Hair replacement surgery and transplantation

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The field of hair replacement surgery has dramatically changed since the first hair transplants were done more than 40 years ago. Surgeons are more cautious in the selection of appropriate surgical candidates as the evolution of male- and female-pattern baldness has been more clearly defined. The development of newer techniques, including minigrafts, micrografts, strip harvesting, scalp extension and expansion, and flap surgery have yielded more natural results with lower morbidity to the patient. These advantages have made the prospect of hair replacement surgery more attractive to patients and more satisfying to the surgeon.

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Current Opinion in Otolaryngology & Head and Neck Surgery 1997, 5:209–213

Abbreviations

AA	androgenic alopecia
MPA	male-pattern alopecia

ISSN 1068–9508

Although hair transplantation was originally described by Okuda in the 1930s, the field of hair replacement surgery did not receive much attention until the 1950s, when Orentreich [1] first described his work with hair transplants. The multiple new techniques and refinements introduced since then have caused a virtual explosion in the interest in hair replacement surgery among both the medical community and lay public. Unlike some of the early "doll's head" or "corn row" results that were obtained using larger standard hair transplant grafts, newer techniques such as minigrafts, micrografts, and flaps have allowed the creation of virtually undetectable "natural" hairlines.

Hair replacement candidacy

The most common form of hair loss is androgenic alopecia (AA), which presents as male-pattern AA, female-pattern AA, or diffuse AA. Although AA is more prevalent in men, it can also be a significant problem in many women. AA in women can be more emotionally devastating because of the associated social stigma [2,3•]. Almost every patient is a candidate for some form of hair replacement procedure, and various factors make some patients better candidates for certain procedures. A small percentage of patients who will ultimately develop excessive alopecia, including the fringe areas, may not be suitable candidates for any form of hair replacement surgery (although this is rare).

A person's candidacy for hair replacement surgery is determined by a number of factors. These include patient age, pattern of alopecia, hereditary history, hair density in donor fringe, hair and skin color, hair texture, and scalp laxity.

Patient age

Although there is no absolute minimum age limit for hair replacement, most surgeons agree that patients should be in their early twenties prior to undergoing any hair replacement procedure. This limit serves two purposes. First, the patient will have the opportunity to mature mentally to the point that he will accept a more mature hairline, one that will stand the test of time and look appropriate for a lifetime. The second purpose is to establish more securely that the patient's alopecia will not be so severe as to preclude him from *any* type of hair replacement surgery. This raises a point that is fundamental to male-pattern alopecia (MPA)—that MPA is *progressive.*

Pattern of alopecia

Although the patient's pattern of alopecia at the time of presentation is important in helping to determine his or her candidacy for surgery, one must keep in mind that

this is only a "snapshot" in time and that the alopecia will progress along some as yet unknown rate of advancement. Marritt and Dzubow [4,5] have helped to redefine MPA as having a progressive tendency as opposed to a "static" state. Therefore the classification of various patterns of male-pattern alopecia is of limited use; however, it is helpful in determining a patient's candidacy for surgery.

The Hamilton-Norwood classification of MPA is widely used to describe the various stages of progressive alopecia [6]. The classification involves seven types of alopecia, ranging from type I through type VII. Type I is essentially a very thick head of hair with no recession or minimal frontotemporal recession. Type VII represents the most severe form of MPA, with complete baldness of the crown except for a narrow horseshoe-shaped band of hair in the temporoparietooccipital area of the scalp. Types II to VI represent the progressive stages of thinning. There is also the Type A variant, which describes those patients who tend to lose their hair anteriorly but retain hair on the vertex of the scalp.

Classification is helpful in describing a particular pattern of alopecia by allowing surgeons to communicate with one another as well as determining a patient's candidacy for surgery. For example: a 25-year-old man with type III MPA (deep frontotemporal recessions) may not be as good a candidate for surgery as a 55-year-old man with type VI (more pronounced frontotemporal recession with vertex thinning). Unfortunately, without knowing these patients' rates of progressive hair loss, it is difficult to know who will do well with surgery. A strong family history will often give insight into a patient's possible future hair loss.

Hereditary history

Hereditary factors play an extremely important role in the presentation of AA. Recent belief suggests that there is a polygenic inheritance. A patient can receive these genes from either parent, and the more AA genes present, the more one is likely to become bald [2]. Patients who have the genetic predisposition for AA are susceptible to the effects of androgens in expressing their degree of baldness. Dihydrotestosterone is the androgen directly responsible. Men who are castrated before puberty will not exhibit this genetic predisposition and will retain their hair. If these same patients are then exposed to dihydrotestosterone, they would then exhibit their hereditary tendency and become bald.

Women may also carry the genetic predisposition to AA. Their expression of this trait depends on their endogenous production of androgens. The level of androgens is usually of no consequence in young healthy women but may be triggered by the loss of estrogen and progesterone that occurs during menopause. Some women will exhibit a diffuse general thinning, whereas some will have a discrete pattern of loss, with more thinning of the crown area.

Although it may not be possible to determine a patient's "final" alopecial pattern, it is usually helpful to know as much as possible regarding the patient's family history of hair loss. A history of severe class VII MPA in a father, grandfather, or maternal uncle may be helpful in planning one's strategy for surgery in a relatively young man.

Donor fringe density

The density of the donor fringe is important in determining the patient's candidacy for surgery. Patients with excellent density and a lower Hamilton-Norwood classification (types I to V) are usually excellent candidates for hair transplant procedures. Of course, the better the density in the donor area, the better the candidate.

Hair and skin color

Hair and skin color are also important considerations. Salt-and-pepper hair color is generally considered to be the best color for giving a natural "full" appearance with transplants. The more contrast there is between the hair color and skin color, the more noticeable the transplants will be, making it difficult to achieve a completely natural result. Black hair transplanted in white skin is most difficult to camouflage unless one uses a large number of micrografts to "feather" the hairline [7•].

Hair texture

Hair texture is of concern in determining a patient's candidacy. Wavy or curly hair can give a more dense appearance than limp, fine hair. A patient with fine black hair would not be as good a candidate as someone with gray or blonde wavy hair, all other factors being equal.

Scalp laxity

The final factor that contributes to a patient's candidacy is the laxity of the scalp. Patients with significant laxity may be candidates for scalp reduction or flap procedures, depending on the pattern of hair loss. These procedures involve excising bald scalp and advancing hair-bearing scalp into the resected areas. If there is insufficient laxity, then the surgeon would be confined to using hair transplants unless the patient is willing to undergo scalp expansion or extension to help stretch the tight scalp.

An important question all hair replacement surgeons must eventually struggle with is, are there *any* patients who are *not* candidates for hair replacement surgery? Most surgeons would not attempt to achieve "full coverage" on a patient with type VII MPA. This patient may be a candidate for an isolated frontal forelock, giving a minimal thinning effect to the frontal scalp, but it would probably

not be wise to attempt to cover the entire crown with transplants. The problem is that there will not be enough residual hair in the donor fringe to cover the expansive bald area adequately. The more baldness you have, the more grafts you need; the more baldness you have, the less grafts you get. Such is the catch-22 of hair replacement surgery [4].

Techniques in hair replacement surgery

All techniques in hair replacement surgery have one basic principle in common: one cannot increase the numbers of hairs on a patient's head; one can only redistribute them in such a way as to make it appear that there is "more" hair on the head. The hairs can either be moved by grafting them, such as with transplants, or by transferring them, such as with flaps or reductions (Table 1).

Hair transplantation

The standard hair transplant used for many years was a 4-mm (seven to 12 hairs per graft) round graft. Excellent density was acheived, but often resulted in a tufted, unnatural appearance. This problem is now avoided with the use of larger numbers of smaller grafts. The combination of minigrafts (three to five hairs per graft) and micrografts (one hair per graft) have revolutionized the field of hair replacement surgery. Depending on the degree of alopecia, it is not uncommon to transplant up to 1000 grafts or more per session. This gives a soft, natural, untufted appearance that was unobtainable only a few years ago.

All types of hair transplants (whether standard, mini, or micro) will go into the telogen (resting) phase of growth when transplanted from one area to another. The hair will temporarily fall out and a new hair will generate from the follicle in about 3 to 4 months. Sequential stages of transplantation can be done at 3- to 4-month intervals, allowing for growth of the previous stage prior to each successive stage. In the past, using standard grafts, at least four stages were required to achieve a final result. Sufficient spacing (roughly the diameter of the transplanted graft) between individual grafts had to be maintained to allow adequate vascular support for the new grafts (*ie*, the larger the graft, the further apart they are spaced). Currently, minigrafts and micrografts can yield natural results with as few as two to three sessions, depending on hair texture and color. The grafts are smaller in size and are placed closer together to one another, giving a softer, more natural result.

Minigrafts are placed into either holes or incisional slits. There is considerable debate as to the "best" method for achieving the most natural results. The holes may be created with either a punch or a laser. The conventional technique has been to use an electric rotary punch of 1- to 2-mm size to create minigraft recipient sites. The recent introduction of extremely sharp, manual round and elongated, linear-shaped punches have markedly improved the ease with which these recipient sites are created [8,9•,10].

Some surgeons believe that holes created with a laser achieve more natural results, whereas others believe the laser can cause thermal damage to surrounding, previously placed transplants, thus negating its benefits with successive stages [11,12••].

Others believe that superior results are achieved with the use of incisional slits. Smaller minigrafts (three hairs) are placed into 3-mm-wide incisional slits. The advantage to the slit is that the grafts can be placed very close together, giving even more natural (and earlier) results. Also, there is no removal or destruction of surrounding hairs, which is beneficial in many situations including female-pattern alopecia [3•]. Larger numbers of grafts can be placed at a single session; in fact, over 1000 grafts can be placed during one single "megasession" [13]. However, there is some question of graft survival when greater than 2000 grafts are placed in a single megasession [14•].

Micrografts are single-hair grafts that are usually placed along the frontal hairline to give a natural, feathered appearance. These grafts are placed in large numbers into stab wounds created by either needles or specially designed small knife blades in order to create a 7- to 10-mm zone of single-hair grafts. The results using micrografts are extremely natural when executed properly.

Minigrafts and micrografts are harvested from the donor-dominant fringe using special multiblade knives. These knives allow for harvesting of multiple strips of hair-bearing scalp simultaneously. The strips are then carefully divided into minigrafts and micrografts. The remaining wound is closed as a single incision, leaving only a narrow imperceptible scar. This technique is in marked contrast to the previous punch harvesting, which was

Table 1

Techniques used in hair replacement surgery

Transplants
Standard grafts: 4mm wide; 7 to 12 hairs per graft
Minigrafts: 1 to 2 mm wide; 3 to 5 hairs per graft
Micrografts: 1 hair per graft
Scalp reduction
Tissue expansion
Scalp extension
Extensive scalp lifting
Scalp flaps
Long flaps
Juri or temporoparietal occipital flaps
Short flaps
Axial temporoparietal flap
Random: Dardour, Nataf, Frechet
Expanded flaps: Anderson (BAT/TAT flaps)

BAT–bilateral advancement transposition; TAT–triple advancement transposition.

more uncomfortable postoperatively and left a honeycomb residual scar pattern.

Scalp reductions

Scalp reduction (or, more appropriately, alopecia reduction) is a technique in which the balding scalp on the vertex area is excised and the dense hair on the temple and parietal scalp is advanced superiorly and medially in order to "cover" the bald areas. The success of this technique depends on scalp laxity. A series of reduction procedures is required to "remove" the bald spot, with a time span of usually 3 or more months between procedures to allow for scalp stretching and relaxation.

The time between reduction procedures may be shortened by the use of a tissue expander or extender. The tissue expander is a silastic balloon or bladder that is placed under the hair-bearing fringe on the scalp and periodically injected with saline, causing a progressive stretching of the hair-bearing scalp [15,16]. After sufficient expansion to ensure that the hair-bearing scalp will adequately cover the entire bald scalp, the expander can be removed, and the alopecia scalp completely excised. The process can be completed in as short as 8 weeks, depending on scalp laxity. The most notable drawbacks of the procedure include the obvious tumor-like deformity that is evident as the expander is filled to its maximum, as well as a considerable amount of discomfort experienced during expansion [17].

The scalp extender, introduced by Frechet [18], is an ingenious device to stretch the scalp without the obvious deformity of the expander. Two series of hooks are attached to a silastic band. The band is stretched under tension and the hooks are engaged into the undersurface of the scalp during a routine scalp-reduction procedure. The extender is left in place, under the scalp, for about 4 weeks, during which time it is exerting constant tension on the temporoparietal scalp, thereby stretching this area much faster than with reduction alone. More bald scalp can be excised per procedure and there is a more rapid turnover time between procedures.

Intraoperative tissue expansion and extension devices, such as the Sure-Closure device (Life Medical Sciences, Princeton, NJ) or Miami Star (Tiemann Instruments, Hauppaughe, NY), have been shown to be somewhat helpful, but increase operating time significantly [9•,19]. A more aggressive reduction procedure, known as the lateral scalp lift, was developed by Marzola and modified by Brandy [9•]. This technique involves wide undermining of the scalp into the nape of the neck in order to achieve maximal movement of the entire donor-dominant fringe. The procedure involves ligation of the occipital arteries in order to achieve maximal dissection below the superior nuchal ridge [9•].

Scalp flaps

Multiple scalp flaps have been designed to improve AA as well as alopecia due to trauma (Table 1). The advantages to flaps over transplants are as follows:

1) Blood supply is maintained to the follicles and therefore the hairs do not go into the telogen phase; hairs do not fall out and continue to grow, giving an "instant" thick area of untrimmed hair.

2) A higher density of hair can be achieved than with transplants.

3) Results can be achieved sooner than with transplants.

Patient selection becomes critically important in order to obtain natural results with these flaps [20]. Patients with alopecia restricted to the frontal area are the most ideal candidates for these flaps. Combinations of various flaps and scalp reduction or tissue expansion may be necessary to achieve optimal results.

Flaps can be grouped into either those of axial or random blood supply. Axial flaps are based on specific arteries and therefore can have a much higher length-to-width ratio than random flaps.

The Juri flap and temporoparietal occipital flaps are both axial flaps based on the superficial temporal artery [21]. The flaps, between 3 to 4 cm wide and approximately 25-cm long, are designed to span the entire frontal hairline. Both flaps require two separate delay procedures 1 week apart prior to transfer of the flap. These flaps can achieve excellent results in a short period of time [22].

The temporoparietal flap is similarly based on the superficial temporal artery, but is shorter (15 cm long) and designed to be used in combination with another flap from the contralateral scalp in order to create a frontal hairline [23]. The longer Juri and temporoparietal occipital flaps are preferable and the use of this flap is reserved for those conditions in which the longer flaps are not possible. Some patients may have had prior trauma or scarring in the scalp that might compromise vascularity to the tip of the long flap, thereby necessitating the shorter flaps.

Random scalp flap procedures include those by Dardour, Nataf, Frechet, and Anderson [20]. These flaps are superiorly based and their primary advantage is that the direction of the hair growth is more natural than the other flaps previously described. Their blood supply is not as predictable as the axial flaps and thus there may be problems with telogen or tip necrosis. Another disadvantage is that they are shorter and cannot span the entire frontal hairline without using bilateral flaps [24•,25]. Anderson's use of tissue expanders prior to his

bilateral advancement transplants or triple advancement transposition flaps have improved survival and utility of these broad-based flaps [26].

Although the results from scalp flap procedures can be both natural and dramatic, it should be noted that they are more complicated than transplantation procedures. Careful preoperative planning and surgical technique are paramount in obtaining the desired results.

Conclusions

Newer techniques in hair replacement surgery have yielded results that were unimaginable only a few short years ago. The use of minigrafts, micrografts, scalp expanders, scalp extenders, and flaps have expanded the surgeon's armamentarium and allowed the creation of virtually undetectable hairlines. When executed properly on the appropriate candidates, results can be remarkably natural with minimal patient morbidity.

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