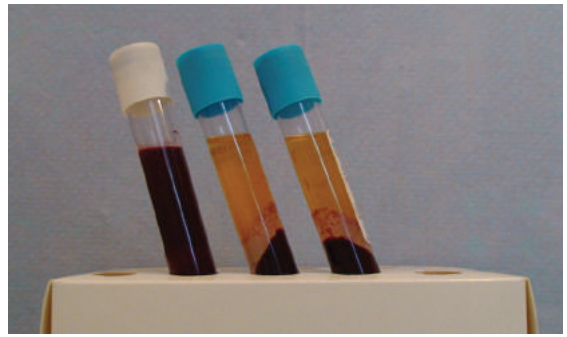


Figure 15.17 Platelet growth factors (PRP) after centrifugation of a blood sample and before transdermal injection.

The PRP injected in the recipient area may stimulate the regrowth of grafted hairs.^{19,25}

New instruments for hair transplants

In recent years, various instruments or devices have been proposed and tested for their interest, reliability, and safety.

- *The Choi hair transplanter*²⁴ allows the introduction of follicular units (Figure 15.18). It may possibly be used for the reconstruction of the frontal hairline with hair implanted “one by one” in a more close-set manner and a better aesthetic refinement.

It is a sterile device. The needle size must fit the hair follicle size and thickness (sizes of 0.8 or 1 mm).

Each follicular unit (FUE, FUL, or FUT) is located in the needle with smooth forceps.

The needle is then inserted deep into the scalp, and the cursor is pushed to implant the follicular unit.

- *The automatic FUE transplanter*²³ (Figure 15.19a) (SAFER/NeoGraft) may be recommended in the absence of contraindication to FUE. Compared to the conventional manual FUE technique, it avoids the need for additional assistance; however, for good results in practice, a long apprenticeship is essential.

The SAFER/NeoGraft for hair transplantation is a patented medical device (Medicamat) used to both extract follicular units from the donor area and implant them in the recipient area via a suction-based system.

The extraction handpiece

It consists of an autoclavable hollow-shafted contra angle on which is fixed a motorized punch with a rotation system (five diameters: 0.8, 0.9, 1, 1.25, and 1.4 mm), and

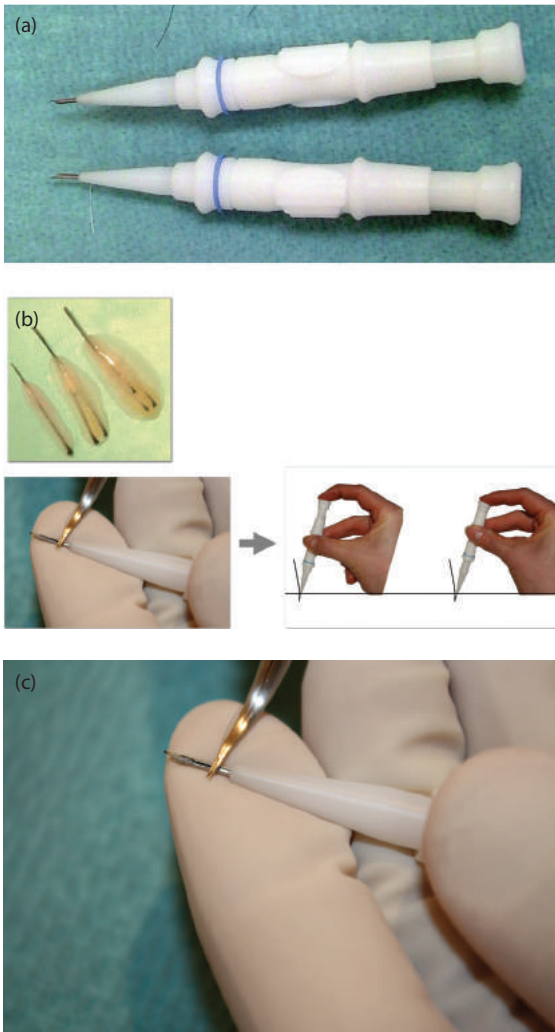


Figure 15.18 (a,b,c) Choi implanter (Lion HT) for combining skin puncture and insertion of the micrograft.

a controlled pneumatic negative pressure to smoothly extract every single graft from the donor area, into a micro flask fixed on the handpiece (Figure 15.19b).

The extraction handpiece superficially penetrates the patient's skin, until the arrector pili muscle is cut ($\cong 2$ mm deep). This superficial penetration avoids any risk of graft transection or trauma, allows a better quality graft (more cells around the graft), and reduces the time of surgery.

Once the graft is harvested from the tissue, it is sucked through a tube into the small flask.

When approximately 50 grafts are extracted from the scalp, the chamber, always wet with saline, is opened and the grafts are manually placed in a saline holding solution.

The recipient site incisions are done in the donor area using conventional instruments, such as 16- or 18-gauge needles or microblades.

The implantation handpiece

It consists of a hollow needle (diameter 0.8 mm and 1 mm) surmounted by a piston allowing the operator to gently implant the grafts into the premade incisions in the bald area with extreme precision and without any "popping" risk, using positive pneumatic pressure (Figure 15.19c). The two implantation handpieces connected to the device allow two operators to work simultaneously, substantially reducing the duration of surgery.

In this step the advantage of the SAFER/NeoGraft is that the grafts are inserted into the recipient site without forceps, thereby reducing potential injury from the forceps (Figure 15.19d).

Advantages of the SAFER/NeoGraft technique

- Productivity 500 grafts per hour
- Average hairs per graft of one to four
- A transection rate between 1% and 5%
- Donor area scarring that is nearly undetectable
- A technique that avoids the possible injury of forceps during implantation
- Gives eventually the possibility of working alone

The Robotic FUE (Artas)^{26,27} (Figure 15.20a) is an interactive, computer-assisted, and physician-controlled robotic system used for the FUE harvest. A double concentric punch on a mechanical arm is guided by a video image. Its purpose is to minimize human error and fatigue while taking a greater number of transplants than the conventional extraction techniques allow (≈ 2000 grafts in 2 days). It also needs a long apprenticeship.

The system is composed of a cart with a six-axis articulated robotic arm.

The needle mechanism houses stereo cameras and force sensors that guide the dissection (Figure 15.20b). The dissection system uses a needle-in-needle (inner needle) configuration that is concentrically arranged within a blunt outer punch. A skin tensioner is maintained for the dissection process (Figure 15.20c). Sharp scoring incision, blunt punches (1.0 mm, 0.9 mm) dilate and dissect with automated depth control and angle adjustment.

The FU selection algorithms allow preferential treatment for multihair FU and adjusts minimum harvest spacing between incisions.

Stereo cameras precisely measure and calculate the angles and direction of each FU (Figure 15.20d). Each FU is then extracted manually with forceps. The surgeon makes slits in the recipient area and the extracted follicles

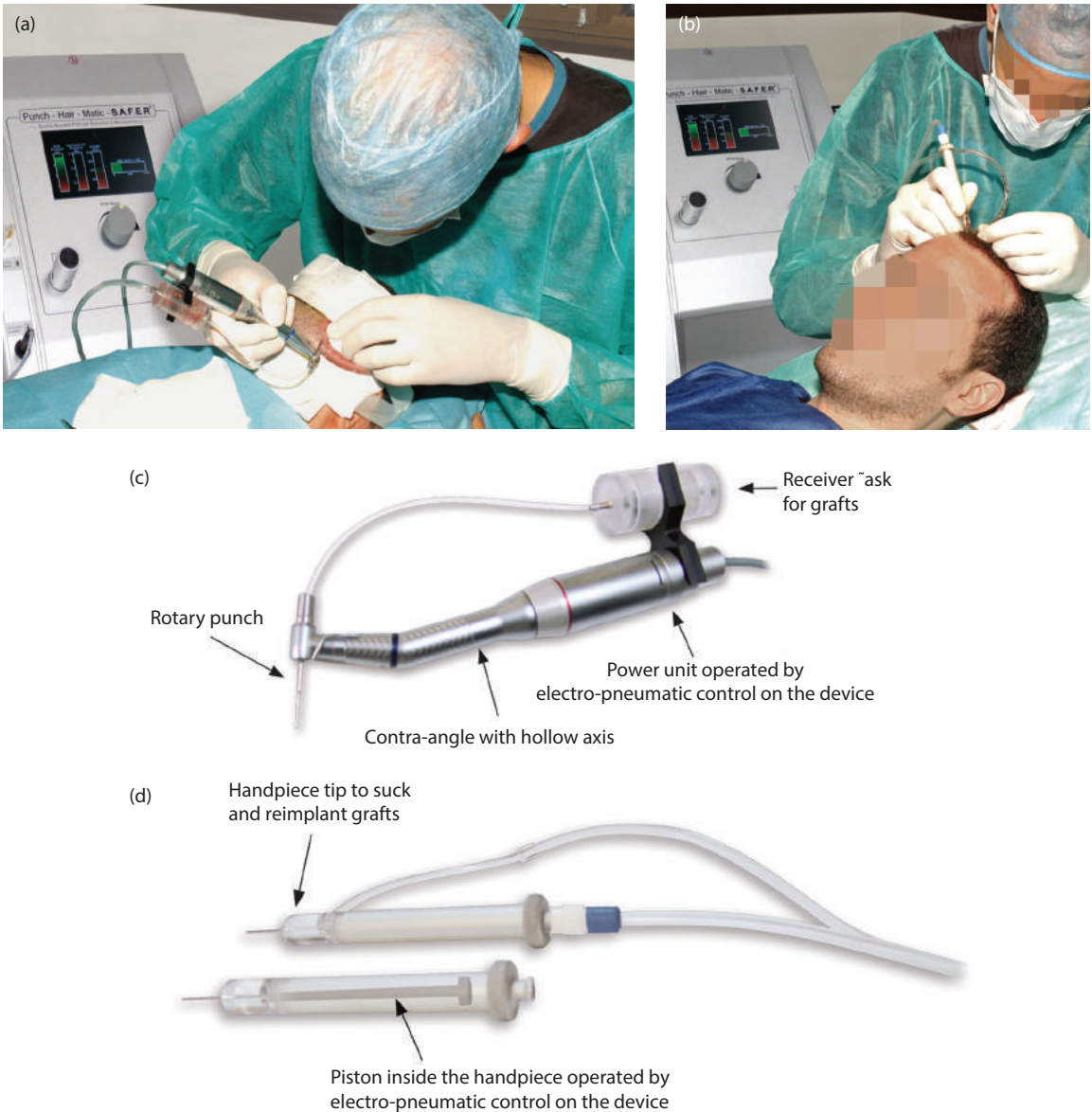


Figure 15.19 (a) Extraction with the automatic system and transplantation of FUE (SAFER/NeoGraft). (b) Aspirating extraction of FUE collected in a chamber. (c) The implantation handpiece. (d) Implantation with the automatic system. (Courtesy of Medicamat.)

are inserted manually with forceps in the slits after proper processing.

To detail the clinical performance, the transection rate is about 8% and the productivity is 500 grafts per hour with an average hairs per graft of 2,4 (evaluation done on 92.485 hair follicles). The donor area scarring is less detectable.

INDICATIONS FOR MICROGRAFTS

The goal is to obtain a harmonious balance between the aesthetic requirements (age, ethnicity, gender, and psychology), the evaluation of parameters for different classifications, the degree to which the alopecia has evolved, the capacity of the donor area, and the technical possibilities of the surgery.²⁸

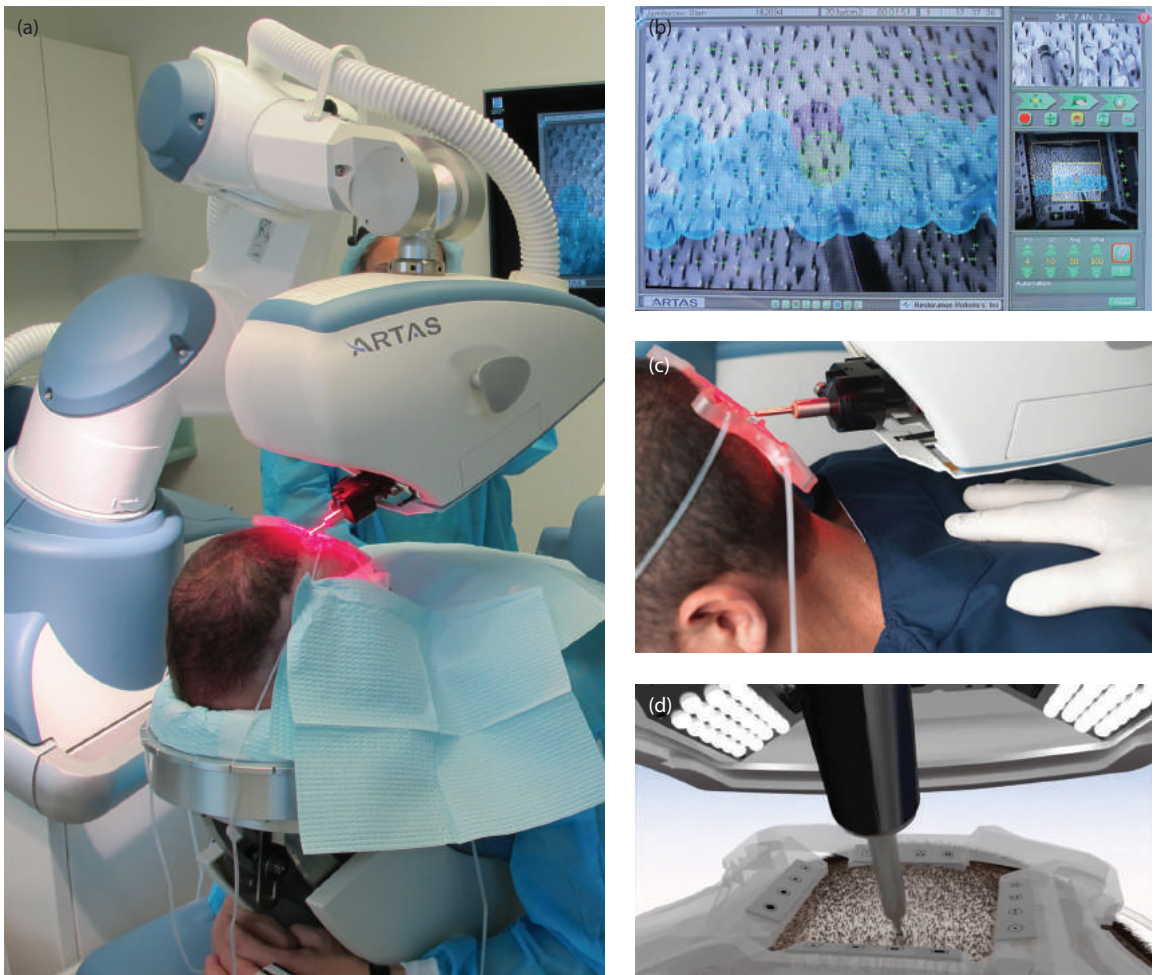


Figure 15.20 (a) The ARTAS robotic system. (b) A stereocamera guides the dissection process. (c) A skin tensioner maintains the skin. (d) A stereocamera calculates the angle of each FU. (Courtesy of Dr. Bernstein and ARTAS.)

Androgenetic alopecia

Various parameters of the Bouhanna multifactorial classification

Measurements are evaluated according to the Bouhanna multifactorial classification that takes into account multiple factors, such as the extent of the bald and hairy surfaces relative to some fixed points of the face, the laxity and thickness of the scalp, and the strength of the hair covering according to the density, size, shape, length, growth rate, and color (Figures 15.21a and b; see Chapter 5).^{29,30}

Predictive evaluation is made of the residual medio-occipital hairy area in the stage of maximal baldness^{29,30}: *superior axis*—eye external angle to earlobe apex; *inferior axis*—eye external angle to external auditory canal (Figure 15.21c).

The digital phototrichogram

The phototrichogram first described by Bouhanna in 1983³¹ provides an objective scalp evaluation, using a digital camera, of the hairy surfaces, donor sites, and recipient sites for the transplant (Figures 15.22a and b).^{31–33} The parameters of the hair growth—their density, size, number of miniaturized hairs, number of terminal hairs, and growth rate—will be measured and digitalized

Male androgenetic alopecia

The degree of baldness is graded to one of three schematic stages of the Bouhanna simplified classification⁷ (Figure 15.23) or, more accurately, through the multifactorial classification³³ (Figures 15.21a–c).^{30,34}

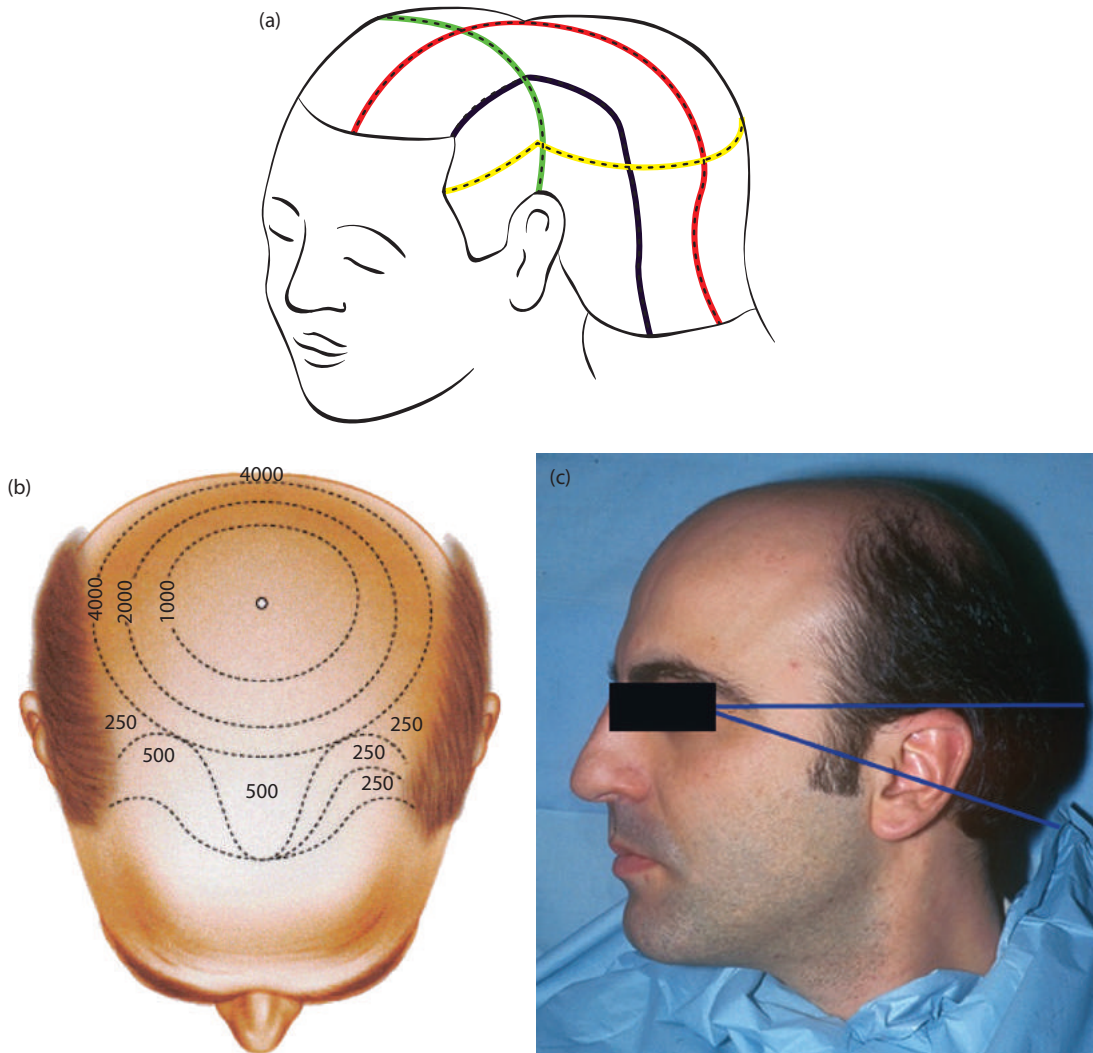


Figure 15.21 (a) Patterns of multifactorial classification with the evaluation of the four axes. (b) Evaluation of the number of hairs required depending on the location and the transplanted area. (c) Predictive evaluation of maximal baldness according to superior and inferior axes. ([a] Adapted from Bouhanna P. *Dermatol Surg*, 2000;26: 555–561.)

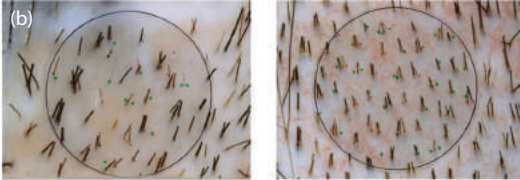
An essential point is that, in our opinion, to estimate the number of transplanted hair needed, the measurement unit is a hair and not a graft, as the graft may not always take.

Surgical correction involves transplantation of micrografts, as adapted schematically for one of these three stages described in 1976⁷:

- Stage I (frontotemporal recession, with possible crown alopecia at the vertex): Implantation of 1000 hairs in one session (Figure 15.24) (implantation

of 2000–3000 hairs is sometimes required when there is associated crown alopecia) (Figure 15.25).

- Stage II (recession of all the frontal line to the vertex, with a possible crown alopecia): Implantation of 2000–3000 hairs in one to two sessions (up to 4000 hairs when there is associated crown alopecia) (Figures 15.26a and b).
- Stage III baldness (called “Hippocratic”) where the hair remain only on the temporo-occipital region and up to 7000 hairs in one to three sessions are implanted (Figures 15.27a and b).



	1 cm ²		1 cm ²
Total hair count	94	Total hair count	171
Hair <40 μm	19	Hair <40 μm	44
Hair >40 μm	75	Hair >40 μm	127

Figure 15.22 Digital phototrichogram of the donor and the recipient area: (a) videocamera and (b) macroscopic views of the recipient and donor areas.

The transplantation of micrografts may be combined with a local anti-hair loss treatment^{17,18} (Figures 15.28a and b) (minoxidil 5%), intradermal injection of PRP (platelet-rich plasma), and/or general (finasteride 1 mg, orally), which aims to decrease the loss of residual hair between the grafts, to reduce the transient hair loss of grafted and nongrafted hair, and to accelerate the regrowth of grafted and nongrafted hair.

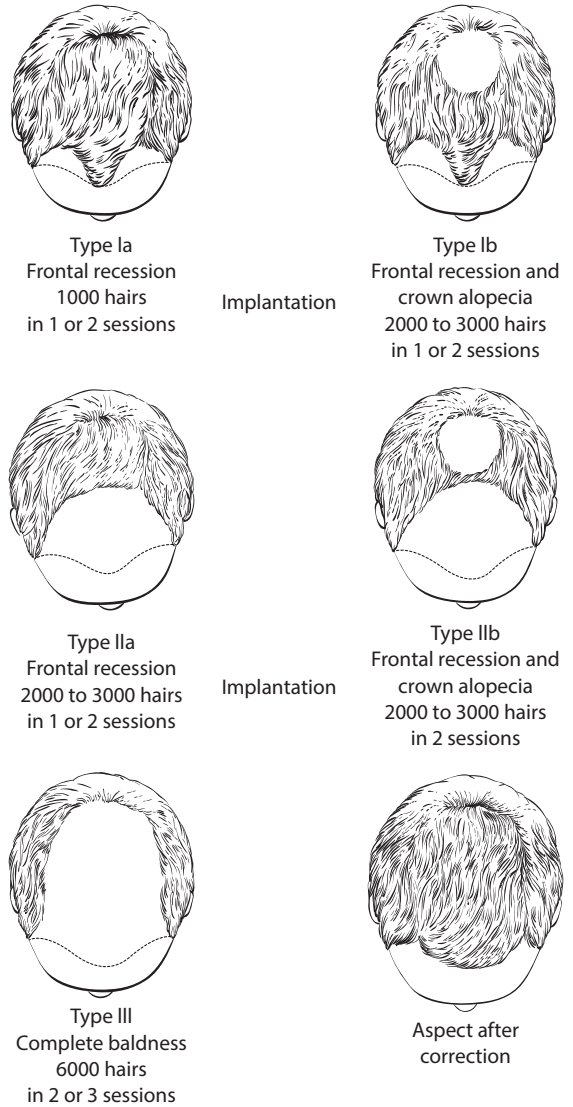


Figure 15.23 The three stages of evolution of the classification of male androgenetic alopecia. (Adapted from Bouhanna P. Le cuir chevelu. Les alopecies definitives et leurs traitements. Thèse de doctorat en médecine, Université Paris XII, 1976.)

Female androgenetic alopecia

The degree of a female baldness androgenetic alopecia can be graded using the classification of Ludwig (1977)³⁵ or more precisely assessed through the multifactorial classification of Bouhanna.^{13,14,21,29,30} Indications following the classification of Ludwig define three stages of evolution (Figure 15.29):

- Stage I: Moderate baldness on the vertex with respect of the frontal line: treated with implantation of 1000 hairs in one session (Figures 15.30a and b).



Figure 15.24 Male frontal alopecia (stage 1 or Hamilton IV) with FUL transplantation (1500 hairs) in one session.



Figure 15.25 Male crown alopecia with FUL transplantation (1600 hairs) in one session.