Advantages and Disadvantages of Graft Preparation Using the Binocular Stereoscopic Dissecting Microscope

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INTRODUCTION

The Binocular Stereoscopic Dissecting Microscope

The binocular stereoscopic dissecting microscope (hereafter referred to throughout this article as the "stereoscope") has been used by Dr. Bobby Limmer for hair transplantation since 1984. Use of the stereoscope was first described by Dr. Bobby Limmer in The Hair Transplant Forum International in 1991,[1] and then again in 1994.[2] Dr. Limmer was initially attracted to the stereoscope by the concept that its use may reduce wastage of hairs and produce better grafts. The stereoscope can achieve these ends by means of the superiority of its magnification (10 to 20 times) over simpler, more conventional magnification methods, i.e. magnifying lenses and loops (usually 2 to 4 times).

An added feature of the stereoscope, not generally known, is that it conveniently provides extremely strong illumination over the very small area upon which the eyes are focused through the stereoscope. This enormous amount of light over a tiny and highly magnified area causes the tissue of the specimen to become translucent and permits the operator to actually see through a further depth of dermis than otherwise would be possible. This enables the operator to avoid transecting hairs immediately adjacent/deep to the hair shafts being cut around. This, together with the enormous magnification that the stereoscope provides, enables one to reduce wastage of donor hairs while cutting donor tissue into grafts.

Another feature of the stereoscope is its binocular *stereoscopic* vision. Substitutes for the stereoscope include magnification devices that display an image on a video screen. These do not render a three-dimensional image. Certain important appendages of the pilo-sebaceous unit, for instance the sebaceous gland, are often virtually the same colour as the rest of the dermis, and are very difficult to see. However, with the three-dimensional view that the stereoscope provides, one can rotate the specimen one is dissecting so as to identify the sebaceous gland as a more easily visible "3D, moving bulge".

These features of the stereoscope permit much more precise and exact dissection of follicular unit micrografts and small minigrafts. The use of the stereoscope in hair transplantation is usually associated with "follicular unit transplantation" (i.e., performing the whole hair transplant using only one- to four-haired micrografts consisting of intact follicular units) for two reasons. First, the advantages about to be described in detail are greater with "follicular unit transplantation"—although the same advantages still apply to mainly minigraft transplantation—but to a lesser extent. Use of follicular unit transplantation is becoming more widespread. It is coming to be regarded by more and more experts as the most highly developed technique of hair transplantation.[3,4] Second, the author believes that the hair transplant practitioner who chooses to go to the trouble of using the stereoscope will also be concerned enough about the quality of his/her results to convert to follicular transplantation if economics permit. These are the reasons why stereoscopic dissection of donor tissue and follicular transplantation are generally performed together.

METHOD

For minimal wastage of donor hairs, the donor area to be dissected into grafts should be excised as an elliptical block (see Figure 1). At the time of writing this article the majority of hair transplantation physicians excise the donor area with a multi-bladed knife. Even the upper and lower blade of a double-blad-

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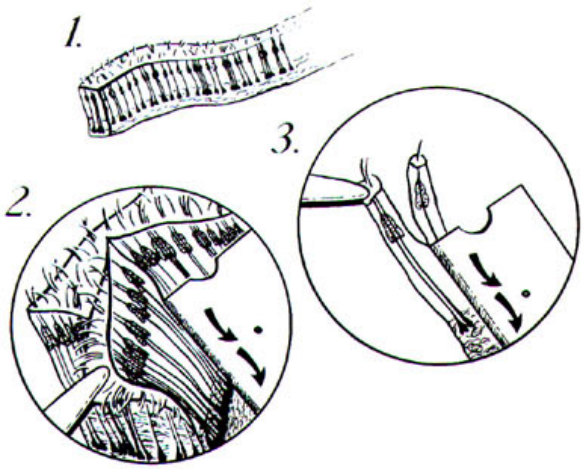

Figure 1. *1. Donor strip already excised. 2. Strip being "slivered" with a razor blade, cutting between the follicular clumps. 3. Two micrografts being separated under microscopic visualization.*

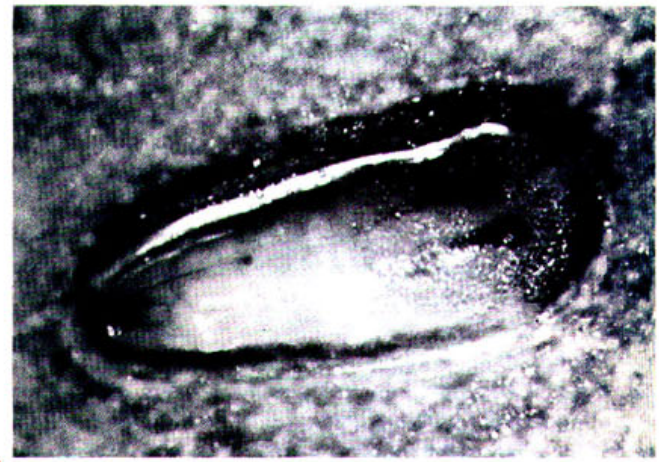

Figure 2. *Two-haired follicular clump/micrograft as seen with ×20 magnification through the stereoscope. Note the visibility of the sebaceous glands, the amount of fat left around the dermal papillae (for protection and grasping with forceps during planting). A miniaturized hair is also visible.*

ed knife causes more transection of follicles than using a single scalpel blade freehand. When one or more blades are used between the outer two, very significantly greater damage to the pilo-sebaceous units of the donor tissue occurs.

Under direct microscopic vision, this block is then sectioned vertically into tiny strips of skin, one follicular clump wide. These small strips of skin are called "slivers". These slivers are then laid on their sides, and with the aid of the stereoscope, dissected into one of two types of grafts:

1. Micrografts, or single, naturally occurring follicular clumps, containing 1–4 hairs. These generally are planted into 19-gauge hypodermic needle sites.

2. Mini-grafts. In the author's practice, these are slit grafts that usually contain 3–6 hairs, and are usually long enough to fit an incision made by a 15c scalpel blade. With the above method, only the upper and lower edges of the elliptical block are cut "blind"—permitting damage to pilo-sebaceous units. With a triple- and quadruple-bladed knife, four and six strip edges (respectively) are cut blind. Moreover, the bending of blades, and "bunching up" of donor tissue between the upper and lower blade(s), all lead to greatly increased transection of hairs and other damage.

ADVANTAGES OF USE

Increased hair yield

The main advantage of using the binocular stereoscopic dissecting microscope to dissect the donor area into grafts is that one is able to harvest about 15–30% more hairs[5–7] from the same size donor area than if one used the naked eye plus simpler, more conventional methods of magnification. The stereoscope provides greater magnification and improved lighting, which allows one to curve and maneuver the dissecting blade around and between follicular clumps while avoiding transection of hair shafts and follicles. If one does not use the stereoscope, there is a greater potential for hair shafts to be transected and important parts of the pilo-sebaceous units, such as sebaceous glands and dermal papillae, to be damaged.

The increase in yield varies with the type of hair. Grey, white, or curly hairs are much more difficult to see and therefore to cut between, so the increased yield may be greater than 20%. However, with jet-black, coarse, or sparse hairs, which are easier to see and cut between, savings may be less than 20%.

While training staff to use the stereoscope, the waste tissue produced from the cutting process is monitored. As the staff become more experienced, the waste tissue becomes less in volume and contains fewer and fewer bits of hair shafts and dermal papillae, and so on, until it eventually contains almost none. This contrasts sharply with the waste tissue produced when using the naked eye alone; usually many spicules of hair, dermal papillae, and so on, can be seen in the waste tissue.

Better survival of micrografts

When micrografts are prepared with the stereoscope, it is easier to preserve vital structures of the pilo-sebaceous unit, such as the sebaceous gland and the dermal papilla (see Figure 2). One can more accurately leave an optimal amount of protective dermis and subcutaneous fat protecting the graft. The stereoscope makes it easier to appreciate the natural clumping in which human hair grows. Improved visualization allows the 'cutter' to avoid splitting a natural follicular clump into its constituent hairs. Micrografts produced by dissecting intact follicular clumps from donor tissue have a higher percentage of survival than micrografts from hairs that are split away from other hairs in a follicular clump.[8]

Less poor growth

During the past 18 months that the author has been using the stereoscope exclusively to dissect every graft, the author has

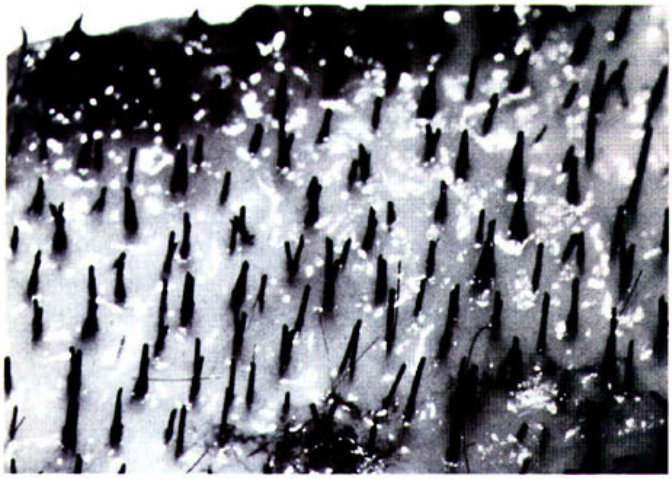

Figure 3. *Portion of an elliptical donor strip viewed through the stereoscope with x10 magnification. Note how much easier it is, with the stereoscope, to appreciate the follicular clumping in which human hair grows.*

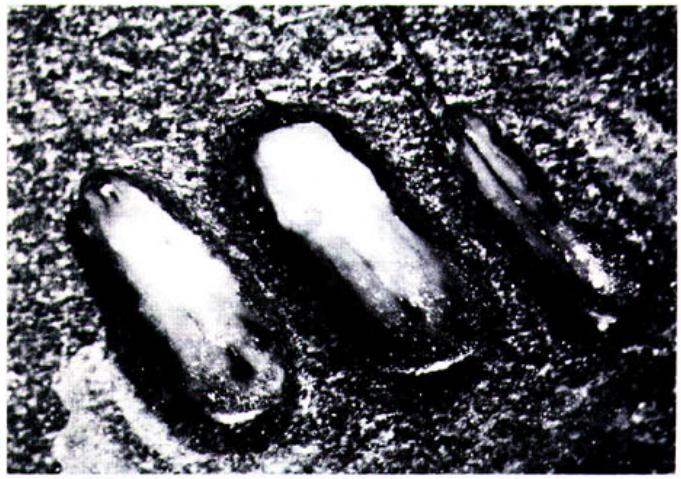

Figure 4. *Each of these grafts has a miniaturized hair visible through the stereoscope (with x10 magnification). These miniaturized hairs would be extremely difficult to spot with simple magnification and to most operators impossible to see with the naked eye alone.*

found not one single case of poor growth. Prior to using the stereoscope, cases of less than optimal growth were occasionally seen. Trauma to the grafts and donor tissue has been suggested as a cause of hitherto unexplained poor growth that many experienced hair transplant physicians have seen. Norwood and Shiell hypothesized that poor growth, when occurring with optimal technique (at a time prior to the use of stereoscopes) and no other accountable circumstances, was caused by the presence of a substance called "X-factor".[9] More recently, Greco[10] has postulated that this poor growth is the result of human-caused trauma during the handling of donor tissue and grafts, and suggested that X-factor be renamed "H-factor" (for human). Cooley and Vogel[11] have illustrated the possible mechanism of trauma to the hair shaft causing damage to the dermal papilla.

When using the stereoscope, one can grasp the donor tissue/graft with forceps more precisely at a non-vital part, thus avoiding compression of dermal papillae and hair shafts near the dermal papillae, as well as the sebaceous glands. One can position the forceps more accurately and visually gauge the pressure one applies with the tips of the forceps so as to produce less trauma to the grafts or donor tissue.

The preparation of single-haired micrografts

When micrografts are carefully prepared and selected so as to contain only one hair, many of these "one-haired" micrografts frequently grow two or more hairs.[12] (Figure 3). When using the stereoscope, one can easily see why. Miniaturized hairs, which are difficult to see with the naked eye or even modest magnification, are clearly visible through the microscope (Figure 4). Sometimes these miniaturized hairs may be parallel to and directly contiguous with a full-sized hair, and impossible to distinguish from the full-sized hair without the aid of the microscope. The stereoscope allows one to identify micrografts containing an obvious full-sized hair, together with miniaturized hairs, and not classify them as one-haired micrografts, which should be set aside for exclusive use in the hairline.

Precise dissection of light grey or white haired donor tissue

Very light-colored hair is difficult to see under the epidermis with the naked eye. When dissecting donor tissue with a lot of white hair, one will inevitably damage a high proportion of hairs, especially when preparing micrografts. With the stereoscope, one is able to see and preserve fine, white hair shafts in donor tissue that would be impossible to identify with the naked eye.

DISADVANTAGES OF USE

Added cost

The disadvantages of using the stereoscope are mainly financial. In addition to the cost of the initial purchase of new microscopes, the cost of replacement light bulbs is significant.

One must also consider the extra cost of staff to clean and drape the stereoscopes so as to avoid cross-contamination. Increased staff hours are also needed to prepare the same number of grafts with the stereoscopes. The same staff must work for about twice as long as without the stereoscopes; more realistically, it would take twice the number of staff the same time. This considerably increases the overhead costs of hair transplantation. The length of day for a large megasession of micrografts can be exhausting for the staff.

Inadvertent wastage of invisible telogen hairs

A recently expounded hypothesis is that by dissecting follicular clumps from the donor strip and discarding the tissue in between the clumps, any hairs in this discarded tissue that are in a telogen state could not be detected because they would be

totally invisible. Therefore these telogen hairs would be wasted. At any one time, approximately 8–12% of human hairs are in a telogen state.

This hypothesis, however, is fallacious because of two reasons. First, not all these "telogen hairs" are totally invisible. For a significant part of the telogen, the follicle is not empty: in fact, new anagen hairs can be seen pushing out the telogen hairs.[13,14] Second, within any follicular unit (a "bundle" of one to four hairs that grow together) there exist hairs at different stages of their growth cycle—from anagen through to telogen. The percentage of follicular units that,when seen through the stereoscope, seem to contain only one hair is around 15% of all follicular units harvested (although this figure may vary in certain individuals and races). Even these follicular units containing only one visible hair, are capable of having one telogen hair that has been pulled out before its succeeding anagen hair becomes visible. It is most unlikely that any young, invisible, anagen hairs (which have had their telogen hairs dislodged prior to being pushed out) exist in isolation without being "connected to" other hairs of a follicular unit. In other words, even if 10% of donor hairs were in the telogen phase and all were rubbed or combed out prior to their respective anagen hairs being visible, most if not all of this 10% of telogen hairs would belong to other hairs in a follicular unit. Therefore, they would not be inadvertently discarded due to invisibility. They may be invisible, but the follicular unit within which they invisibly exist would be dissected and transplanted (complete with the invisible telogen hair within it) in the usual way; hence, the fallacy in the hypothesis.

In attempting to quantify the extent to which this hypothesized loss of telogen hairs may actually occur, one might consider the following: The overwhelming majority of telogen hairs occur in conjunction with follicular units and not as isolated single telogen hairs in between the units. Single-haired follicular units only comprise about 15% of all follicular units in Caucasians in the author's experience. Given that telogen hairs comprise about 10% of the total number of hairs in a given area, the *maximum* number of telogen hairs "in between" follicular units could be around 1.5% (i.e. 10% of 15%) of total hairs in the same given area of scalp. However, the real percentage of *invisible* telogen hairs in between clumps will be much less because: 1) A high percentage of telogen hairs are visible through the microscope as miniaturized hairs, with or without the terminal club hair being visibly pushed out and 2) A portion of these "single-haired" follicular units already have invisible telogen hairs associated with them and so will never become "isolated".

With our technique, there is not much waste tissue from in between follicular units produced and discarded: although Figure 3 shows considerable distance between the hairs of each clump—with "bare" epidermis in between, a look at the actual relative dimensions of the clumps themselves (see Figure 2) shows that the distance between adjacent follicular clumps deep to the epidermis is relatively minute. This is why so little waste is produced. Most of this waste tissue is either epidermis around the hairs, or subcutaneous fat and some galea. However with sparse donor hair there may rarely be significant waste.

For these reasons the author believes that any wastage of invisible telogen hairs must be a very small percentage of the total number of telogen hairs existing throughout the entire donor strip (i.e. a very small percentage of the total percentage of 8–12%). Therefore the total percentage of hairs that may be wasted according to this hypothesis is probably *far less than 1%*. This is totally insignificant when considering the reduction of hair wastage in the order of 20% with the use of the stereoscope. Thus the inadvertent wastage of invisible hairs theory as an argument against microscopically aided follicular unit transplantation is unscientific and wrong.

Practical difficulties in introducing binocular stereoscopic dissecting microscopes into an established hair transplant practice

Nurses and technicians who have been used to cutting grafts for years with the naked eye, with or without simpler forms of magnification, are frequently reluctant to adopt microscope dissection. Two of my colleagues, both highly established and respected, have tried unsuccessfully for over a year to convert their staff to the exclusive use of the stereoscope in dissection of donor tissue into grafts. In the author's own practice, there was initially strong resistance by some of the staff towards use of the stereoscope.

To overcome this difficulty, the author suggests that a hair transplant physician intent on converting his/her established hair transplant practice to exclusive use of the stereoscope in donor dissection do the following:

1. Bring two of the most experienced "cutters" to observe a practice where the stereoscope has been used exclusively and is well established. They will then see that with sufficient practice, it becomes just as easy (although not as fast) to cut every graft with the stereoscope.

2. Purchase two stereoscopes and let all of the "cutters" train with them intermittently for an initial period, perhaps two to four months, depending upon the amount of microscope use.

3. Set an arbitrary date beyond which all graft "cutters" will dissect all grafts exclusively with the aid of the stereoscope. Announce that any staff member unwilling or unable to convert to exclusive use of the stereoscope by this date will be relegated to other tasks in the practice.

4. Hire at least one new staff member, new to hair transplantation, to be trained exclusively in microscope dissection of donor tissue. (More staff will be necessary in any case because more staff are needed with exclusive use of the stereoscope). This new member will usually set an example to his/her established seniors and be cutting amazingly higher-quality grafts after the second day of cutting! This encourages the "old" staff to keep up to the standard set by the new staff member.

SUMMARY

The major benefit of using the binocular stereoscopic dissecting microscope is less wastage of patient's donor hair—a finite, non-renewable resource. This is not only important for those patients who are extensively bald when they begin hair

transplantation, but also for those who are young and seem to have ample donor hair. Years later, their need for additional donor hair is frequently much greater than anticipated earlier and only then will the true advantage of saving every single donor hair possible be appreciated.

Disadvantages are the cost of the stereoscopes, plus the need for a larger staff, together with all the administrative problems and additional expense that a larger staff brings.

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