Micrograft Size and Subsequent Survival

DAVID JULIAN SEAGER, MBBS, MRCS, LRCP

BACKGROUND. *Micrograft survival rates in hair transplantation have been frequently described in private conversations by hair transplant doctors as variable at best. References in medical literature may grossly underestimate the prevalence and magnitude of poor growth. This is probably because most hair transplant surgeons are concerned that publication of a significant incidence of poor growth would reflect negatively on their practice.*

OBJECTIVES. *The purpose of this research was to study micrograft survival rates using microscopic dissection techniques. The author also presents a hypothesis regarding the relatively poor survival rates reported by hair transplant physicians.*

METHODS. *Two different groups of micrografts were prepared. One group, mainly single-haired with tissue trimmed close to the hair shaft, was planted into one test patch in the bald crown of a patient's scalp. Another group of intact follicular clumps, prepared with more dermis, subcutaneous fat, and intact sebaceous glands, was planted into another test patch. These test patches and their growth were documented with close-up photography.*

RESULTS. *The micrografts prepared as existing follicular clumps had a much higher survival rate (over 100%) than the micrografts cut as slender single hairs.*

CONCLUSIONS. *Extremely high survival rates of micrografts are obtainable by transplanting intact follicular clumps with protective tissue around the micrograft, and preserving the follicular clump's sebaceous gland. These survival rates were not achieved when micrografts were produced by splitting individual hairs away from a naturally occurring follicular clump.* © *1997 by the American Society for Dermatologic Surgery, Inc. Dermatol Surg 1997;23:757–762.*

Few hair transplant physicians who examine the results of their work closely would claim to be consistently happy with the survival rate of their transplanted micrografts. References in medical literature[1–15] may grossly underestimate the prevalence and magnitude of poor growth. Personal experience has shown a highly variable rate of survival of transplanted micrografts. One well-known hair transplant doctor had hair transplants performed at two different prestigious, well-known centers in the United States. Each inserted exactly 50 micrografts into his hairline. However, 1 year after the second session, only 50 micrografts, or half of the transplanted hairs, could be counted growing (personal communication, Sandoval A, 1993).

I believe that this 50% survival rate of micrografts is probably typical of micrograft survival in many hair transplant practices. Greco has postulated that the reason for this may be "crush injury."[15,16] He believes that the increased handling of micrografts with forceps and the tremendous pressure exerted with the very fine tips of the forceps on vital parts of the pilosebaceous units may contribute to poor growth. This paper will elaborate on this point and suggest other possible causes of poor growth in micrografts.

Observation at 10 different hair transplant facilities has shown considerable variation in size of the micrografts cut. Some facilities cut single-haired micrografts, trimmed almost down to the bare hair shaft, with the sebaceous gland and most of the protective dermis and fat dissected away. Other facilities produce mostly two- and three-haired micrografts, with plenty of dermal and adipose tissue left around the hair shafts and dermal papillae. They also deliberately leave the sebaceous glands, which are usually straddled by hair shafts, comprising a single follicular clump (Figure 1).

Hair grows naturally in follicular clumps (Figure 2). Although there is considerable individual variation, in most Caucasians these follicular clumps exist in the

Figure 1. *On the left there are two micrografts cut "skinny." Little protective dermis/subcutaneous fat is present and no sebaceous gland is visible. To the right of these are three "chubby" intact follicular clumps. Left to right: one haired, two haired, and then three haired. Note the preserved, distinct sebaceous glands and ample protective dermis and fat left all around the hair shafts and dermal papillae.*

From the Centenary Health Centre, Scarborough, Ontario, Canada.

Address correspondence and reprint requests to: Centenary Health Centre, 2863 Ellesmere Road, Scarborough, Ontario, Canada M1E 5E9.

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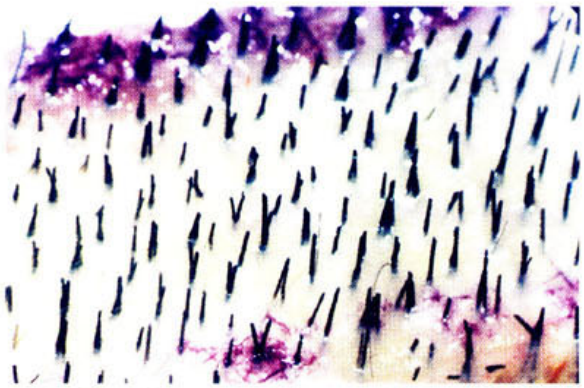


Figure 2. The skin surface of a harvested donor strip, illustrating the way hair naturally grows in follicular clumps. The two edges of the strip have been marked prior to excision with Gentian violet surgical skin marker. The hairs are growing in naturally occurring clumps of one to four hairs.

following distribution: approximately 10% follicular clumps grow as one-haired units, about 50–60% grow as two-hair follicular clumps, and the remainder grow as three- or four- (or rarely, even five-) haired follicular clumps (author's experience). These are shown clearly in Figure 2, which was taken through a binocular stereoscopic dissecting microscope. It shows the skin surface of a freshly harvested donor strip. Note the large area of epidermis without hair between the various follicular clumps. This "empty epidermis" is dissected away as waste tissue, leaving only follicular clumps plus a small amount of waste tissue containing epidermis, dermis, and fat. Micrografts are cut in this practice into one-, two-, three- or four-haired, naturally occurring, follicular clumps similar to those shown in Figure 1. Figure 3 shows a perfectly cut two-haired "chubby" micrograft (as planted on the right side). These miniature hairs and smaller telogen hairs are likely responsible for the greater number of transplanted hairs growing than were transplanted.

Figure 3. Close-up of a perfectly cut two-haired "chubby" micrograft that was preserved as an intact, naturally occurring follicular clump. There is excellent visualization of the sebaceous glands, over which can be seen lying a miniaturized hair. An ample fat pad deep to the dermal papillae has been deliberately left to provide an area that can be grasped with jewelers forceps for insertion, etc without damaging any vital structures.

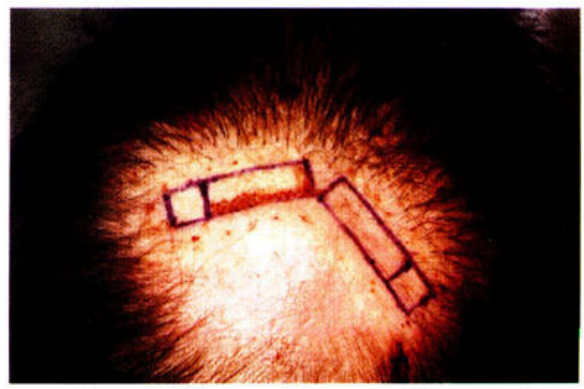


Figure 4. Two marked test patch areas on the crown of the experimental subject's scalp. Planting of skinny one-haired micros had already been initiated at the time this photograph was taken.

Methods

Two equal-sized areas were marked on the bald crown of a volunteer patient (Figure 4).

Left Side

Only "skinny" micrografts were planted into the left side. The term "skinny" is meant to describe micrografts with the epidermis, dermis, and subcutaneous fat largely trimmed away, leaving minimal tissue around the hair shaft (Figure 1). The sebaceous glands were also largely or completely trimmed away. The dermal papillae were left almost completely exposed. Most importantly, to obtain a significant number of single-haired micrografts, it is necessary to split up follicular clumps. When single-haired micrografts are dissected away from a two- to four-haired follicular clump, the resulting single-haired micrografts will be trimmed close to the hair shaft with less of its sebaceous gland preserved and less protective dermis and fat around it. This will occur whether or not one is deliberately trying to produce a skinny graft; that is, skinny single grafts cannot be avoided when they are dissected from follicular clumps. If one-haired micrografts are prepared exclusively from the (approximately, subject to wide individual variation) 10% of follicular clumps that naturally exist as one-haired follicular clumps, adequate sebaceous gland preservation and adequate amounts of protective dermis and fat are possible.

A total of 86 grafts were planted in the left side area, 84 one-haired micrografts and two two-haired micrografts (Figures 5 and 6). This is a total of 88 transplanted hairs.

Right Side

Chubby micrografts prepared as intact follicular clumps, complete with abundant surrounding protective dermis, fat, and

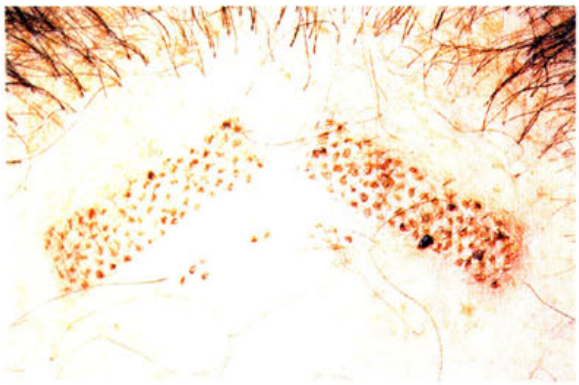


Figure 5. *Close-up of both test patches. One can see that on the left side nearly all one-haired micrografts were planted, whereas, on the right side, one can see two hairs coming out of most of the micrografts.*

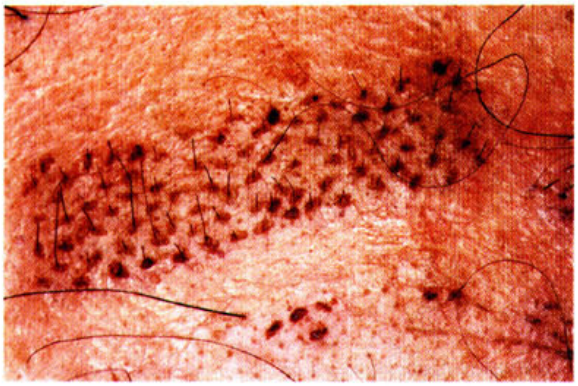


Figure 6. *This macro photograph of the left sided test patch shows crusts over skinny, mainly one-haired micrografts, 4 days following transplantation.*

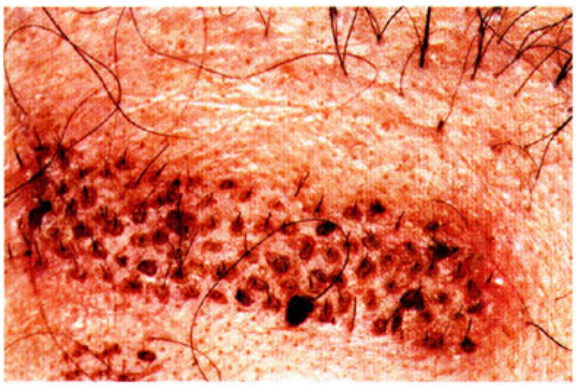


Figure 7. *Right sided test patch with an equal number of micros, "dense packed" in an area of equal size to that of the left side, but mainly containing chubby, two-haired, naturally occurring follicular clumps.*

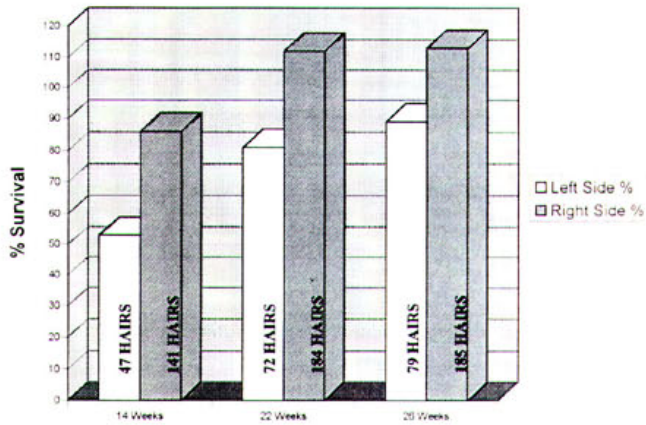


Figure 8. *Hair counts were obtained at the described time intervals.*

intact sebaceous glands, were planted into identically sized contralateral areas. Into this area were planted a total of 78 two-haired micrografts and seven one-haired micrografts, for a total of 85 (research) micrografts. Into this right side area were planted a total of 163 hairs (Figures 5 and 7).

All of the micrografts in both patches were produced by dissection using binocular stereoscopic dissecting microscopes, as described by Limmer.[17] They were then planted by the same two nurses using the same dissection and planting techniques. Both of the test patches were planted to exactly the same micrograft density, 32 micrografts per square centimeter (Figure 7).

Results

Hair counts were performed on both groups at 14, 22, and 26 weeks after transplantation. Using double-blinded, single-blinded technique, three technicians performed three separate hair counts on each side of the crown during each evaluation. Magnifying loupes and a needle were used to facilitate counting. Therefore, during each evaluation both areas were counted nine times. Average count rates rarely varied by more than one or two hairs. These counts, together with the number of hairs originally planted, are listed in Table 1 and Figure 8. The large difference in number of hairs and the different textures of the hair in the two groups was obvious at first glance (Figure 9). Initially, the number of hairs on the left side was a lot lower and many of the hairs were of fine shaft diameter and frizzy (Figure 10).

Table 1. The Following Hair Counts Were Obtained at the Described Time Intervals

	Number of Hairs Planted	*Hairs Counted after 14 Weeks of Transplant*	*Percentage of Survival*	*Hairs Counted after 22 Weeks of Transplant*	*Percentage of Survival*	*Hairs Counted after 26 Weeks of Transplant*	*Percentage of Survival*
Left side	88	47	53%	72	81%	79	89%
Right side	163	141	86%	184	112%	185	113%

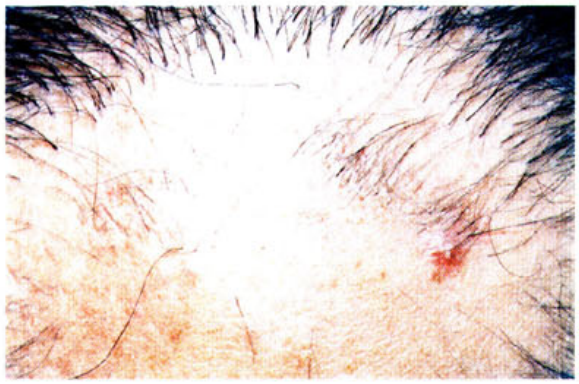


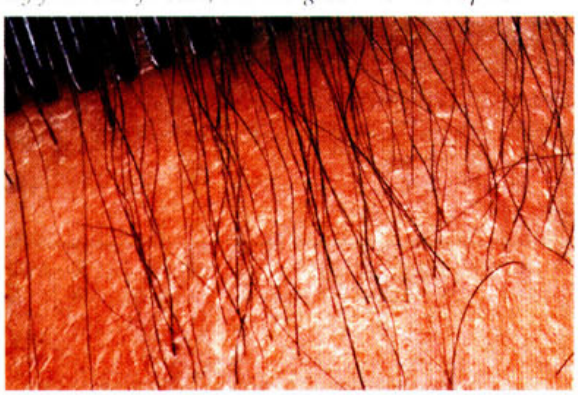
Figure 9. Both test patches 14 weeks after transplantation. Note the greatly increased growth on the right side and the finer, slightly frizzy hairs on the left side.

Discussion

It is clear from this observational study that when micrografts are left as intact follicular clumps with ample protective dermis, fat, and intact sebaceous glands, they have a much higher survival rate than slender, one-hair denuded micrografts.

A question not yet answered is, "Why did hairs left as 'chubby' intact follicular clumps do better than the more closely trimmed single hairs used in this study?" The greater magnification obtained using binocular stereoscopic dissecting microscopes (used to prepare the micrografts in this study) enabled one to grasp the micrografts by their more abundant donor tissue with less pressure and at a less vital site. One can avoid grasping the sebaceous gland, the dermal papilla, or the hair shaft. The graft is held more precisely by its peripheral epidermis, peripheral dermis, or subcutaneous fat, thereby lessening the severity and the location of any crushing that may occur. Greco demonstrated poorer growth resulting from crush injury to one-haired micrografts.[16] Presumably, most of these would have been cut by stripping them off of follicular clumps, thus producing slimmer micrografts with less preserved protective dermis, sebaceous gland, and fat around the hair bulb.

Figure 10. Left test patch, 33 weeks after surgery. The hairs are slightly finer and frizzier, and the growth is more sparse.



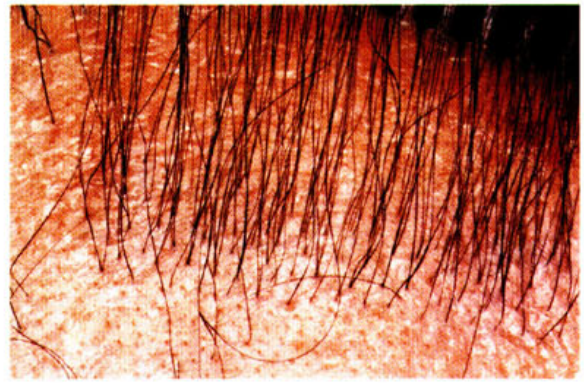


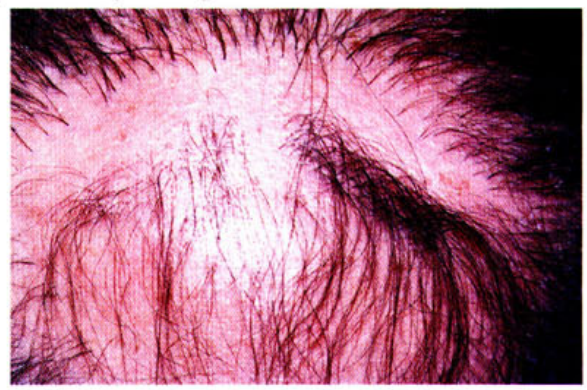
Figure 11. Right test patch, 33 weeks after surgery. The growth is better and the hairs are coarser and straighter.

Several questions have been raised as a result of the author's observations. Could poor growth be directly attributed to sebaceous gland damage? Could it be H factor[15,16] due to the "skinny" micros having less dermal and adipose tissue to both act as a cushion to protect more vital areas of the graft from trauma and to act as a safe "handle" by which to grasp the graft with forceps? Or could it have more to do with some other factor, such as the physiological and anatomical bond between the hairs of naturally existing follicular clumps that, when disrupted, produces poorer growth?

From a practical point of view, these questions and their answers are largely irrelevant. This observational study demonstrates that, by preparing all micrografts as intact follicular clumps and leaving them "chubby," it is possible to get very high survival rates.

It is believed that it is only important to use single-haired micrografts in the front two or three rows of the hairlines of patients with very dark course hair. Fine hair, blond hair, grey hair, and so on, looks very natural with two-haired micrografts in the very front hairline. Even for dark, coarse-haired patients, it is usually possible to obtain enough single-haired micrografts for the

Figure 12. Left and right sides at 26 weeks.



front two rows of the hairline as naturally occurring one-haired follicular clumps (which represent only about 10% of all follicular clumps). One simply has to ask the technicians to save all naturally occurring one-haired micrografts in a separate petri dish and keep them for the front two or three rows of the hairline.

The single-haired micrografts, mainly produced by splitting follicular clumps, tended to grow thinner than usual hairs. They looked slightly more frizzy, and took longer to grow (Figures 8–10 and 12). Kim noticed fine hair when he reported that after implanting transected hair follicles, the upper halves grew hair in a proportion of cases. This hair was of fine shaft diameter.[18]

This observational study also demonstrates that the number of transplanted hairs growing from the chubby micrografts was greater than the number originally planted. A similar increase was originally described by Unger when counting hair survival in 4-mm-diameter plug grafts.[19] The most likely explanation for this phenomenon seems to be the growth after transplantation of hairs that prior to transplantation were in the telogen state.

Another interesting point that may be derived from this study is the optimum time for performing hair counts. Limmer has done research on the survival rates of micrografts with a varying number of hours between harvesting from the donor area, and replanting in the recipient area. Most of the statistics in his paper were derived from hair counts performed 5 months after transplantation. Dr. Limmer's experimental findings showed a 90–95% micrograft survival rate at 5.5 months. Many of his one- to two-haired micrografts were obtained by splitting apart larger follicular clumps.[20] In addition, had he waited another few months before performing his hair counts, his figures might have been higher. This can be postulated by the delayed but continued growth rate/yield of micrografts split off of larger follicular clumps in this study.

The 113% growth rate of this observation study was verified by extensive use of photography at all stages. The macro photographs of the test patches, both immediately after surgery and 1 week later, are of such resolution and clarity that it is possible to do hair counts in 8×10 prints of them. No further grafts will be planted into these areas again so they will remain countable for posterity. Thus, these results can easily be validated.

Conclusion

Extremely high survival rates following micrograft transplantation (well over 100% because of telogen hairs) were obtained by preparing micrografts as naturally existing follicular clumps, complete with most of their sebaceous glands and adequate dermal and adipose protective tissue left around them. One-haired micrografts split away from follicular clumps produced a lower proportion of hairs that survived transplantation. This may be due to crush injury resulting from having less protective dermal tissue and fat left around them, damage to sebaceous glands, or other factors compromising the integrity of the follicular unit.

References

1. Ceccolini E. Reduced growth. Hair Transplant Forum International 1995;5(5):17.
2. Holzberg M. Poor growth? Hair Transplant Forum International 1991;2(1):8.
3. Lucas M. Dialogue: Dr. Manfred Lucas responds to Dr. Richard Shiell. Hair Transplant Forum International 1992;2(4):11.
4. Pomerantz MA. More 'Problems with Megasessions.' Hair Transplant Forum International 1995;5(3):4–5.
5. May MW. Laser troubles. Hair Transplant Forum International 1995;5(4):11–7.
6. Norwood OT. We have evolved. Hair Transplant Forum International 1992;2(6):1–3.
7. Pouteaux P. Pierre Pouteaux offers explanation for poor regrowth, "Piggy-Backed" Minigrafts. Hair Transplant Forum International 1992;2(3):8.
8. Pouteaux P. From Pierre Pouteaux. Hair Transplant Forum International 1995;5(1):16–7.
9. Straub P. The cause of poor growth? Hair Transplant Forum International 1993;3(5):17–8.
10. Elliott M. Megasessions & dilators. Hair Transplant Forum International 1995;5(6):8.
11. Shiell RC. Report on the Toronto meeting. Hair Transplant Forum International 1994;4(5):3–10.
12. Shiell RC. The Australians view of the Las Vegas meeting. Hair Transplant Forum International 1995;5(5):3–9.
13. Shiell RC. Poor hair growth after transplantation: the X factor. In: Stough DB, ed. Hair Replacement. St. Louis: Mosby Press 1996; 314–6.
14. Shiell RC, Norwood OT. Hair Transplant Surgery. Springfield, IL: Thomas Books, 1984:148–50.
15. Greco JF. Is it X factor or H factor? Hair Transplant Forum International 1994;4(3):10–1.
16. Greco JF. The H-factor in micrografting procedures. Hair Transplant Forum International 1996;6(4):8–9.
17. Limmer BL. Elliptical donor stereoscopically assisted micrografting as an approach to further refinement in hair transplantation. J Dermatol Surg Oncol 1994;20:789–93.
18. Kim JC. Regeneration of the human scale hair follicle after horizontal sectioning. Implication for pluripotent stem cells and melanocyte reservoir. In: Van Neste DJJ, Randal VA, eds. Hair Research for the Next Millennium. New York: Elsevier Science Inc., 1996;135–9.
19. Unger WP. Hair Transplantation, 1st ed. New York: Marcel Dekker Inc., 1979:209.
20. Limmer BL. Micrografts survival. In: Stough DB, ed. Hair Replacement. St. Louis: Mosby Press, 1996;147–9.

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Commentary

This article has tremendous implications on the field of hair restoration surgery. It appears that the use of the dissecting microscope and the preservation of follicular units may be the method of the future. Dr. Bobby Limmer has been advocating the dissecting microscope since the mid 1980s. Other transplant surgeons now seem to be embracing this concept. If transplanting only by follicular units is beneficial in regard to maximizing growth and minimizing "plugginess," then it follows that the dissecting microscope would be the instrument of choice to produce follicular units. Those physicians and technicians who utilize the dissecting microscope believe that efficiency of sectioning donor tissue cannot be achieved by a simpler means of magnification. Maximum efficiency in any endeavor comes at a price. The decision to cut with a microscope is not without substantial expense and training by transplant surgeons. Indeed, this method has proved to be slower than cutting a thin strip strictly by size. It appears that the benefit of the technique advocated by Dr. Limmer and Dr. Seager is chiefly an improvement in preservation and yield of the harvested donor tissue. What degree of preservation and what percentage of improved hair growth this technique yields remains to be proven with more extensive comparison studies.

The field of hair transplantation stands on the threshold of a new era. Microscopically dissected follicular unit grafts may soon yield the ultimate transplant. Nevertheless, the added cost and technical difficulty of this approach may lead to this technique being used by a select few. Alternately, market forces may force all transplant surgeons to adopt this approach. Further studies and the test of time will reveal the practical effectiveness of this seemingly superior approach.

Dow Stough, MD
John Miner, MD