Hairline Design/Holding Solutions/Graft Creation

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**HAIRLINE DESIGN**

The single and most important aspect to achieve a natural appearance to the hair transplant is the creation of the anterior hairline design. This is accomplished through the appropriate location of a few landmarks that help to design the hairline as well as the use of a large number of small grafts [one and two hair follicular units (FUs)].

The equipment needed for hairline design is simply a marking pen, a ruler, alcohol swabs (to remove markings), and a handheld mirror. I recommend the use of a ruler specifically made for hairline design known as an Assist to Hairline Design (Cole Instruments, Alpharetta, GA), because it has several vertical scales and horizontal and vertical reference lines that allow the surgeon to take hairline measurements at different levels of the forehead to ensure the symmetry of the hairline (Figs. 4.1A and B). More sophisticated devices to assist in the hairline such as the Pathomvanich laser device can also be used for this purpose.²

**Landmarks for Creating a Natural Frontal Hairline**

The first thing to do is to draw the landmarks that establish the height and shape of the frontal hairline. These landmarks are only guidelines to determine the hairline placement and have to be individualized depending on the size and shape of the head and the degree of alopecia.

- **Midfrontal point (MFP):** The first landmark that needs to be drawn is the MFP, which is the most anterior point of the frontal hairline (Fig. 4.2). In
most male patients, the MFP is located between 7 and 9 cm above the glabella. In extreme balding, it is preferable to make the MFP a little higher, at about 10–12 cm from the glabella in order to conserve donor hair. In females, the MFP is lower than in males, normally at 6–7 cm.³

- **Frontotemporal point (FTP; the apex):** This should be the next point to be drawn. This point is located where a vertical line upward from the lateral canthus of the eye meets any remaining temporal hair (Fig. 4.2). A gently curving hairline should be drawn joining the MFP with the two FTPs. In males, it is important to always maintain a significant frontotemporal recession. As a general rule, the apex must never be lower than the MFP, as this creates a feminized hairline. The problem in advanced balding is that the parietal border might be so low that it does not allow creation of an aesthetic FTP. In this circumstance, we first have to raise the parietal border by creating so-called lateral humps, which enable proper design of an FTP. In females, the hairline requires a design that includes a more rounded temporal infill and a lower hairline than that created for males (Fig. 4.3).

- **Lateral (parietal) humps:** The lateral hump is the superior extension of the inferiorly directed hair of the temporoparietal fringe (Fig. 4.4). This landmark is important because it represents the lateral extent of the anterior hairline (AHL).⁴

- **Transition zone:** The hairlines should be designed with a 5–10 mm wide transition zone that merges the bald forehead to a zone of increasing gradient of density. This transition zone is where most single hair grafts are placed (Fig. 4.5). The transition zone should be created with irregularities to mimic a natural hairline.

- **Irregularities of the hairline:** As an absolute rule, hairlines should never be flat, but broken up with irregularities. They are normally created using triangular clusters of hairs and gaps. These triangles are of varying depth and width (Fig. 4.6). The more irregularities we create in the hairline, the more natural it appears (Figs. 4.7A and B).

**Landmarks for Creating the Temporal Triangles**

Restoration of the temporal triangle is performed according to the personal preferences of patient and surgeon. The temple is difficult to recreate and there is no need to do it unless the patient asks for
The single hairs to place the finest hairs at the anterior border will allow the most natural result. Two hair grafts can be placed more posteriorly in the temple.

The Parietal-Vertex Posterior Transition Zone

This zone indicates the posterior border of the parietal scalp, where the vertex starts. In this zone, the shape of the scalp changes from the horizontal plane of the parietal scalp to the more vertical plane of the vertex and occipital scalp. In many severe balding patients, the goal is to first complete the placement of grafts in the frontal and parietal scalp ending in this transition zone. This zone is called “transition zone” because the grafts should not create a posterior wall, but as mentioned before in the transition frontal zone, the grafts should be placed creating an irregular line with...
Fig. 4.8: Location of the temporal point. This point can be found by the intersection of two lines: a line from the “cresc of helix” of the ear to the mid-frontal point and a line from the tip of the nose through the pupil of the eye.

Fig. 4.9: In hair restoration of the vertex region, it is important to follow the direction of the fine existing hairs and recreate the original swirl pattern.

a transition of density and placing also numerous single hairs in the most posterior part of this transition zone. This will help to recreate the naturalness of this zone.

The Vertex

The key to recreating the vertex is to identify and follow the direction of the hair swirls. The vertex may have one or two swirls, on the right or left side. The existing miniaturized hairs are very helpful for identifying the swirl and lines should be drawn following the changes in the direction of the hair (Fig. 4.9).

The vertex usually needs more hair than one would expect. So, the vertex should be filled when the transplant on the frontal and parietal scalp has been completed and if the patient still has enough donor hair remaining.

Key Points to Follow in Creating the Hairline

1. The hairline should be placed in a conservative location so that it will look natural as the patient ages and continues to lose hair.
2. Measure the hairline with the ruler as much as possible, but then take a step back and make sure it looks correct.
3. In males, never draw the MFP <7 cm from the glabella.
4. Never chase the receding temporoparietal fringe with the hairline; instead, build up the “parietal humps”.
5. Remember you can always lower the hairline in a subsequent session, but hairlines cannot be raised.

6. In males, try to maintain a significant frontotemporal recession.
7. You can never create too many microirregularities in the frontal hairline.
8. The direction and acute angle of the hair are an important consideration in restoring the temporal triangles.

● HOLDING SOLUTIONS

Any topic related to maneuvers that can enhance hair graft survival is of considerable interest for hair transplant surgeons. For this reason, holding solutions are currently a hot topic in hair transplant meetings.

During the course of a hair transplantation procedure, the cells and/or tissues experience multiple forms of stresses related to the procedure from before extraction of the donor area, through the dissection and past the point of reimplantation. Once the donor strip is removed [or once the FU is removed in the case of follicular unit extraction (FUE)], the cells within the tissue are immediately cut off from their supply of oxygen, glucose, and other necessary nutrients. During this ischemic phase, the donor hair is maintained in petri dishes filled with a solution (holding solution) to keep the grafts hydrated. In the strip harvesting technique, these hair grafts may be kept in the holding solution an average of 3–6 hours (depending on the speed of the cutting process and the length of the session). In the FUE technique, the grafts are also kept in holding solutions until implantation, but the length of time may vary because the hair surgeon might decide to start implantation
after, e.g. 500 extractions and then continue with the extractions or to begin after all the FUs have been extracted. In any case, the time that the hair graft is left out of the body in the holding solution until it is implanted is a critical factor for hair growth survival. In a classical research study, Limmer showed that survival of grafts stored in chilled saline decreases with the length of time between removal from the donor site and implantation in the recipient sites. Limmer showed that the survival rate is high if the FUs are transplanted in <6 hours (95% at 2 hours and 86% at 6 hours between harvest and transplantation), but that it fell significantly after that timeframe.

The most common holding solutions used among hair transplant surgeons are normal saline and Ringer’s lactate because they are intravenous solutions that are cheap and easily available and because their successful use has been observed over a period of decades. However, it is worth considering how saline lacks many of the key elements of an ideal holding solution: (1) correct osmolarity, (2) correct pH and buffering capability, (3) antioxidants, and (4) nutrients. For this reason, other holding solutions that include additives that work as energy sources and antioxidants could in theory be more beneficial. These include culture media-based solutions like Williams E, multiple electrolyte solutions like Plasma-Lyte A, or intracellular-type solutions like Hypothermol. Unfortunately, the lack of evidence-based studies means no conclusion can be made as to the best holding solution for hair transplantation. Platelet-rich plasma (PRP) containing numerous growth factors such as platelet-derived growth factor or vascular endothelial growth factor has been reported to improved survival of hair grafts when added to the holding solution. However, to date, the use of PRP in hair restoration surgery is still controversial and no standard protocols have as yet been established.

Temperature is thought to be a factor that may influence graft survival. At low temperatures, the oxygen and energy demand of the grafts falls as metabolic activity is reduced. However, a cold temperature can also injure the grafts by perturbations in osmoregulation and intracellular acidosis. In this situation, an intracellular-like solution, as opposed to an isotonic/extracellular-like solution such as culture media or saline, would be more suitable to balance the altered cellular ion concentrations that result from hypothermic temperatures. The current perception is that if the grafts are to be kept out of the body for <6 hours, they can be left at room temperature with no difference in the survival rate than at chilling storage (1-4°C). For long sessions lasting over 12 hours or on those rare occasions when the surgeon needs to store the grafts overnight in a standard refrigerator, an intracellular-like solution such as Hypothermol-FRS has been shown to be an ideal environment for the grafts.

Adenosine triphosphate (ATP): When a hair follicle is transplanted, the grafts can take from 3 to 5 days to be reconnected to their own blood supply. During this time the follicle graft is ischemic, resulting in decreased production of the cell’s refined fuel ATP. Adenosine triphosphate driven cell membrane pumps maintain the osmolarity balance of the cell. The addition to the holding solution of a recently commercialized liposomal ATP solution has been proposed in order to counterbalance the ischemic environment that the grafts endure after removal from the donor scalp. Liposomal ATP has the capacity to efficiently deliver ATP into the cells by fusing the lipid membrane of the liposomes with the cells’ own lipid membranes. Protocols for use of liposomal ATP are based on personal experience, and further studies are needed to evaluate its real impact on graft survival. When using ATP as an additive for the holding solutions, 1–10 cc of the concentrated ATP can be added to 100 cc of holding solution. When used as a postoperative solution, the current recommendation is to add 10 cc of concentrated ATP to 90 cc of saline in a spray bottle and have the patients spray the solution in the recipient area every 2 hours for the first 48 hours and then every 4 hours thereafter for a further 2–3 days.

**GRAFT CREATION**

**Strip Harvesting with Microscopic Dissection of the Grafts**

Once the donor tissue has been harvested, the donor strip is immediately immersed in the holding solution and given to the technician to cut into slivers.

**Instruments Used for Graft Creation**

Graft preparation is performed immediately using stereomicroscopes and microsurgical instrumentation. Stereomicroscopes are the gold standard for FU graft preparation (Fig. 4.10). They offer the proper magnification and have an excellent light source. There are several brands that are popular for hair
transplantation including Zeiss, Mantis, Meiji, Nikon, and Motic. Most assistant cutters use 10 x magnification. The Mantis scope is a stereo-optical viewer with no eyepiece. Even though the optics are mediocre, it has the big advantage of a wide screen through which the cutters can see the work that is being performed with their head facing forward and without having to bend their neck.

**Slivering Dissection**

The initial step of slivering the donor tissue into smaller units is the most critical and technically exacting step. Normally, the most experienced and skilled technician will perform this task. The donor strip is fixed to a tongue depressor with a needle and the technician begins to create slivers or slices from the strip (Fig. 4.11). Instead of tongue blades, some surgeons prefer to use other cutting surfaces such as plastic sheets, and soft silicon pads.

The slivering technique has been compared to "slicing a loaf of bread", an analogy in which the loaf is the strip and the emerging slices are the slivers. The ideal sliver should have a width of one FU so that the other technicians can dissect each sliver easily. Number 10 surgical blades or razorblades encased in a razorblade holder and a jeweler's forceps are the basic instruments needed for dissection of the donor strip. All slivers are immersed in the holding solution and the other technicians start dissecting the FU grafts from the sliver (Fig. 4.12).

**Follicular Unit Graft Dissection**

The sliver is placed on a tongue blade or special cutting board and the technician should identify and dissect under the microscope the FUs (seen as hair follicle groupings), which mostly contain two to three hairs. Grafts are separated and counted in one, two, and three to four hair FUs.

As the grafts are dissected they are immediately placed in petri dishes containing the holding solution to keep them hydrated and avoid desiccation. Some clinics prefer to have the grafts immersed completely in the holding solution, while others prefer to have the grafts on a piece of gauze in a petri dish filled with holding solution (Fig. 4.13). The first method ensures the grafts are always hydrated. The second method allows the grafts to be clustered together in order to facilitate counting, but the techs need to pay close attention to prevent desiccation. The author prefers complete immersion of the grafts in the holding solution.
The graft cutting procedure should be performed with great care so as to obtain hair follicles with their dermal papillae and sheaths intact. Grafts should neither be too "skinny" nor too "chubby". "Skinny" grafts are more difficult to handle, and more prone to desiccation and trauma at implantation that can reduce graft survival. Excessively "chubby" grafts can also make implantation more difficult and force the surgeon to make bigger recipient sites. The perfect graft should have a pear-shape or tear-drop shape with little epidermis and little but sufficient amount of protective dermis and subcutaneous fat around the dermal papilla.

The number of cutters needed for the process of strip graft dissection in a hair transplant session varies in different practices according to the size of the session. I would recommend having at least one cutter for each 500 grafts. For example, if the plan is to perform 2,000 grafts, I would recommend four cutters, one acting initially as the sliverer and then as a cutter once slivering is finished.

**Follicular Unit Extraction**

In the technique of FUE, the FU is sectioned in situ, so the step of microscopic slivering and graft dissection is not needed. This is in theory a theoretical advantage provided that the hair transplant surgeon has sufficient skill and experience to harvest the majority of the FUs intact with a low rate of complete transection. In less experienced hair surgeons, however, the rate of transection can be so high that this theoretical advantage is offset by the poor quality of the grafts.

When one compares under the microscope FU dissected grafts (from strip) with FUE grafts, the microscopically dissected grafts usually have more surrounding tissue and are chubbier. The FUE grafts tend to have less fat tissue surrounding the inferior portion of the follicle. These small changes in FU histomorphology between FUE and microscopically dissected grafts should not affect hair graft survival, provided that the critical elements of the FU, the bulge stem cell region, and the dermal papillae are kept and implanted intact. The survival rate of a hair graft depends on many factors, and in the author’s experience, the most critical step is the trauma and manipulation of grafts at placement. In this regard, it is important to note that FUE grafts are more delicate to handle and more prone to damage during placement.

- REFERENCES