Does the Recipient Site Influence the Hair Growth Characteristics in Hair Transplantation?

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BACKGROUND. **Recently hair transplantation has been widely applied not only to correct androgenetic alopecia, but also to correct hair loss on other parts of the body such as the eyebrows and pubic area. It is believed that the transplanted hairs will maintain their integrity and characteristics after transplantation to new nonscalp sites.**

OBJECTIVE. **To evaluate whether the transplanted hairs maintain their hair growth characteristics after transplantation to a new anatomic site other than the scalp.**

METHODS. **Three study designs were used. Study I: Hair transplantation from the author's occipital scalp to his lower leg was performed and clinical evaluations were made at both 6 months and at 3 years after the transplantation. Study II: After finding changes in hair growth characteristics, transplanted hairs were harvested from the leg and retransplanted to the left side of the nape of the neck (group A). As a control study, occipital hairs were transplanted to the opposite side (group B). Observations were made at 6 months after the operation. Study III: An observational study was done in 12 patients with androgenetic alopecia about 1 year after transplantation of occipital hair to frontal scalp. At each step, survival rates were documented and the rate of growth and the diameter of the shafts were measured for both recipient and donor sites.**

RESULTS. **Study I: Surviving hairs on the lower leg showed a lower growth rate (8.2 ± 0.9 mm/month), but the same diameter (0.086 ± 0.018 mm) compared with occipital hairs (16.0 ± 1.1 mm/month, 0.088 ± 0.016 mm). The survival rate 3 years after transplantation was 60.2%. Study II: There was no significant difference in the growth rate, shaft diameter, and survival rate between retransplanted hairs (group A) and controls (group B). Groups A and B showed a lower growth rate, but the same diameter, compared with occipital hairs. Study III: There was no significant difference in the growth rate and shaft diameter between the transplanted hairs on the frontal scalp and the occipital hairs.**

CONCLUSION. **These results strongly suggest that the recipient site affects some characteristics of transplanted hairs, such as their growth and survival rates.**

S. HWANG, MD, J. C. KIM, MD, H. S. RYU, MD, Y. C. CHA, MD, S. J. LEE, MD, G. Y. NA, MD, AND D. W. KIM, MD HAVE INDICATED NO SIGNIFICANT INTEREST WITH COMMERCIAL SUPPORTERS.

DR. NORMAN ORENTREICH defined the term "donor dominance" as meaning that autografts maintain their integrity and characteristics after transplantation to a new site.[1] With this concept in mind, there have been many developments in hair restoration surgery, and recently hair transplantation has been widely applied not only to correct androgenetic alopecia, but also to correct hair loss on parts of the body other than the scalp.[2,3] It is believed that the transplanted hairs will maintain their growth characteristics on any recipient site. However, there have been few studies done to confirm this belief.

The purpose of this study was to evaluate whether the hairs would keep their original growth characteristics after transplantation to a new anatomic site.

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Study I

To evaluate the hair growth characteristics of a recipient site other than the scalp, we transplanted hair from the author's occipital scalp to his lower leg.

Methods

In March 1998, an elliptical strip (1 cm × 2 cm) was harvested from the occipital scalp and 93 hairs were transplanted to the medial aspect of the lower leg using a KNU implanter. Both at 6 months and at 3 years after transplantation, there were 20 surviving hairs on the lower leg (recipient) and 150–200 occipital scalp hairs on the occipital area (donor) area were cut using Iris scissors. Hairs were cut as close to the skin surface as possible. After 4 weeks, the same hairs were cut again from both the recipient area (lower leg) and the donor site (occipital scalp) in a similar fashion as before. Twenty hair specimens were collected from each group and attached to a glass slide using double-sided

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and one-sided cellophane tape. The length and diameter of the hairs (in millimeters) was measured by means of a microscope equipped with an ocular micrometer.[4,5] At 3 years, the number of surviving hairs in the recipient were counted. Student's *t*-test was used to analyze the difference in the hair growth rate and the diameter of the shaft. When $P < .05$, the difference was considered significant.

Results

The survival rate was about 60.2% at 3 years after the transplantation. The surviving hairs on the lower leg showed a significantly lower growth rate, but the same diameter, compared with the occipital hairs. However, the results were equal both at 6 months and 3 years after surgery (Table 1). After 3 years the longest hair was measured at 12 cm during the follow-up examination (Figure 1).

Study II

After finding unexpected results, such as a lower growth rate and survival rate in the lower leg, we wondered whether the hair would recover from the lower growth and survival rate when it was retransplanted to a location near the donor site.

Methods

We harvested some of the transplanted hairs from the leg and transplanted 20 of them to the left side of the nape of the neck near the occipital scalp (group A). As a control study, 24 occipital hairs were transplanted to the right side at the same time (group B). At 6 months after surgery, the survival rate, growth rate, and shaft diameter were measured using the same method as in Study I (Figure 2).

Results

There was no significant difference in the growth rate, survival rate, and shaft diameter between group A and group B, but the growth rates in these groups were much lower compared with the occipital hairs (Table 2).

Table 1. The Growth Rate and Shaft Diameter of Transplanted Hairs on the Lower Leg and Occipital Scalp Hairs

	Growth rate (mm/month)		*Shaft diameter (mm)*	
Follow-up	*Lower leg*	*Occipital scalp*	*Lower leg*	*Occipital scalp*
At 6 months	7.9 ± 1.3*	15.5 ± 0.9	0.084 ± 0.013	0.087 ± 0.015
At 3 years	8.2 ± 0.9*	16.0 ± 1.1	0.086 ± 0.018	0.088 ± 0.016

*$P < .05$.

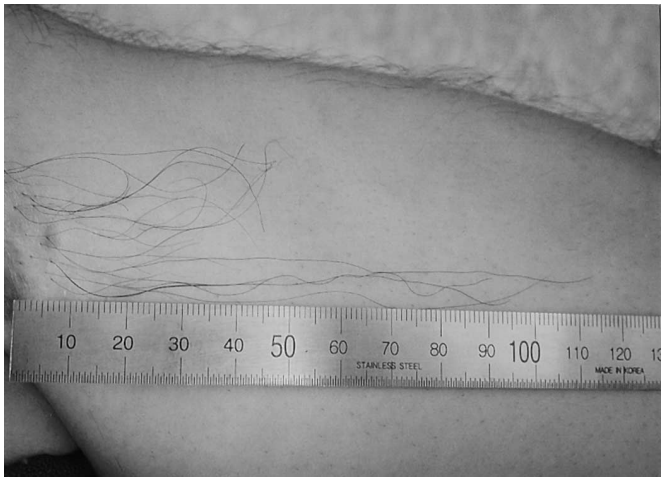

Figure 1. Transplanted hairs on the lower leg. After 3 years, the longest hair was measured at 12 cm during the follow-up examination.

Study III

It was found that survival and growth rates differed according to the location of the recipient site. To evaluate whether or not this resulted from follicular damage during graft preparation, an observational study was made in patients with androgenetic alopecia after hair transplantation.

Methods

Between August and September 2001, male patients with androgenetic alopecia agreed to participate in this study. About 1 year had passed since each had hair trans-

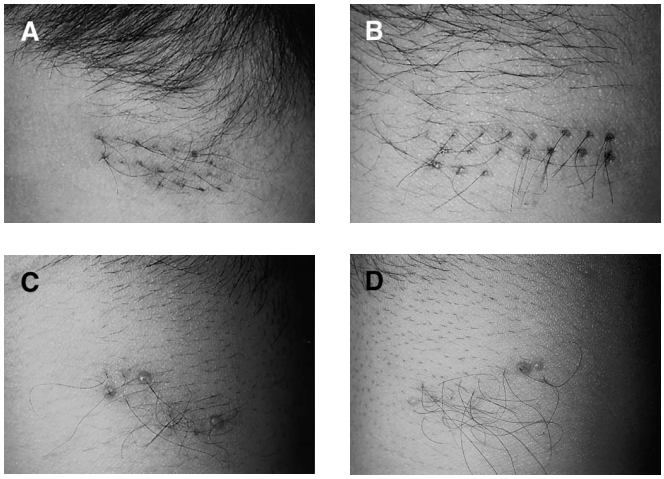

Figure 2. A) Hair transplantation from the lower leg to the left side of the nape of the neck. B) Hair transplantation from the occipital scalp to the right side of the nape of the neck. C) The surviving hairs at 6 months after transplantation, left side. D) The surviving hairs at 6 months after transplantation, right side.

Table 2. The Growth Rate and Shaft Diameter of Transplanted Hairs on the Nape and the Occipital Scalp Hair at 6 Months After Transplantation

Group[a]	Growth rate (mm/month)	Shart diameter (mm)
A	9.0 ± 1.2	0.087 ± 0.009
B	9.3 ± 1.1	0.086 ± 0.010
C	15.8 ± 0.9	0.085 ± 0.010

[a]Group A: surviving hairs on the nape from previously transplanted hair on the lower leg; group B: surviving hairs on the nape from the occipital scalp; group C: occipital scalp hairs.

plantation. They did not have any significant systemic diseases that might have influenced hair growth. The patients ranged in age from 31 to 56 years (mean 42 years). Twenty hair specimens were collected from both recipient (frontal scalp) and donor (occipital scalp) sites using the same method as in study I.

Results

There was no significant difference in the growth rate and the shaft diameter between the transplanted hairs and the donor hairs (Figure 3).

Discussion

In 1959, Dr. Orentreich suggested the term "donor dominance" in androgenetic alopecia to convey that the hair in the grafts continued to grow in the area of the alopecia (the recipient area) and that it maintained the same texture and color, and apparently grew at the same rate and with the same period of anagen that governed the nature of the hair in the donor site.[1] A standard punch technique was used at that time and changes in the size of the grafts employed in hair transplanting have evolved since then. There are new terms to reflect the changes, such as minigrafts, micrografts, and follicular unit grafts. With the use of follicular unit grafts, hair transplantation can be applied not only to androgenetic alopecia, but also to other hairless areas such as the eyebrows and pubic area.[2,3] It is believed that the hairs in the latter sites will maintain their growth characteristics as in transplantation for androgenetic alopecia, but there have been few studies done to confirm this assumption.

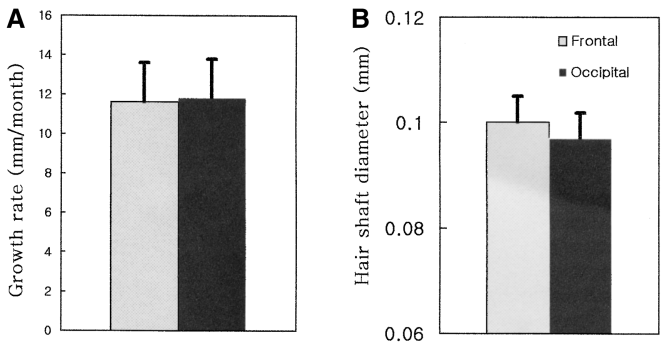

Figure 3. There was no significant difference in A) the growth rate and B) the shaft diameter between the transplanted hairs (frontal scalp) and the donor hairs (occipital scalp).

In these studies, the survival rate was 60.2% in the lower leg at 3 years after surgery. This is a much lower survival rate than that for transplantation in androgenetic alopecia (92%).[6] The hair also showed a marked decrease in growth rate—half that of the donor area hair. There may be many factors involved in these differences. It may be that the thickness of the epidermis, dermis, or subcutaneous tissue, blood supply, or other factors play a role in survival and growth rate differences. However, hair shaft diameter did not change at all, so we suspect that the volume of the surviving hair follicles does not decrease after transplantation to a new site, regardless of the recipient's anatomic site.

We previously reported that the rate of hair growth changes after eyebrow transplantation in patients with madarosis due to leprosy.[7] In that study there was no significant correlation between the hair growth rate and the period of time after its transplantation. Also in this study, the surviving hairs on the leg showed the same growth rate both at 6 months and at 3 years after surgery. Therefore, based on these results, it appears that the cause of the slowed growth rate is not due to adaptation to the recipient site over a long period of time, but apparently occurs immediately after transplantation, and it maintains this lowered growth rate in the recipient site.

In the human scalp, the duration of anagen has been estimated as between 2 and 6 years, and on the leg from 19 to 26 weeks.[8] The expected length of the surviving hair on the author's lower leg was about 31–32.4 cm by calculation (7.9–8.3 mm/4 weeks × 3 years). Of interest is that the longest among them was about 12 cm at the 3-year follow-up examination. This suggests that the anagen period on the leg decreased to 14.5 months or less (120 mm/8.3 mm). Therefore we think that the cycles of transplanted hair may change according to the anatomic location of the recipient site.

After finding these extraordinary results, including the lower growth rate of occipital hairs transplanted to the leg, it was asked whether the hairs would recover from the lower growth and survival rates when they were retransplanted back to a location near the donor site. We harvested some of the transplanted hairs and retransplanted 20 of them to the left side of the nape of the neck (group A). As a control group, 24 occipital hairs were transplanted to the contralateral side of the nape. The survival rates of group A and B

were 95% (19/20) and 91.7% (22/24), respectively, which was much higher than the 60.2% survival rate that occurred in the lower leg. Stated differently, it appeared that the hair recovered from the lower survival rate when it was retransplanted to the nape of the neck. In addition, the hairs in group A and B showed a much lower growth rate, similar to that of hair transplanted to the leg. We previously reported[7] that the growth rate of transplanted eyebrow hairs decreased compared with occipital hairs (7.72 versus 10.43 mm/month). Therefore it is suspected that hair survival and growth rates are influenced by the anatomic location of the recipient site.

During hair transplantation, damage to the follicle may occur while sectioning harvested graft tissue.[9–11] Tissue pressure causing distortion, inadequate magnification, dull cutting instruments, and drying can easily result in follicular damage. A question was raised: Is the lower growth rate due to follicular damage during graft preparation? To answer this question, an observational study was conducted on patients with androgenetic alopecia after hair transplantation. There was no significant difference in growth rate and shaft diameter between surviving hairs in the recipient area and occipital hairs. Based on these results, we feel that the lower growth rate on the leg and neck was not due to follicular damage occurring during hair transplantation.

Hair follicles undergo cycles of growth, involution, and rest. The entire skin changes during the hair cycle, with a generalized thickening during anagen and a thinning during telogen, and the vasculature is also known to undergo changes related to the hair growth cycle. Therefore it is thought that the follicle may influence the physiology of many cutaneous structures, such as the sebaceous glands and subcutaneous fat.[12] Conversely, as a result of our studies, we think that the physiology of transplanted hair follicles may be influenced by the recipient area's cutaneous structures.

Conclusion

According to the results, we think that

- The survival rate and growth rate of the transplanted hairs is influenced by the recipient site.
- The cycles of the transplanted hairs may change according to the recipient area.
- The hair growth rate may change immediately after transplantation according to the recipient site and is maintained afterwards.
- The volume of transplanted hair follicles may not change, regardless of the recipient site.

Therefore we think that the recipient site influences the growth characteristics of transplanted hairs.

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Commentary

In 1959, Dr. Norman Orentreich provided the scientific basis for the field of hair transplantation. In his landmark paper, "Autografts in Alopecias and other Selected Dermatological Conditions," published that year in the Annals of the New York Academy of Science, he put forth the concept that in androgenetic alopecia "the transposed grafted skin maintains its integrity and characteristics independent of the recipient site." He called this phenomena "donor dominance" and, since its first proclamation, there has been no concept more fundamental, or immutable, in the field of hair restoration surgery. The term he coined was an appropriate one, for it has "dominated" our thinking in hair transplantation for the past 40 years. At least until now!

The first inkling that the powers of the donor tissue were not omnipotent came from Dr. Norwood's clever observation that transplanted hair took on the characteristic wave of the hair that originally grew at that spot. Just the fact that transplanted hair could "wave" spoke for recipient site influences, since a surgeon is not capable of orienting each hair so that it will grow in perfect spatial harmony with its neighbor.

The second challenge came in 1999 when Dr. Lee transplanted hair from the scalp into the eyebrows of patients who had alopecia caused by leprosy (a condition called madarosis). He showed that the graying and growth rates of the transplanted hair gradually conformed to the eyebrows rather than the scalp from whence it came.

The present study of Hwang et al. mounts the third formida-

ble challenge to Dr. Orentreich's famous hypothesis. In this work, Dr. Hwang and company provide additional evidence that the recipient area can influence hair growth rate, the cell cycle, and even graft survival. They showed that hair transplanted from the occipital scalp (the author's) to the lower leg took on the growth characteristics of leg hair and then partially reversed itself when transplanted back to the nape of the neck. There was no placebo effect here. There is firm scientific proof of recipient site influences.

The early hair transplanters in Japan must have had some appreciation for these effects as they began to transplant scalp hair to the pubic region in the 1930s and 1940s. As surgeons become more creative in finding new areas of the body to take hair from and new places to put it, the influences of the recipient region take on additional significance. Wouldn't it be nice if that coarse hair taken from a bald man's beard during a facelift could be placed on the top on his bald pate and grow to approximate the quality of his original hair. And wouldn't it be comforting to the female patient who has had an eyebrow transplant to know that the hair growth will slow and that she can eventually stop trimming it.

The greatest significance of the powers of the recipient scalp, however, lies further in the future. When cloning finally arrives, it will probably not follow the model of "Dolly" the sheep, where an unlimited supply of complete follicles are grown outside the body and then transplanted into the scalp. Rather it will likely follow the model that Dr. Jahoda described, where a component of the follicle is multiplied and then used to induce the remainder of the follicle in vivo ("Trans-gender induction of hair follicles." Nature 1999;402:33–4).

In Dr. Jahoda's experiment, cells from the outer root sheath of the hair follicle were shown to induce the growth of a complete hair, and since these cells were fibroblasts, they could theoretically be cultured in a test tube to produce an unlimited supply. In addition, it was shown that these "immunologically privileged" cells could be transferred from one person to another without rejection. The success of these experiments therefore rests largely on the ability of the patient's recipient area to regenerate a cosmetically acceptable follicle from these primitive cells.

In the future, when the dream of cloning becomes a reality, the ability to understand exactly how the recipient area modulates the follicle and how it affects the characteristics of the growing hair will ultimately determine this new technologies success . . . or failure. With this article the authors have taken an important first step toward achieving these goals.

Surgical hair restoration has undergone a surprising number of changes over the past 40 years, but throughout we have been secure in the belief that Dr. Orentreich's dictum would be upheld. Now that donor dominance has yielded to the forces of the recipient site, what other immutable laws will be the next to fall?

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