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REVIEW ARTICLE

# Alopecia and techniques in hair restoration: an overview for the cosmetic surgeon

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## Abstract

**Purpose** Alopecia is a debilitating disorder affecting millions of individuals worldwide. Although challenging to treat, advances in hair restoration technologies have led to multiple viable options with excellent clinical results. This paper seeks to provide an overview of hair loss and the currently utilized techniques in hair transplantation in order to serve as a reference source for the facial plastic surgeon.

**Methods** A comprehensive review of recent literature regarding the evaluation of, and management modalities for, alopecia was performed.

**Results** The follicular unit extraction technique and the strip harvest technique are both widely used for patients desiring transplantation. While both techniques can lead to successful outcomes, each has pros and cons that are important to understand prior to engaging in the procedure.

**Conclusion** Advancements in hair restoration technologies implementing robotics, manual, or motorized follicular unit extraction have facilitated optimization of outcomes. Adjuvant treatment modalities including robotics and platelet-rich plasma injections have shown utility in augmenting transplantation.

**Keywords** Alopecia · Hair transplant · Strip technique · Follicular unit extraction

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## Introduction

Hair plays an integral role in the perception of oneself and is often associated with youthful vitality. Hair loss affects a vast portion population ranging from 65 to 85% of males and 30–40% of women depending on age [1, 2]. While the causes of hair thinning are multifactorial, androgenic alopecia is the most common etiology and leads to male pattern androgenic alopecia (MPA) in men and female pattern hair loss (FPHL) in women [3].

The prevalence of hair loss increases with age. MPA affects 16% of males age 18–29, 30% of males in their 30s, 52% of males in their 40s, and 80% of males in their 70s [1, 2]. In females, the incidence of FPHL is 6% among women < 50 years, but increases significantly after this period, affecting 40% of women age 70–79 [4]. Hair loss most commonly affects Caucasians, followed by Asians and Africans [5].

## Anatomy of the hair and follicular unit

### Embryology

The primary hair bud begins developing by the 10th week of gestation. By the 18th week of gestation, all of the hair follicles on the body have developed [6]. The body will not create any new follicles with aging. Instead, the hair density will increase in proportion to the increase of surface area during growth.

### Hair follicle

A mature hair follicle is divided into three segments: the infundibulum, the isthmus, and the bulb. The infundibulum is the most superficial segment, extending from the epidermal insertion of the hair into the follicle to the entrance of the sebaceous duct. The isthmus extends from the sebaceous duct to the insertion of the arrector pili muscle. The bulb is the deepest segment and contains the hair matrix, the dermal papilla, and the melanocytes. The dermal papilla regulates growth and development of cells of the hair matrix, which divide and give rise to the hair shaft. The melanocytes are responsible for hair color.

### Follicular unit

Follicular units are groups of hair seen on the scalp [7]. A follicular unit is made up of several terminal hairs, a sebaceous gland and duct, and an arrector pili muscle. The unit is packaged by a collagen band called the perifolliculum. These naturally occurring units serve as the base elements for hair transplantation.

## Growth phases of the follicular unit

There are three phases of growth of the follicular unit: anagen, catagen, and telogen. At any point, 90% of hairs on the scalp are in anagen phase. This phase is characterized by a 3- to 4-year period of growth. This is followed by catagen phase, which represents the involution of the hair follicle. During this phase, which lasts 2 to 3 weeks, the inferior portion of the follicle ascends to the level of the arrector pili muscle attachment. The final phase, telogen, represents the resting phase and lasts for 3 months. At any time, approximately 10% of hairs are in this phase. An additional phase, known as exogen, is also often described. Each day, between 50 and 100 hairs enter this phase and shed before entering the anagen phase once more to produce new hair shafts.

## Etiology and presentation of alopecia

Androgenic alopecia is the most common cause of hair loss. In MPA, androgenic effects lead to a disruption of growth phases causing a decreased ratio of hairs in the anagen phase to those in telogen phase. This ratio continues to decrease with each cycle until a majority of the hair follicles are in telogen phase causing the characteristic appearance of hair thinning [8, 9]. In women, the role of androgens and the pathways of hair loss are less well understood.

There is a clear genetic basis for androgenic alopecia, and it is widely accepted to have a polygenetic mode of inheritance. A frequently cited gene in males is the androgen receptor/ectodysplasin A2 receptor (AR/EDA2R) locus located on the X-chromosome [10]. The genetic basis for FPHL is less understood [11].

The pattern of hair loss also differs between MPA and FPHL. MPA (as described by Norwood in 1975) tends to follow a consistent pattern [12].

FPHL is less consistent in its presentation, and at least three separate patterns have been described [5]. A commonly cited pattern and staging system—first described by Ludwig in 1977—involves diffuse hair loss in the vertex region with sparing of the frontal and occipital regions [13]. A second system was defined by Olsen who reported that women frequently present with hair loss primarily in the anterior aspect of the scalp with encroachment and loss of the frontal hairline can result in a “Christmas tree pattern” [14]. Finally, FPHL can follow a pattern similar to male pattern baldness and can thus be classified by the Norwood system discussed above [12].

## Patient assessment

A complete history and physical evaluation is vital in the assessment of hair loss, as the etiology can often be elucidated through careful questioning and examination.

### History

On history, physicians should determine the duration and progression of hair loss (including migratory loss and previous spontaneous resolution), as well as previous attempted treatments (conservative, medical, and surgical). Associated symptoms including pruritus and overlying skin changes such as scaling, pustular rash, and erythema can also provide clues to the etiology.

On past medical history, physicians should inquire about skin conditions that can lead to alopecia or excessive scalp scratching. Physicians should also inquire about a personal or family history, particularly in younger patients in order to gauge the potential for further progression of balding, as well as associated symptoms of relevant systemic illnesses such as thyroid disease, diabetes mellitus/metabolic syndrome, vitiligo, systemic lupus erythematosis, sarcoidosis, cicatricial pemphigoid, and lichen planopilaris [15–22]. Systemic infections such as HIV, tuberculosis, and syphilis have been implicated in cicatricial alopecia, and local infections frequently associated with hair loss include tinea capitis and chronic staphylococcal folliculisis [23–25]. It should be noted that histopathological assessment in the form of scalp biopsy is useful in the evaluation of cicatricial alopecia. Autoimmune-related conditions should be considered when evaluating patients as identification of these underlying processes and adequate treatment may lead to optimized surgical outcomes. Similarly, underlying inflammatory conditions, that may predispose individuals to cicatricial alopecia, such as frontal fibrosing alopecia and lichen planopilaris should be appropriately assessed and treated prior to procedural intervention. Malnutrition and vitamin deficiency resulting from inadequate routine dietary intake or purposeful vigorous dietary restriction have also been implicated in alopecia [26, 27]. Finally, a wide array of medications can lead to hair loss. Other risk factors should also be investigated such as family history of hair loss, hair trauma (excessive brushing, head scratching, and blow-drying), trichotillomania, and history of exposure to radiotherapy and/or chemotherapy [28, 29].

A thorough psychiatric history including stress, anxiety, psychiatric disorders, and prior emotional trauma is also a critical component of the alopecia history. Finally, for surgical candidates, a basic preoperative history should also be undertaken, including history of cardiopulmonary or renal disease, as well as use of anticoagulant and antiplatelet agents.

### Physical exam

Clues regarding the etiology of the hair loss can be elucidated from the physical exam. Focal loss is more likely to be due to conditions such as alopecia areata or trichotillomania. Conversely, diffuse loss is more often attributed to conditions such as anagen and telogen effluvium. While androgenic alopecia may either be focal or diffuse, it will frequently follow a classic pattern and progression.

Careful examination of the remaining hair should be undertaken, including the use of a Wood lamp. The characteristics of the hair (brittle, fine, oily, dry, etc.) should be noted, as should any color change (focal or diffuse). Close examination of the follicles should be performed to differentiate between cicatricial (typically permanent) and non-cicatricial (potentially reversible) etiologies. Scalp biopsies may be performed, as can KOH preparations and fungal cultures.

## Non-surgical hair restoration

Non-surgical therapeutic modalities play a central role not only as an adjunct to surgical interventions, but also an important primary means of therapy in the early phases of hair loss. In theory, medical treatment modalities that act through differing underlying mechanisms may have a summative or synergistic effect. The interventions listed below are of particular use in the early stages of hair loss, prior to significant loss of hair density. In cases of more severe hair loss, surgical intervention is likely to yield more esthetically pleasing outcomes.

### Minoxidil

Originally developed as an antihypertensive agent, patients taking this drug were noted to undergo hypertrichosis, leading to its ultimate use as a first-line therapy for androgenic alopecia [30, 31]. Minoxidil may be applied as an over-the-counter preparation as a 2% or 5% solution. The 5% formulation appears more efficacious, however, with an average of 45% greater hair growth over a 48-treatment course [7]. Side effects can include allergic or irritant contact dermatitis. Females with alopecia are treated with 2% minoxidil due to a greater incidence of hypertrichosis with the more concentrated solution [32]. Of note, women should be counseled that minoxidil may be harmful during pregnancy or breastfeeding.

### 5α-reductase inhibitor

This class of drugs directly inhibit 5α-reductase, preventing the conversion of testosterone to dihydrotestosterone (DHT). Finasteride, a systemic 5α-reductase inhibitor, gained popularity in the 1990s due to its capacity to halt the progression of hair loss and, in some instances, results in regrowth [33].

Common side effects associated with finasteride use include decreased libido and erectile dysfunction while less-common side effects include breast tenderness or enlargement, depression, testicular pain, allergic reactions, and rarely male breast cancer [34, 35]. Although several case reports support its use in females, the role of finasteride in female pattern hair loss is at this time equivocal due to limited clinical studies showing variable results [36, 37]. Prior to initiation of therapy, pregnancy must be ruled out, and women should be maintained on a contraceptive while taking the medication due to a risk on the fetus. Dutasteride, a type I and type II 5α-reductase inhibitor, was approved for use by the FDA in 2002 for the treatment of benign prostatic hyperplasia [33]. It has since been used for off-label treatment of both male and female hair loss. While significantly more potent than its counterpart, finasteride, the risk of sexual side effects may also be greater [38, 39].

### Phototherapy

Laser phototherapy has been demonstrated to result in hair growth [40, 41]. In recent years, a low-level laser therapy (LLLT) mediated comb has been approved by the FDA for the treatment of hair loss. Studies comparing these devices with placebo, or sham devices, have demonstrated a statistically significant increase in hair counts [42]. Treatment regimens vary widely due to indeterminate optimal frequency, power, or duration of therapy.

### Platelet-rich plasma

Platelet-rich plasma (PRP) has become quite popular in recent years following the discovery of platelet-derived growth factor (PDGF) and its role in promoting wound healing [43, 44]. Essentially, concentrated autologous platelets are injected into the patient's scalp. When activated, these platelets release growth factors including PDGF, vascular endothelial growth factor, insulin-like growth factor, and interleukin-1 [45]. Preliminary studies have demonstrated the potential efficacy of PRP in accelerating the healing phase following hair transplantation [46]. However, data supporting the direct stimulation and subsequent growth of hair is limited.

## Surgical techniques in hair restoration

Several surgical options are available to treat the balding scalp. Treatment should be tailored to the individual and will depend on several factors including patient age, degree of hair loss, donor site density and elasticity, hair texture and caliber, skin tone, and of course, patient expectations. The most common procedures to address alopecia include follicular unit transplantation (FUT) techniques, which have recently replaced traditional procedures such as plug grafts, scalp reductions, and transposition flaps. These techniques achieve excellent outcomes in an inconspicuous fashion.

### Strip technique/follicular unit transplantation

The strip technique, or follicular unit transplantation, remains one of the most popular methods in hair restoration. It is based upon the concept of the follicular unit. Follicular unit transplantation uses microscopic dissection to harvest donor hair from the back and sides of the scalp using a long, thin strip of tissue. These tissue strips are then further dissected into individual follicular units using stereomicroscopes and implanted along the recipient site [47].

Grafts are harvested from areas with terminal hairs, which generally grow indefinitely. Although different in every patient, the superior boundary of graft harvest should be 2 cm below the area of crown thinning while the inferior boundary is planned approximately 2 cm above the nape of the neck.

The total number of grafts needed is calculated by measuring the recipient site area and then multiplying this by the final required recipient graft density. This generally ranges between 20 and 40 follicular units per square centimeter ($cm^2$). The primary factors that determine the size of the donor strip are the donor site follicular density and the overall elasticity of the scalp. The maximum strip length is limited to the span of one supra-auricular area to the contralateral corresponding side. Strip width will depend on scalp elasticity and is variable. The total number of follicular units along the occiput of the donor area in a Caucasian male is estimated to be approximately 100 units per $cm^2$. One can also estimate this density by counting follicular units using a densitometer. After establishing the density, scalp laxity is evaluated by stretching and compressing the area to define a safe maximum strip width. Strip length is then calculated using the following equation [48]:

$$\text{Strip length (cm)} = \text{desired graft number} \Big/ \left[\text{graft density } \left(\text{FU}/\text{cm}^2\right) \times \text{width (cm)}\right]^{62}$$

After establishing the above parameters, the procedure is performed with the patient in the prone position. The planned donor site hair is trimmed to a length of approximately 2–3 mm. Allowing the hair above the harvest site to remain long will assist in camouflaging the incision in the immediate postoperative period. Following administration of local anesthetic, the epidermis is initially scored along the superior and inferior borders of the planned strip using a scalpel. Follicular units are then separated along both these borders from those on the opposing native donor site edges. After completing dissections of these borders, the delineated strip is undermined, freeing it from the underlying tissue in a sub-follicular plane. Many physicians prefer to leave the galea aponeurotica and

occipital fascia intact to minimize risk of permanent numbness. Minor skin-edge bleeding is disregarded in order to prevent damaging donor site follicles with aggressive electrocautery. The donor site strip is then prepared, excising excess tissue and leaving 1 to 2 mm of fat below the follicular unit. Under direct magnification, the strip is dissected with a scalpel into vertical segments one follicular unit thick. These segments are then further dissected, isolating individual follicular units.

Strip harvesting should result in only one incision regardless of the number of harvesting procedures. Multiple harvests are possible but carry a risk of scar widening. If a preexisting donor site scar exists from prior harvest, the surgeon may reorient subsequent incisions in order to place the old scar along either the superior or inferior border of the new strip. Alternatively, the scar may be placed within the middle of the new donor strip. This is ultimately contingent on the design that allows for both optimal closure and cosmesis. A tension-free closure is critical in preventing resultant donor site follicular necrosis, and widening of the scar and such closure is obtained without difficulty if the strip is less than 1.5 cm in width. The donor site incision is closed in one or two layers depending on which layers were dissected and resected during harvest. First, the deep fascia is approximated with running 2–0 polyglycolic acid sutures, or those of the surgeons choosing, in order to redistribute tension from the superficial cutaneous closure. It is imperative that this suture remains deep to the follicular plane to mitigate risk of follicular damage. The skin layer is then closed with either surgical staples or running 3–0 nylon suture.

The trichophytic technique in donor site closure is a modification intended to facilitate hair growth through the mature surgical scar [48, 49]. In this method, a 1–2-mm strip of skin and papillary dermis is removed from either the superior or inferior border of the donor site, effectively de-epithelializing it. The epidermal wound edge is then approximated to the de-epithelialized border. This results in a deeper segment of follicular units to be buried beneath the surgical incision line. As the scar matures, hair will grow through the wound to provide improved donor site camouflage.

## Follicular unit extraction: manual, powered, and robotic techniques

Follicular unit extraction (FUE) is a method of graft harvest employing various punches to remove individual FUs from the donor region [50]. Advantages to this technique include prevention of a potentially unsightly donor site linear scar and shorter postoperative healing time. Furthermore, FUE facilitates revision of "pluggy appearing" or improperly placed hairlines following prior hair restoration. Additionally, this technique is particularly advantageous in patients with poor scalp laxity or patients who prefer to wear their hair short resulting in increased scar exposure such as military personnel. Given the above advantages, this technique has gained considerable popularity within the last decade and is the most commonly utilized approach towards hair restoration [51].

Two basic punch techniques are implemented in FUE, dull- and sharp-tip punching, and within each subtype, manual and powered instrumentation exists. Sharp techniques are limited in the depth of punch insertion in order to decrease risk of follicle transection while blunt punch techniques allow for deeper dissection while mitigating the force on the graft site during harvest [50].

Indications for FUE in both reparative and restorative procedures are similar to that for the strip method. In addition, certain patients are better suited to FUE. These include patients with low donor hair density or those that prefer to wear their hair short. Postoperative pain following FUE is also considerably less in comparison to strip surgery.

It is important to note that FUE and FU strip techniques are not mutually exclusive and may be performed concurrently. A combination of a strip harvest and FUE technique can be used to maximize the total number of grafts obtained from a single surgery. Typically, a strip is obtained and the grafts are subsequently implanted along the recipient site. This procedure is then followed by an FUE procedure. Combination of strip harvest and FUE approach has been shown to increase a graft yield by approximately 50% for a single procedure [52]. This approach may yield particularly noticeable benefits in patients with Norwood class 6–7 hair loss. Lastly, an added benefit to this technique is the surgeon's ability to harvest hair from areas of the body other than the scalp, including the chest, back, extremities, abdomen, pubis, or submandibular regions. It should be noted that although body hair harvest techniques are feasible, with anecdotal evidence supporting their use, there is no evidence within the primary literature that examine graft survival rates [53].

Follicular transection is a major concern with use of FUE due to the lack of visualization of the follicular unit as the punch device penetrates the donor site. While small punches further mitigate the risk of residual scarring following surgery, decreased punch diameters increase the risk of follicular transection [54]. Several modifications have been proposed to address the risk for transection. A two-step technique, in which a sharp punch is initially used to score the epidermis and a dull punch is then implemented for deeper dissection of the follicular unit and deeper subcutaneous tissue, has gained popularity [50]. Mechanized rotary and robotic surgical devices have also been introduced as an alternative to manual FUE. These devices facilitate the extraction of larger numbers of follicular units during a single surgical procedure [55, 56].

In preparation for graft harvesting, the donor site area is shaved to a length of 2–3 mm in order to facilitate visualization of both the direction and angle of the hair follicle. The patient may be placed in either a seated or prone position.

Local anesthesia is injected along the donor site in standard fashion. Punch diameters, ranging between 0.8 and 1.2 mm, are then used to score the skin confirming that the follicular unit is oriented within the center of the anticipated circumferential incision. The punch is subsequently advanced using an oscillating motion to further dissect and isolate the follicular unit from the surrounding soft tissue. Meticulous dissection is required as the predicted trajectory of the hair shafts must be followed in order to avoid follicular transection.

Following release from the underlying subcutaneous tissue, the follicular unit is removed using micro-forceps. This protocol is repeated until a sufficient number of grafts is obtained. Grafts are then examined under high-power microscopy to verify both their integrity and remove additional excess soft tissue.

Of particular importance, the sharp punch technique, when implemented, should be performed with depth limitation in order to decrease follicular transection as follicle transection rates have been noted to correlate directly with dissection depths. In general, transection rates should be less than 5% regardless of technique employed [57]. "Dull" dissecting punches are often employed to circumvent the risk of transection [50]. In theory, the dull tip is less likely to transect the follicles. Rather than cutting, the tip acts as a "guide" during dissection, recruiting the follicle within the lumen of the punch. This allows for a deeper plane of dissection, further separating the follicles from the underlying tissue while mitigating associated risks of follicular injury. Modifications of this technique include a device with a vacuum apparatus which facilitates extraction of the follicular units, preventing microtrauma associated with manual extraction. This vacuum apparatus then reverses to implant the grafts. Powered devices with programmable functions such as oscillatory or rotating punches have also been documented in the literature [50, 52].

The dull punch technique involves several distinct modifications. The manual dull punch technique is a two-step procedure [54]. The first step involves scoring both the epidermis and dermis to a depth of approximately 0.3–0.5 mm using the sharp punch. The blunt punch is then aligned with the projected angle of the emerging hair follicles and inserted into this initial incision. The dull punch is then manually rotated to a depth of approximately 4 mm, and the follicular unit is removed. The primary complication associated with this technique is a 7% graft burial risk. The majority of grafts are salvageable; however, there remains a graft loss rate of 1.4% [54–56, 58].

The powered dull punch device involves a single-step dissection process [58]. The donor area is first shaved, and a 4 $cm^2$ area is infiltrated with 1-2 ml of dilute epinephrine solution. This is meant to facilitate hemostasis throughout the process. While traction is applied in a direction opposite to that of hair growth, the rotating dull punch device is positioned over the emerging hair at the estimated angle of the hair follicles. The punch is then pressed into the skin while perpendicular pressure is held along the handpiece dissecting the follicular unit free. The dull punch can be inserted to an automated depth of 4 mm or to a lesser depth if desired [58].

Robotic devices have been developed as a modification of these techniques and facilitate extraction of increased follicular units during a single procedure [55]. A skin tension device, a "tensioner", is first placed, stabilizing the skin. This device is equipped with fiducial markings along the peripheral margins that define the parameters for the donor region and allow for algorithmic assessment of the angle and trajectory of hair follicles emerging from the scalp. The robot is physician-driven and implements a two-step process similar to manual dull punch systems described above. After the physician selects a targeted graft site, an inner sharp punch scores the skin to a depth of 1–2 mm. A 1.2-mm dull punch is then inserted to a depth of 4 mm and rotated to dissect the follicular unit from the underlying soft tissue. Adjustments may be made to the incision depths of the punches, the angle of insertion and the speed of rotation; however, these settings are also preprogrammed and automated. In this fashion, the system can move from one donor site to the next for repeated harvesting. Potential advantages with use of the robotic FUE technique, in comparison to manual extraction, include increased accuracy of graft harvesting with decreased risk of follicular unit damage, reduced harvesting time, increased accuracy in recipient site implantation, and avoidance of damage to the native hair at both the donor and recipient site [59–61].

## Considerations in recipient site creation

Following graft dissection and removal, grafts must be stored in an atraumatic fashion within a holding solution, such as sterile saline. Follicular grafts are devoid of investing adipose tissue. Therefore, their time outside of holding solution should be limited in order to prevent desiccation.

The implantation process must be similarly performed in a meticulous fashion to prevent injury to the follicles. Graft exposure should typically be limited to less than 2 min [60]. The majority of alopecic areas may be augmented with dense hair within a single session, if adequate donor site reserves are present. The original hair angle and direction should be followed meticulously when preparing the recipient openings in order to maintain the native hair growth pattern while also preventing transection of the recipient area hair. Consideration of hair growth patterns is important in recipient site planting. Hair along the frontal aspect of the hairline is angled anteriorly at a 15–20° angle. Laterally, this angle changes to 10–15° although the orientation is otherwise similar. As the lateral hairline transitions to the temporal region, hair follicles are oriented inferiorly. These directional changes must be accounted for during the implantation process. Great care should be taken when accounting for the design of the

temporal recess. Males tend to have a sharp temporal recess while females tend to have a rounded temporal recess. It is very difficult to revise an implantation if a male is given a rounded temporal recess in error. Implantation surrounding the crown is angled and oriented in a radial fashion to mimic the "natural whorl" or spiral within this region.

Following graft harvesting and recipient site preparation, including consideration of hair pattern, small slits are made along the recipient bed using flat-edged blades. Alternatively, a combination of 19, 20, or 21gauge needles may be used to create recipient sites that will accommodate individual follicular units composed of 1–4 follicles. Again, surgeons must be careful not to transect native hair follicles during this process. The majority of surgeons advocate for use of magnification, either with microscopy or surgical loupes, in order to limit microtrauma to the native hair [62]. Recipient sites are created in a random, irregular pattern with 10–30 sites/cm$^2$, although this largely depends on the existing density of the native hair. Grafts are manipulated using the perifollicular tissue thus avoiding direct trauma to the follicles. The graft is then placed within the recipient site. Light pressure is applied for 10–15 s with a saline-soaked cotton tip applicator to achieve both hemostasis and to prevent "popping" of the graft.

### Complications

Complications following hair restoration procedures are rare. The robust vascularity of the scalp allows for rapid wound healing and low infection rates [63]. The most common documented complications include postoperative edema (~5%), postoperative bleeding (< 0.5%), folliculitis, and numbness of the scalp. Telogen effluvium, or "shock" hair loss, may occur along both the donor and recipient site. Although uncommon, this occurs due to hair loss as the growing anagen hair transitions to the telogen resting phase secondary to physiologic stress from microtrauma to the surrounding native follicles. This is typically short-lived as the majority of dormant follicles regrow within 3–4 months. Epidermal cysts and ingrown hair are commonly encountered 2–3 months following surgery. These processes are self-limited in nature but may trigger an inflammatory reaction throughout the implanted graft population until the majority of hairs emerge from their subcutaneous implanted plane. Cutaneous eruptions may occur and are often responsive to exfoliative therapy including warm compresses, vigorous shampoo regimens, or antibiotic agents. Overall, infections occur in less than 1% of patients [63–65].

### Summary

Hair restoration is a dynamic field with continually evolving treatment modalities. Advances in non-surgical medical management have allowed for stabilization of the hair loss process and partial regrowth. However, follicular unit hair transplantation remains the gold standard for addressing advanced alopecia in these patients. Overall, the key components for postoperative success are patient selection, managing expectations, and careful hairline design.

## Postoperative management

As with many surgical procedures, the postoperative care following hair restoration procedures is largely surgeon dependent. No published guidelines are available, and there is a lack of consensus regarding which medications should be prescribed to patients postoperatively [66].

Bruising and edema around the surgical site are common, and patients should be made aware of this preoperatively. Ice packs are frequently recommended to help mitigate the edema, and some surgeons offer systemic corticosteroids. Many surgeons recommend that patients not take NSAIDs, antiplatelet agents, or anticoagulant drugs leading up to and in the immediate postoperative period to limit bruising and reduce the risk of hematoma formation.

Analgesic medications are provided to the patient. While topical minoxidil is commonly offered to patients before and after hair transplant, it has not been shown to result in better outcomes following hair transplant than shampoo alone [67, 68]. Some surgeons routinely prescribe postoperative antibiotics, although there is little to no evidence in the published literature to support or refute their use.

It is universally accepted however that the patient should perform frequent wound care, starting with regular shampooing (ranging from one to multiple times per day) typically on postoperative day 1. Patients are asked to refrain from rigorous physical activity, although the duration of restriction varies widely. Surgical staples and/or sutures are typically removed 7–14 days postoperatively. Patients should refrain from smoking and should avoid direct sunlight to the surgical site in the early postoperative period.

## Conclusion

Hair loss can be an inevitable and debilitating condition for some. However, through the use of both non-surgical and surgical techniques, this process can be reversed and even cured.

### Compliance and ethical standards

**Conflicts of interest** The authors declare that they have no conflicts of interest.

**Informed consent** This article does not contain any studies with human participants or animals performed by any of the authors.

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