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The surgical treatment of cicatricial alopecia

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ABSTRACT: Surgical correction of cicatricial alopecia can yield exceptional results when performed in the appropriate clinical scenario. To facilitate determination of the most suitable corrective therapy, we propose two new categories of cicatricial alopecia: "unstable" and "stable." Unstable cicatricial alopecia is intermittent and results in possible subsequent scarring hair loss in either new or old areas. Stable cicatricial alopecia, on the other hand, refers to fixed permanent scarring. While surgical excision is preferred to hair transplantation for both categories of cicatricial alopecia, this preference is even stronger in cases of unstable cicatricial alopecia due to its intermittent and progressive nature. Regardless of which corrective technique is used, analysis of specific physical patient characteristics coupled with a careful view towards the possible evolution of male pattern baldness or female pattern hair loss are essential to achieve superior long-term results. Herein we also outline guidelines for identifying these physical traits as well as for performing hair transplantation and surgical excision in order to achieve optimal cosmetic outcomes and minimize postoperative complications.

KEYWORDS: alopecia reduction, female pattern hair loss, hair transplantation, male pattern baldness, stable cicatricial alopecia, unstable cicatricial alopecia

Introduction

Surgical correction of cicatricial alopecias is highly effective, provided the physician follows certain guidelines with regard to both timing and technique. While the affected area is most often treated with hair transplantation, alternative approaches include alopecia reductions (the excision of the hairless region) and/or flap procedures, alone or sometimes in conjunction with hair transplanting. Our discussion here will be limited to the two most common of these options: hair transplantation and excision. The latter is in fact frequently the preferable method of correction for reasons that will be explained below. Fortunately, excision is also practical for virtually all dermatologists with a modicum of surgical experience. For purposes of clarity, we have divided cicatricial alopecia into two main categories that we will refer to as "unstable" and "stable" cicatricial alopecia (Table 1).

"Unstable" cicatricial alopecias (UCAs) are secondary to disorders that have a tendency to progress and recur intermittently over the course of time. These disorders include, but are not limited to, conditions such as lichen planopilaris, pseudopelade of Brocq, and discoid lupus erythematosus. Their diagnoses, courses, and medical treatments have been described in detail elsewhere, but their periodic nature may result in new regions of cicatricial alopecia developing in what would be considered both recipient and donor areas if hair transplantation were the anticipated course of treatment. Therefore, prior to considering any surgical treatment, it is vital to have identified the type of alopecia and also to have confirmed quiescence preferably for at least 1 year (1). It is also important to explain to the patient that if their disease becomes reactivated at any time, the success achieved with surgery would likely be affected unless the disorder is promptly controlled. Many of the dermatologic diseases

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Table 1. Causes of stable and unstable cicatricial alopecia

Stable cicatricial alopecia (SCA)	Unstable cicatricial alopecia (UCA)
Trauma	**Lymphocytic**
Burns	Cutaneous discoid lupus erythematosus
Radiation-induced alopecia	Classic lichen planopilaris
Prior hair transplantation	Frontal fibrosing alopecia
Prior rhytidectomies and brow lifts	Graham–Little syndrome
Traction alopecia	Classic pseudopelade (Brocq)
Trichotillomania	Alopecia mucinosa
Pressure alopecia	Keratosis follicularis spinulosa decalvans
Congenital	**Neutrophilic**
Aplasia cutis congenital	Folliculitis decalvans
Lymphocytic	Dissecting folliculitis
Central centrifugal cicatricial alopecia	**Congenital**
	Conradi–Hunermann chondropysplasia punctata
	Incontinentia pigmenti
	Ankyloblepharon
	Hallerman–Streif Syndrome
	Generalized atrophic benign epidermolysis bullosa
	Other
	Acne keloidalis/Acne necrotica
	Erosive pustular dermatosis
	Infection (deep fungal infections, zoster, massive bacterial folliculitis, tinea capitis with keratosis)
	Metastatic/primary neoplasm
	Graft-versus-host disease

that have the potential to develop into UCA can be successfully treated medically before scarring actually occurs. However, the insidious intermittent nature of progression of most of the causative disorders can lead to less-than-aggressive medical intervention. This unnecessarily allows the disease to permanently destroy follicles; hence, the urgency of dealing with any recurrences, especially after surgical correction.

Stable cicatricial alopecias (SCAs) are secondary to isolated events that cause permanent scarring in a hair-bearing region. Once successfully corrected surgically, there is no need for the constant vigilance that is required after treated UCA. Common inciting events resulting in SCA include trauma, burns, infection, radiation, and prior head and facial surgeries. The approach and technique for surgical treatment varies with the size, location, and other characteristics of the scarred regions.

Both UCA and SCA must also be treated with a view to the possible evolution of male pattern baldness (MPB) or female pattern hair loss (FPHL) in the areas surrounding the treated areas. If either MPB or FPHL did occur and one had only transplanted the affected areas, an unnatural appearing island or islands of hair in a "sea" of alopecia would result, hence, the aforementioned frequent preference for the excision of involved areas, whenever this is practical, instead of the employment of hair transplantation (or flaps).

Surgical excision vs. hair transplantation

As noted earlier, because the cause of UCA can be expected to be intermittently recurrent with subsequent cicatricial hair loss in new areas, excision is often the best choice for UCA provided the pattern and size of the scarring lends itself to that option. However, the decision as to whether hair transplantation or excision or "alopecia reduction" (AR) should be utilized requires consideration of not only whether one is dealing with UCA or SCA, but also five additional interdependent factors: the availability of donor hair, scalp laxity, the patient's healing characteristics, vascular supply, and the location of the subsequent scar.

Availability of donor hair

As with hair transplantation for MPB and FPHL, the long-term donor-recipient area ratio – that is, the ratio of "permanent" donor hair relative to the

ultimate size of present, as well as future areas of alopecia that might develop – is perhaps the most important factor to consider. In rare cases, the individual may have ample amounts of acceptable "permanent" donor follicles to treat the area of scarring with little concern for the development of new areas of alopecia. In many more patients, however, the ratio is inadequate to satisfactorily treat both the current and possibly future areas of cicatricial alopecia, in addition to addressing surrounding areas that are likely to develop MPB or FPHL and that the patient might have to treat in order to avoid the aforementioned unnatural-looking islands of hair in a sea of alopecia. Furthermore, if donor hair is taken from an area that is eventually destined to lose its hair secondary to MPB/FPHL or some of the diseases that cause UCA, it will also be lost in the recipient area. In the case of UCA, if the disease eventually affects the recipient area and is not satisfactorily treated medically, the transplanted hair will be lost, creating a new demand for additional donor tissue. These possibilities obviously must be factored into the long-term donor-recipient area ratio. Given the difficulty in accurately estimating this ratio, excision is generally preferable to hair transplanting. This is especially true with respect to larger alopecic regions in younger individuals, while older patients with small areas of scarring may often be appropriately treated with hair transplantation.

Scalp laxity

As alluded to above, in some patients with UCA, the affected area(s) are few and small. They are therefore easily transplanted or excised—the latter without any depletion of potential donor follicles and without the necessity of having to treat evolving MPB/FPHL in the surrounding areas. Obviously, however, one should never attempt to excise a region of cicatricial alopecia unless acceptable laxity is present to allow for low-tension wound closure. In general, the less scalp laxity, the more preferable hair transplantation is to excision. However, for patients who are judged to be poor candidates for hair transplantation, and who also have minimal scalp laxity (see Tissue expansion and extension below), soft tissue expansion (2) or the use of extenders (3), prior to single or sequential AR of the cicatricial areas, may be the best first-line treatment. Small hair transplantation sessions (or occasionally flaps) may then subsequently be utilized to conceal any resultant surgical scars, or remaining areas of alopecia.

Patient's healing characteristics

Healing characteristics vary widely between patients. There are some individuals, for example, who have had previous surgeries which resulted in highly visible scars, despite good surgical technique. Patient characteristics that increase the likelihood of poor wound healing after surgery include those with a history of hypertrophic or keloid scars, less or greater than average scalp laxity (especially those with Elhers–Danlos syndrome), and individuals who have experienced inexplicable excessive postoperative bleeding in the past. All of the foregoing favor a decision to utilize hair transplantation as opposed to excision (4).

Vascular circulation

It is important to decide whether the vascular supply is sufficient to provide adequate support for the grafted hair follicles. In particular, grafts in the center of a large scar are most distant from a good blood supply. Atrophic or fibrotic areas, secondary to an inflammatory disease, may also sometimes lie close to the other cicatricial areas and further compromise blood supply. Inadequate perfusion may not only result in poor growth of the transplanted grafts but, worse yet, may cause ischemic injury to the tissue which may be severe enough to result in necrosis or infection. To test the blood supply of a large area, it is recommended that one first anesthetize a portion of the area with a 2% lidocaine solution without epinephrine. Then a 19-G needle can be used to make several incisions. There should be evidence of bleeding when this is done. If not, the area would be best treated with surgical excision. If a single AR cannot be expected to remove the entire area of scarring with both wound edges passing through normal scalp tissue, then serial surgeries can be performed with one edge of each excision passing through normal tissue on each occasion.

Area of involvement

If even flawless excisions can be expected to leave a small but easily visible scar in the alopecic area, hair transplantation is preferable. Examples of such sites include the hairline and eyebrow. Also vertical scars are, in general, more difficult to conceal than horizontal or oblique ones as they require longer hair to fall over the entire alopecic vertical plane. Where possible, excisions in these areas should therefore be performed horizontally. If this is not a feasible or satisfactory approach to

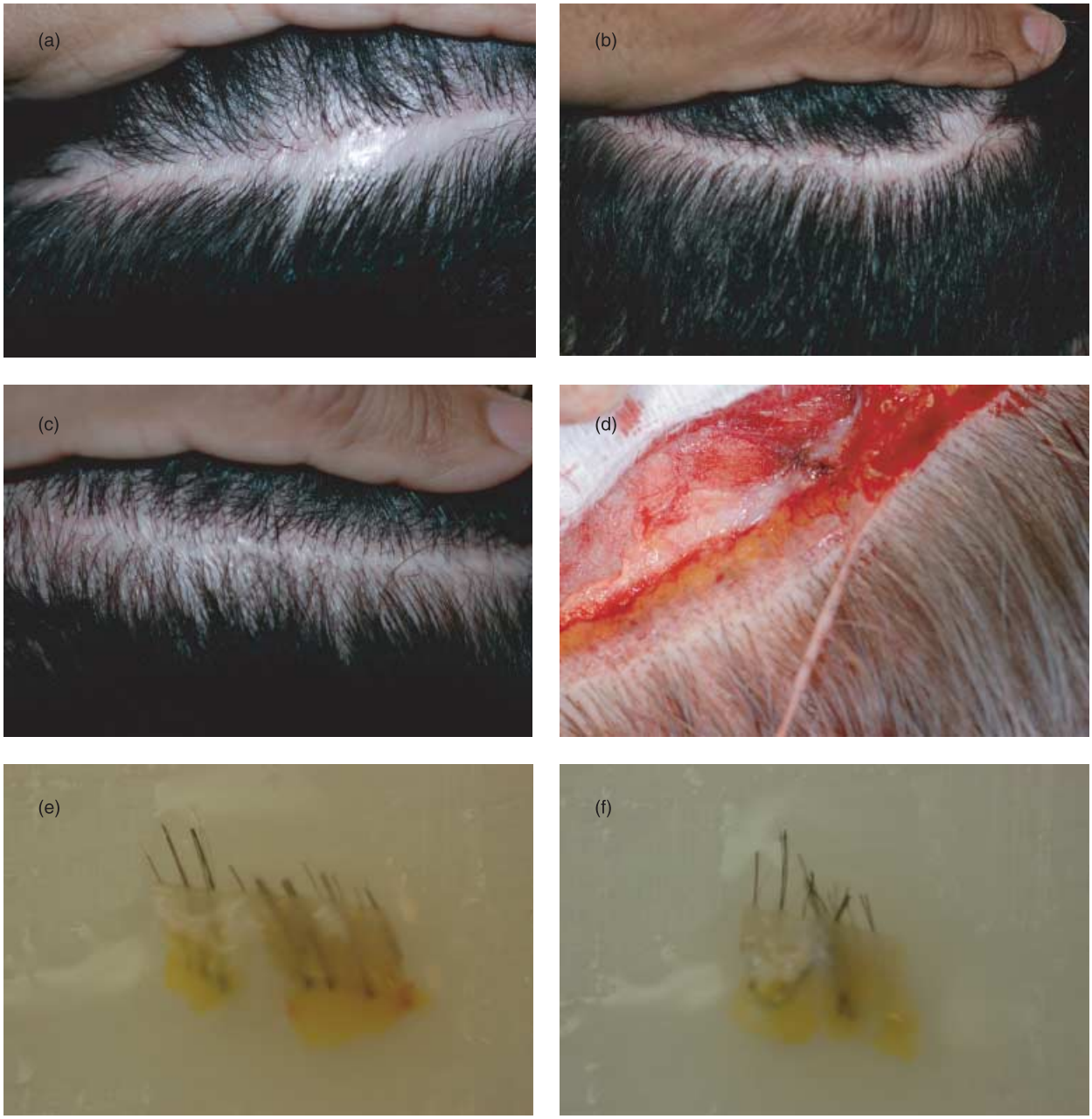

FIG. 1. **(a) A patient with wound healing characteristics that tend to result in scars more visible than average. He previously had had three surgeries with an excellent surgeon. The photo shows the donor area before his fourth surgery. (b) Right donor area after his fourth surgery in which half the donor area was closed with the traditional closure technique under no tension (right side) and half was closed utilizing the trichophytic technique (left side). (c) A close-up photo of the trichophytic side of the donor scar after the fourth surgery, showing the hair growing through the scar tissue. (d) A photo showing the trichophytic technique in which a small edge of epidermis is removed from the inferior edge of the wound. (e) A sliver of tissue dissected from the area which was closed previously with a nontrichophytic technique, showing the central area of tissue which has no follicles. (f) A sliver of tissue dissected from the area which was closed previously with a trichophytic closure, showing the hair growing through the scar tissue.**

the goal or problem area, a hair transplant may be the preferred approach, or may be required as a second phase, to camouflage the resulting scar. If excision is employed, ideally the surgeon should use a "trichophytic" closure in which a narrow zone of the epidermis of one flap of the wound is removed and the wound is closed in such a way as to result in hair which grows through the scar itself (5) (FIG. 1). This technique is particularly useful when one carries out revisions of overly wide donor area scars from prior hair transplants (FIG. 1).

FIG. 2. **(a) A scar from an infection in the donor area during a preceding hair transplant done elsewhere. Many people believe that such scars cannot be improved upon by additional strip harvesting. This is not necessarily true. (b) The same patient immediately after excision of the strip from the area shown in FIG. 2(a). In such cases, it is particularly important (a) to not close the wound with any tension whatsoever and (b) that one border of the new incision should run through intact hair-bearing skin, thus supplying an optimal blood supply to the new wound. (c) Six months after the photo in FIG. 2(b) showing that the scar did not return to anywhere near its original size with the passage of time. The hair adjacent to the remainder of the scar has been clipped short just prior to another strip being removed in order to further improve the scarring. Perioperative prednisone, intralesional triamcinolone acetonide (3.33 mg/mL), and perioperative topical minoxidil solution (3%) were also employed, to minimize postoperative edema and maximize blood supply to the wound.**

Special considerations in SCA

Although the aforementioned five criteria help guide physicians when selecting the most appropriate surgical treatment of cicatricial alopecia, there are unique forms of SCA resulting from trauma whose aspects of management merit additional discussion.

Previous hair transplant surgeries. Unfortunately, this is one of the more common types of SCA the authors see on a regular basis in their practices. Occasionally, poor wound healing characteristics are the sole cause of unsightly donor area scars. More often, however, they are due to the trend toward larger hair transplant sessions which utilize unacceptably wide donor strips and tight wound closure. The most conservative approach to repairing these scars is to perform an excision that allows for wound closure without tension. In order to facilitate this, the patient is encouraged to firmly massage his or her scalp for 1–2 h daily for several months prior to the repair. The intention is to increase scalp laxity sufficiently to allow for maximum or even complete excision in a single session. More commonly, serial excisions are required because of inadequate scalp laxity (FIG. 2). In such situations, we also typically employ perioperative oral prednisone (60 mg immediately prior to surgery and a dose-pack over the seven following

days), inject a 3.33 mg/mL solution of triamcinolone acetonide into one side of the closed wound, and prescribe a 3% minoxidil solution to be applied twice daily for 5 weeks beginning a week before surgery. The purpose is to minimize postoperative edema and to maximize blood supply to the wound. If the patient has displayed poor wound healing characteristics in the past, the surgeon may employ other methods of prevention and treatment of unsightly scars, for example, silicone elastomer sheeting (6) as well as the aforementioned "trichophytic closure." If wound healing has been consistently poor after multiple procedures, despite having been performed with optimal technique (an unusual situation), then the best choice may be to transplant into the donor area scar. In this instance, the grafts should ideally be harvested using follicular unit extraction (FUE) (see below).

Previous rhytidectomies and brow lifts. After cosmetic surgery in the facial area, hairlines may be altered and scars may be left in visible areas which the patient cannot camouflage. This is the second most common cause of SCA seen in the authors' practices. It is not necessarily the result of a "mistake" by the cosmetic surgeon but rather is frequently a natural sequela of the patient's healing characteristics and/or of the necessary locations of the incision(s). A rhytidectomy, for example, results in a scar in the temporal hairline and posterior to or within other hair-bearing areas. Often these fine scars do not concern the patient. However, in cases where they are problematic, hair transplantation is a useful adjunct surgery. If the hairline has been significantly pulled posteriorly or superoposteriorly, it can be re-created with very natural results. This requires aesthetic restoration in which a large number of fine one-haired and two-haired grafts are used to create a tapering look in the temporal, supra-auricular, postauricular and "tell-tale" preauricular or "sideburn" areas. Similarly, if scars resulting from a brow lift lie within the frontal or temporal areas or anterior to the hairline, a border of transplanted follicles created anterior to and within any scars will effectively provide camouflage (FIGS. 3 and 4).

Previous maxillofacial or neurological surgeries. In cases where surgery has been carried out in a hair-bearing region, the resultant scar can be a constant reminder to the patient of a difficult experience. It may also be cosmetically unacceptable. The authors' experiences include patients who have had craniotomies for removal of tumors, shunt procedures, skin grafts in eyebrows following trauma or surgery, and patients with traumatic head injury. These hairless regions can be addressed in the same manner as other areas of cicatricial alopecia, except that transplantation can sometimes be performed at higher than the typical follicular unit (FU) densities utilized in scar tissue, for example, 25–35 FU/cm (2) if the scars are relatively narrow, and therefore have an excellent adjacent blood supply (FIGS. 5 and 6). If a shunt is in place, the transplant can surround it, but should remain well clear of the path of the shunt itself so as to not accidentally puncture it. The *rare* exception to the latter statement is if the scalp laxity is sufficient to pull the scar *well* away from the area of the shunt.

Scars secondary to nonsurgical trauma

So as not to be outdone by surgeons in generating new areas of SCA that require repair, numerous resourceful patients have discovered creative ways to inadvertently inflict scarred zones upon their own scalps. Examples of frequent presentations of SCA resulting from nonsurgical trauma include:

1 "Hot comb" use, for the most part in African Americans (7).
2 Products causing either severe allergic or irritant contact dermatitis, or less severe forms of those entities that are poorly managed and become severely infected.
3 Trichotillomania, in which the repetitive pulling on the follicles eventually causes permanent alopecia.
4 Hairstyles in which there is constant traction applied to certain hair follicles.
5 "Hair extensions": one of the newest trends embraced by women to create a fuller look or longer hair.

Hair extensions are created by attaching small groupings of artificial or real hair to the individual's own hair. If the extensions are used on a short-term basis for special events and are easily removed, the damage is minimal. However, as the prolonged use of hair extensions has gained in popularity, the number of patients seen with permanent traction alopecia has risen. The resulting hairless patches are usually scattered throughout the caudal and temporal scalp as well as potential donor areas. The latter is of particular concern to the hair restoration surgeon as it limits the number of available donor FU and, therefore, sometimes the efficacy of repair. Excision of the areas of SCA can be coupled with hair transplantation to improve

FIG. 3. (a) The right side of the hairline in a female patient 1 year postrhytidectomy. The previous surgery had altered her hairline bilaterally, with a combination of cicatricial and noncicatricial loss of temporal as well as pre- and supra-auricular hair. (b) A photo showing the patient 10 days after hair transplantation with the pattern of sites created clearly evident. (c) The same female patient 10 months post-hair transplant. The hairline has been re-established with excellent density and a very natural appearance.

the regions with sparse hair that served as the initial impetus which caused the patient to resort to hair extensions in the first place (FIG. 7).

Basic technique

Surgical excision

Alopecia reduction or excision may be utilized to reduce or eliminate an area of scarring, with or without the use of expanders or extenders. Typically, an incision is made (where possible parallel to Langer's lines) and then undermining in the subgaleal layer is performed. The scarred area is removed and the two edges of the wound are brought together. Closure is achieved with as little tension as possible, which can be determined prior to excision by pulling one of the wound flaps on top of the opposing flap. This provides an estimate of how much of the tissue can be removed without tension and the surgeon can mark the upper flap in the appropriate location before excising it (8). The AR is completed using a two-layer closure technique. The first layer is usually approximated using 2-0 interrupted sutures to join the galea aponeurotica. The second layer of sutures brings together the skin edges and is usually achieved using a 4-0 running suture. As noted earlier, if the area is closed utilizing a trichophytic technique, approximately 1 mm of the epidermis is trimmed from one edge of the wound prior to approximating the epidermal layers of both edges of the wound. This results in the positioning of the trimmed follicles directly below the wound and, thus, the hair will grow through the scar. If serial excisions are anticipated, the trichophytic approach would only be utilized in the final closure.

A single surgical excision is very effective for the removal of small areas of cicatricial alopecia

FIG. 4. **(a) A patient with a scar running along the temporal hairline and absence of sideburn hair after a face-lift. (A common hallmark of face-lifts.) (b) The same patient 6 months after a transplant to the scar and the sideburn area. Scarred areas can be successfully transplanted whether they are caused by cosmetic surgery, trauma, or some skin diseases. (c) The same female patient with a scar posterior to her ear. (d) Nine months after a single session of transplanting to correct the scar shown in FIG. 4(c).**

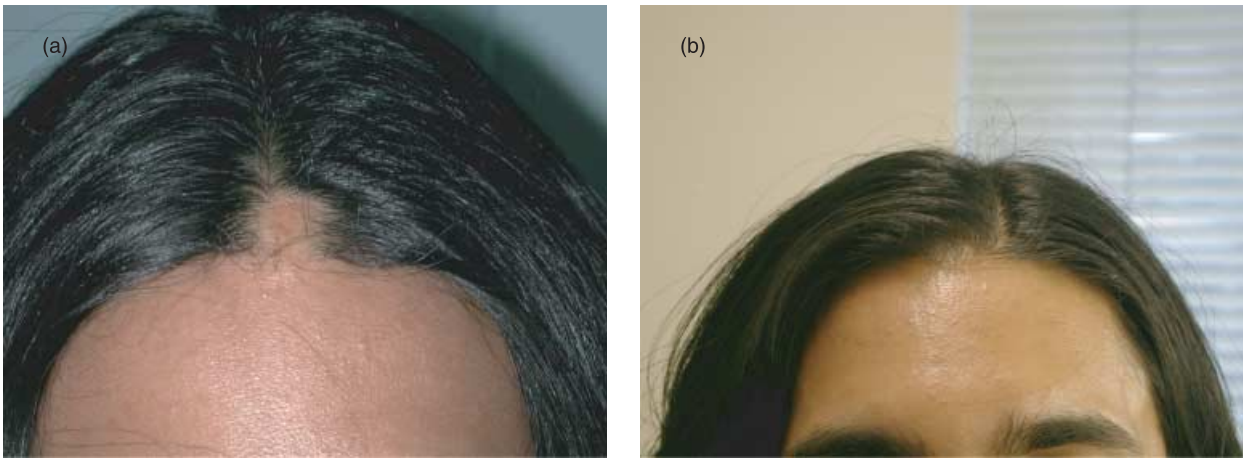

FIG. 5. **(a) A young male patient who had previously undergone a craniotomy to remove a brain tumor. The resultant hairline scar was almost directly in the midline and caused him significant emotional distress. (b) The patient 1 year after a single hair transplant surgery to the craniotomy scar. Despite the initial precaution given by the surgeon that it was likely that more than one surgery would be necessary to achieve optimal cosmesis, the patient was happy after his first session.**

FIG. 6. **(a) A female patient in her 30s who suffered severe head trauma in her early teens. The left side of her scalp was almost completely lost in the accident and she had worn a hairpiece for most of her life. Her first procedure was done by another surgeon and involved tissue expansion and excision of a significant portion of the alopecic area; as a consequence of that surgery, the hairline on the right side of her head was pulled posteriorly. (b) A scar in the central "part" area remained after the expansion alopecia reduction. (c) The same woman only 6 months after a hair transplant. (d) A closer view of the left side, showing good growth in the scar tissue, although at a lower density than that which was deemed acceptable on the narrower right side. (e) The central scar showing early growth of the grafts. This area was also treated with a lower graft density (20 follicular unit/cm^2) and the growth was slower than seen in noncicatricial areas.**

where the scar will not be particularly visible or may be treated by subsequent hair transplantation. However, if the hairless region is particularly large, the AR would involve closure under tension, which could result in several complications. The most notable complications include "stretch-back," in which some of the gain originally achieved is lost over time, and decreased blood flow to the wound area, possibly resulting in infection or necrosis. To avoid these problems, serial AR can be performed 8–12 weeks apart or an extender or expander may be employed prior to the AR.

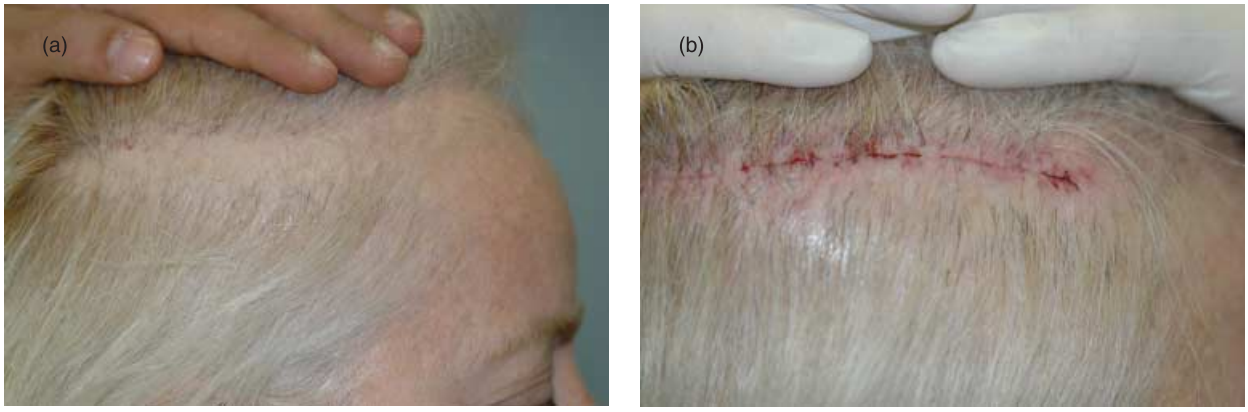

FIG. 7. (a) This photo shows the severe traction alopecia which can occur after prolonged use of hair extensions – a growing trend among women. Some of the loss may be temporary, but a significant portion of the area was cicatricial. Its linear shape was ideal for excision. The latter was carried out at the same time as a transplant was being performed in the areas of female pattern hair loss (FPHL) that initially caused the patient to try hair extensions. (b) Eight days after excision of an inferior portion of the scarred area. The inferior incision passed through intact hair-bearing skin and the wound was closed without any apparent tension. The balance of this scar will be excised during a planned second transplant to areas of FPHL. Excision of this scar left all of the limited donor tissue to be utilized in the areas of FPHL rather than having to use a substantial amount of it to transplant the areas of cicatricial hair loss.

Tissue expansion

Tissue expansion involves the insertion of expanders under the hair-bearing scalp adjacent to the area of alopecia to be removed (9). Two weeks following the procedure, saline is injected progressively into the expander on a weekly basis until the desired inflation is achieved – usually in 6–8 weeks. In the final session the expanders are removed, the alopecic tissue is excised and the wound is closed as described above. This procedure can significantly increase the size of the area which can be safely removed. However, there are some difficulties inherent to this approach. Most significantly, the patient has to go through a prolonged course of treatment during which there is both considerable cosmetic deformity and often substantial, although short-lived, discomfort following each saline inflation of the expander. Another drawback is that the hair on either side of the closed wound may fall in opposing directions if the excised area is large and in a region where hair direction normally changes gradually (10). Other uncommon to rare complications include tissue necrosis, seroma formation, nerve damage, chronic pain, and infection.

Tissue extension

The use of tissue "extenders" is an alternative technique to expansion, which helps to create scalp laxity so that a greater amount of tissue can be safely removed and the wound closed without tension. It was first described by Frechet, who also described a follow-up triple flap procedure to correct the defect caused by hair direction changes on either side of the closure (11). The tissue extender is a thin sheet of a silicone elastomer that has a strip of metal with protruding hooks attached to its two contralateral ends. The extender can stretch up to 100%, yet maintains a strong tendency to return to its original size. In the first procedure a standard AR is performed to remove part of the alopecic area. Before closure, the extender is placed by attaching the metal hooks to the underside of the galea. The first side is placed 1–2 cm lateral to the hair-bearing margin. The extender is stretched usually to double its length, and then the other row of hooks is attached 1 or 2 cm lateral to the opposite hair-bearing margin. The wound is closed in the usual manner used for AR and the extender is left in place for 30–40 days during which time the silicone sheet gradually tries to return to its original size and, therefore, results in bringing the lateral hear-bearing fringes toward one another. After this time interval, a second AR is performed in which the redundant tissue is removed and the wound is closed without tension. The extender can significantly increase the size of the alopecic area which can be safely removed through excision, but sometimes serial extensions and excisions are necessary to completely eliminate the alopecia.

Once again, there are some potential disadvantages including increased initial postoperative pain, and the rare development of seromas. There is also the need for at least two separate procedures.

The other difficulty, already alluded to, is that a "defect" may be created in which the hair on either side of the suture line lies in oppositional directions, resulting in an unnatural appearance. Sometimes the surgeon will intentionally leave a wider zone of alopecic skin, so that hair transplantation can be used to create a natural transition in hair direction. An alternative is the use of a flap procedure to redirect the hair at the borders of the wound. In the crown and midscalp areas, Frechet uses a triple flap procedure with excellent results. This approach is not practical in other caudal areas and it significantly reduces the amount of temporal and parietal donor hair available for hair transplantation in the future, should that be desired.

Hair transplantation

Anesthesia

Anesthesia for hair transplantation is usually achieved using a ring block technique, although nerve blocks are also occasionally utilized (12). The initial injections, as performed in the authors' office, involve the use of 2% lidocaine which is mixed with 1 : 1000 epinephrine on the morning of surgery to produce a solution containing 1/100,000 epinephrine. Stock solutions of lidocaine with epinephrine are not utilized because their acidic pH causes greater patient discomfort. A series of small regions in the donor area, spaced approximately 3.5 cm apart, are infiltrated with the lidocaine mixture. A few minutes later, these anesthetized wheals are joined by injecting through them and advancing laterally to produce a field block. Epinephrine 1/50,000 is then injected superficially into the donor region superior to the field block to reduce bleeding during the excision of a donor strip of tissue. In addition, normal saline is infiltrated immediately prior to incising the donor area, in order to produce greater turgor and to elevate the donor tissue away from the deeper vasculature. In select patients, solutions of 3% or 4% lidocaine with 1/50,000 epinephrine is employed if it is required to produce total anesthesia.

In the recipient area a field block is created in much the same manner, initially creating anesthetized areas approximately 3.5 cm apart using lidocaine 2% with 1/100,000 epinephrine and then injecting laterally until the anesthetized areas are joined. However, as noted earlier, within the areas of cicatricial alopecia, the use of any additional epinephrine is avoided, in order to properly assess the vascular supply as one is proceeding with surgery.

Donor selection and excision

The donor area is defined as the region which contains hair that has been and will most likely continue to remain largely unaffected by hair loss (13). In men, the preferred donor site is in the middle of the most dense region of hair within what is projected to be a rim of permanent follicles traversing the occipital, parietal, and posterior temporal regions. In women, the donor area is in a similar location except it is limited to the occipital and postero-parietal areas (14). The amount of hair to be harvested depends on how large a recipient region needs to be covered, the density of follicles in the donor area, and the laxity of the scalp. If the scar is relatively small (e.g., a region of the eyebrow), it only requires that a short strip be removed. Larger scars, or those destined to be subsequently surrounded by MPB or FPHL, require a maximum-length donor ellipse to yield a sufficient number of grafts for optimal coverage.

Theoretically, the width of the strip may be 7–20 mm. However, in order to produce a tension-free closure, the authors usually remove longer, relatively narrow strips of 8–10 mm, and rarely exceed a 12 mm width. The lengthy elliptical excision also incorporates a greater variety of hair with different caliber and color. FU containing finer textured hair can be used to create hairline areas, eyebrows, or eyelashes, while those containing coarser hairs help to give more body and apparent density to areas further posteriorly on the scalp. Additionally, the temporal regions usually turn gray or white long before the occipital hair; thus, a sprinkling of the temporal donor follicles in the frontal area will also help maintain a more long-term natural appearance in men.

After the donor site has been chosen, the hair in the area is clipped to approximately 3 mm in length and is then anesthetized as described earlier. The methods for harvesting the strip vary; they include single-blade or multiblade excision (15), scoring the epidermis followed by blunt dissection (16), and the aforementioned "FUE" (17,18). The authors prefer the use of either single- or double-blade excision in the shape of an ellipse with tapered ends. Using this method, the transection rate is minimal, closure occurs without tension, and the resulting scars are usually 0.1–2 mm in width and unnoticeable without parting the hair and inspecting closely. In some cases – especially if the procedure is likely to be the last one – a

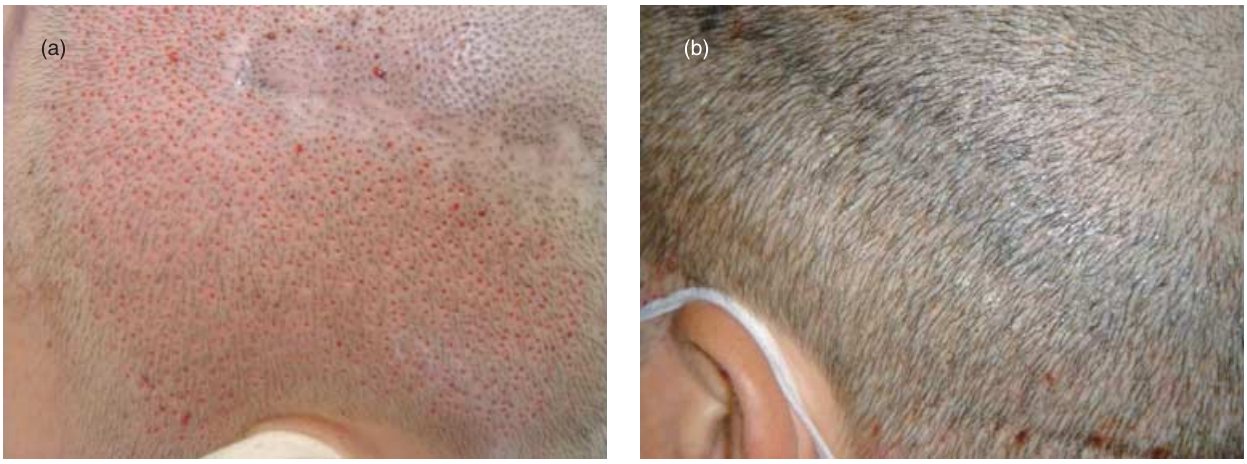

FIG. 8. (a) An intra-operative photo of a patient who had an unacceptable donor area scar in his left temporal area. A small punch has been used like a cookie cutter to punch out individual follicular units (FU) in the donor area, instead of excising a donor strip and dissecting it microscopically. (b) Same patient as in 8a, six months after follicular unit extraction (FUE). There is no visible scarring at the FUE sites and the FU that were transplanted into the scar completely conceal it six months after surgery. (Some of the FU were also used in areas of male pattern baldness at the same time.) The FUE session for this individual was done by another surgeon to whom we referred the patient.

trichophytic closure may be utilized to further minimize any noticeability of the donor scar even upon close inspection.

FUE is a method of donor harvesting in which a small trephine is utilized to punch out individual FU from the donor area (17,18). This method has several important advantages, such as "cherry-picked" FU with particularly desirable characteristics, decreased postoperative discomfort, no need for suturing, and the absence of even a thin linear scar (which often allows the patient to shave his head without any noticeable scarring). In addition, as noted earlier, if the patient has very little scalp laxity or poor healing characteristics, it is often a better option for obtaining grafts (FIG. 8). The disadvantages include increased time required to extract grafts reduces the potential size of surgery; scarring at each individual "punched out" site (a "buck-shot" pattern) may limit the possibility for future donor harvesting in the same area; and higher rates of hair transection as well as buried tissue that can cause inflammation and cyst formation. In light of these disadvantages, inherent or potential, only a small minority of operators prefer this method for routine harvesting in most patients.

Recipient site creation

Preserving adequate tissue vascular perfusion is of paramount importance in recipient site creation. In the vast majority of patients, FU are the graft of choice as they cause the least damage to the vascular supply and generate an even distribution of transplanted hair. The FU grafts contain between one and five hairs. Donor tissue permitting, there may also be "follicular family" grafts (FF) available. The latter contain two FU so closely spaced that the resulting grafts have a combined four to seven hairs yet still easily fit into a single site created with a hypodermic needle or small custom-made blade. These FF are particularly useful in creating density in a scarred area because they significantly increase the amount of transplanted hair while still fitting into a relatively small incision, thus minimizing vascular damage.

The optimal recipient site size is one that provides a "snug" fit, allows the graft to be inserted with minimal manipulation, prevents "popping" or slipping above the surrounding epidermis, and causes minimal damage to the vascular supply. The optimal size of the hollow-bore hypodermic needle or small blade "cut to size" that is used to create the recipient site depends on several factors:

1 The *size* of the graft. For example, an FU with only one hair can usually be relatively easily inserted into a site created with a 20-G needle. The two-haired grafts generally require a larger incision made with a 19-G instrument. Three-to-four-haired grafts fit best into 18-G sites. FF most often can fit into an 18-G incision, but occasionally require that of a 16-G.
2 The *dermal recoil and laxity* of the tissue in the recipient area. These are very important considerations in patients with cicatricial alopecia,

which has a tendency to alter skin elasticity as well as laxity in the area. There is an important interaction between these two characteristics, in that one can cancel out the other. For example, if a scar has less dermal recoil (i.e., the incisions have a tendency to gape) the site should be made smaller in order to prevent grafts from easily slipping out after placement, often referred to as "popping." However, if the tissue is particularly tight and fibrotic there may be absolutely no laxity or "give" to the edges of the site and, hence, the incision must be made large enough to avoid excessive handling of the graft during its insertion. The general rule therefore is sites should be smaller in tissue with great laxity or very little recoil. Whereas sites need to be larger if the scar has limited laxity or significant recoil. Nonetheless, the interaction between the two characteristics can nullify the general rules. Using small blades that make similar size incisions as needles can sometimes result in less "popping" of the grafts in patients prone to that unusual but disadvantageous problem.

3 The *angle* of the incision. If the incisions are made in a direction parallel to the existing hair, the more acute the angle the longer the incision will be at the level of the epidermis despite using the same size needle or blade. Thus, the diameter of the needle may need to be reduced when the required angle is markedly acute (e.g., the eyebrow, the temporal regions, and the hairline in supra-auricular and preauricular regions). This is not the case if the incisions are made in a direction that is perpendicular to the hair direction. However, the authors generally create sites parallel to the direction of hair growth as this causes the least vascular damage.

4 The *caliber* of the hair. FU containing larger caliber follicles tend to be wider, whereas fine-haired FU can be smaller in size. This may require some adjustment in the diameter of needle required for creation of the recipient sites.

The above criteria help guide the surgeon in creating appropriately-sized graft sites. Additionally and importantly, we recommend that the physician ask the technicians for a variety of sizes of "sample grafts" and test these at the beginning of the stage in the procedure when sites are being prepared, attempting to place them in different sized "test" incisions within the scar. When examining the fit, one should remember that sites do contract slightly with time.

It is difficult to give similar guidelines regarding the depth at which the recipient sites should be created when addressing areas of cicatricial alopecia. Both UCA and SCA can develop into either thin and atrophic or thick, fibrotic, and hypertrophic tissue. Thin, atrophic skin may raise the risk that the sites will be too shallow for the entire transplanted follicle to be completely enveloped and adequately perfused. If this is noted during test graft insertion, the surgeon can lengthen the depth of each incision by creating the remainder at a more acute angle. Hypertrophic skin may raise concern that the follicles will not reach a good vascular supply. Therefore, the grafts may be made longer and recipient sites may be made deeper than usual. A patient's personal history of keloid healing should prompt the surgeon to carry out a small test procedure consisting of a few to a dozen FU, and wait at least 3 months before determining whether a typical-sized session is warranted (19).

The number of incisions (grafts)/cm^2 created in the recipient area is one of the most difficult decisions facing a surgeon who is operating in a region of cicatricial alopecia. The area is completely alopecic and, thus, the tendency is for surgeons to want to create a high density of sites in order to minimize the possibility that the patient will have to return for a second surgery to achieve an acceptable cosmetic result. However, the blood supply in scars is limited. Thus, the higher the density of incisions, the less likely that the blood supply will support the growth of these grafts. In worst-case scenarios, this may lead to postoperative complications (see complications).

As the surgeon operates he/she must repeatedly assess variations in localized perfusion by noting the amount of bleeding which occurs when making incisions. Areas with a less satisfactory blood supply should have site densities of at most 15–20 FU/cm^2. In zones with better perfusion it is generally safe to increase that concentration of follicles as high as 20–30 FU/cm^2. In general, higher FU densities are not recommended in areas of cicatricial alopecia. However, higher *hair* concentration can be created by utilizing three- and four-haired FU, FF, or "pairing" of two smaller grafts into one incision (20,21).

To ensure a natural appearance of any transplanted hairline the surgeon should create an irregular border composed of both macro- and micro-irregularities. The irregularities in this region should consist of fine single-haired FU anteriorly and should be *exaggerated* in order to ensure that the hairline looks natural (FIGS. 9 and 10). It is almost impossible to create a hairline that is cosmetically too irregular, but very easy to make it too linear appearing.

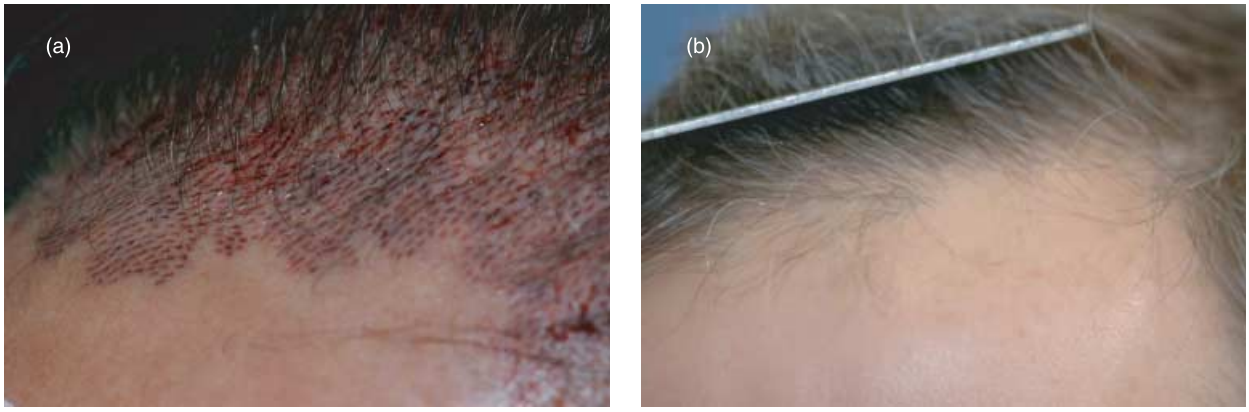

FIG. 9. **(a) An example of the manner in which a hairline is initially constructed, creating an irregular border composed of both macro- and micro-irregularities. Although this patient has no scar tissue in the area, the hairline would be created in a similar fashion if the area had consisted of scar tissue. (b) The patient nine months postoperatively.**

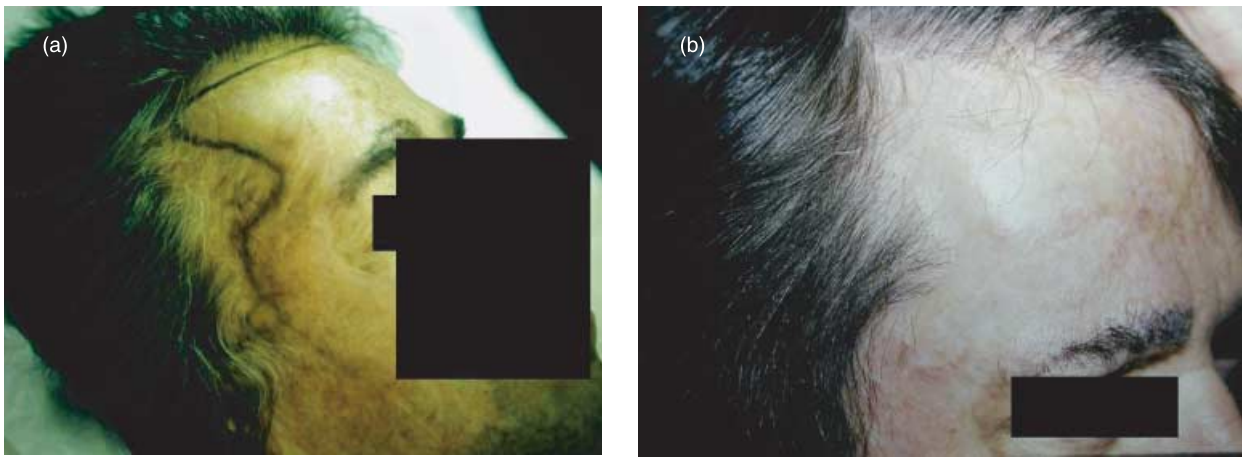

FIG. 10. **(a) A patient who had been in a car accident and had severe scarring alopecia in the temporal area. (b) The same patient 9 months after a single session of grafting into the temporal area. Hair transplanting into scar-bearing tissue can produce substantial improvements.**

Graft storage and insertion

We store our grafts in chilled saline contained in the "wells" of ceramic escargot dishes, which in turn sit on ice-filled containers. Each well is labeled in order to identify characteristics of the grafts: fine or normal caliber, and number of hairs. We also place white-haired FU and partially-transected FU in separate wells (FIG. 11). This allows for accuracy in graft placement, while accelerating the selection of appropriate grafts for specific areas.

Insertion has already been partially discussed in the preceding section. FU are selected based on directions given by the surgeon prior to beginning placement, they are chosen from the designated well, and are kept moist at all times. Grafts should ideally be grasped in the fatty tissue, below the hair matrices, with fine straight or angulated forceps and be inserted in one smooth movement. The latter is accomplished by aiming the forceps in the same direction as the incisions were made and pulling rather than pushing the grafts into them. Ideally the grafts should end up sitting *slightly* above the surrounding skin.

Postoperative care: precautions/complications

The most important precaution, as it pertains to hair transplantation into scars, is to be respectful of the vascular supply in the region. To that end, the smallest gauge needle that is appropriate should be used. If the surgeon creates sites at too great a density and ischemia develops, the *best*-case scenario is that the graft survival will be poor. The more serious risks include infection and necrosis. Any suggestion of either should prompt the surgeon to start the patient on antibiotics immediately and to follow the progress of the

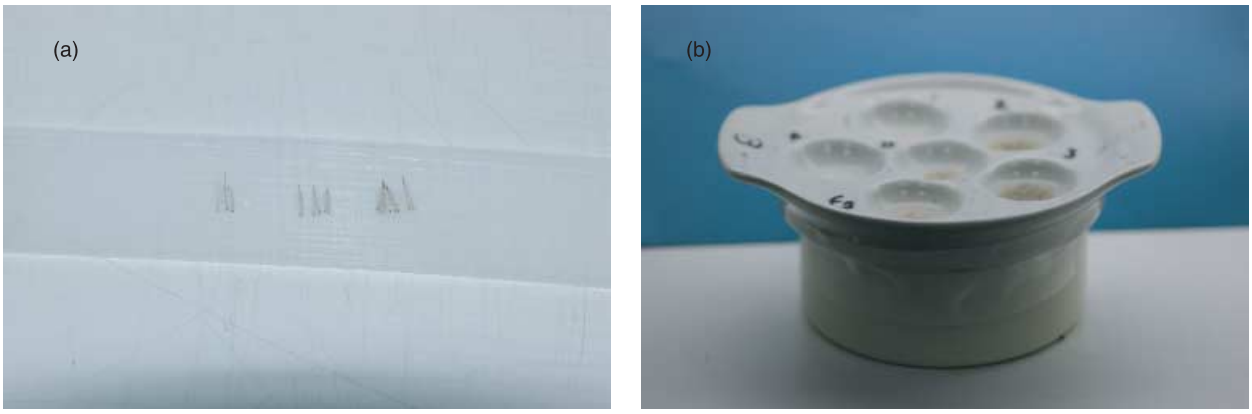

FIG. 11. (a) Examples of grafts of different sizes containing a variable number of hairs. (b) Grafts are stored in the saline filled "wells" of a ceramic escargot dish. Each well is labeled to identify the type of graft it contains. This accelerates the choosing of the appropriate grafts for different areas during the insertion stage of the procedure. The escargot dish sits on a specially designed Pyrex dish filled with ice.

condition every 1 or 2 days. If necrosis develops, the area will need to be debrided and left to heal by secondary intention. A safe alternative is to produce lower graft densities initially and perform a second surgery in the same area 9–12 months later. Often after the first hair transplant, the scalp characteristics tend to improve, with thin atrophic scalp tissue becoming somewhat thicker after the initial session (1).

Several doctors, including the authors, recommend using minoxidil (2–5%) in the recipient area for 2 weeks before and at least 5 weeks after surgery (22). The theoretical benefit is enhanced local vasodilation, prolonged anagen (hair growth) phase, and subsequent improvement in graft survival (1). Another treatment which may provide a potential advantage via increasing oxygenation to the tissue is the use of pentoxyfylline (Trental), 400 mg, thrice a day with meals, for 2 weeks prior to surgery (1).

The other sequelae the authors always relate to patients include postoperative hypo- or hyperaesthesia in surgically treated areas (lasting 6–18 months), potential postoperative telogen effluvium in hair-bearing areas between closely arranged patches of cicatricial alopecia or tight donor areas, and postoperative edema. These conditions generally cause minimal discomfort and resolve spontaneously.

Alternatives to excision or hair transplantation

While the purpose of this article is to discuss the surgical treatment of cicatricial alopecia, sometimes such a solution is simply impractical, or does not completely solve the problem. If that is the case, there are three alternatives that should not be forgotten: (i) applying a temporary coloring agent such as Toppik or COUVRe to the area of alopecia (23); (ii) tattooing the scar with 2–3 mm long individual strokes of appropriately colored pigment (mimicking hair) throughout the scarred area (24); and (iii) employing a partial hairpiece or pastiche (FIG. 12).

Conclusion

Both hair transplantation and surgical excision of cicatricial alopecia can yield gratifying results when properly planned and performed. In order to facilitate an understanding of the effect of the cause of cicatricial alopecia on planning and ultimately the most appropriate form of surgical therapy, we have defined two new categories of cicatricial alopecia: stable and unstable (SCA and UCA). Detailed criteria regarding specific characteristics of the alopecic area have been outlined to assist the physician in the selection of the optimal course of treatment. When surgical intervention is impractical or insufficient, temporary scalp coloring agents, tattooing or a variety of "pastiches" or full wigs should be considered.

In general, surgical excision is preferred to hair transplantation in the treatment of both SCA and UCA. The preference towards excision is even stronger in cases of UCA due to its progressive and intermittent course. However, when the alopecic area does not lend itself to surgical removal, hair transplantation can yield excellent cosmetic results.

FIG. 12. **(a) A woman with female pattern hair loss and inadequate donor-recipient area ratio to make hair transplanting a practical option. Alopecia reduction was also not a feasible option in this individual. (b) A partial hairpiece or "pastiche" was designed to cover the most cosmetically obvious problem areas and was clipped into place as shown above. (c) Frontal view with the pastiche in place. (d) The pastiche prior to its placement. (Photos courtesy Dr Michael Beehner.)**

When hair restoration is preferable, the physician should be sure to anticipate the possibility of continued postoperative hair loss beyond the periphery of the current alopecic region(s), and allow for concomitant or future treatment of these areas as well. This subsequent hair loss may be secondary to MPB, FPHL, or the progression of UCA.

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