Objective: To evaluate and compare past and present hair replacement techniques of standard grafts, minigrafts, micrografts, scalp reduction, scalp flaps, strip harvesting, and punch harvesting procedures with regard to aesthetic improvement, effectiveness, postoperative pain, and complications.

Design: Three hundred surveys were mailed randomly to patients who had undergone hair replacement over the last 3 decades. The questionnaire asked patients to rate the level of postoperative results and complications in several comparison groups with regard to the following factors: itching, pain, swelling, scarring, bleeding, altered sensation, poor growth, color and texture, infection, hairline, and natural appearance. Each factor was rated by the patients on a scale of 0 to 3 (0, none [best]; 1, minimal; 2, moderate; and 3, worst [severe]).

Setting: Private facial plastic surgery practice.

Methods: A hypothesis about each set of survey questions was formed based on general trends in patient responses, also known as the null hypothesis; \( \chi^2 \) tests were conducted for each of the survey questions to determine the statistical trend with a certain level of confidence. The weighted arithmetic mean of the expected response was used for the varying number of patients responding to each question. Using the \( \chi^2 \) test, the formulated hypotheses can be accepted or rejected based on the observed and expected responses.

Results: Between 1981-1990 and 1991-1996, there was a reduction of 38 percentage points in the number of standard graft procedures performed, an increase of 31 percentage points in the number of minigraft procedures, and an increase of 48 percentage points in the number of micrograft procedures. The complication rate was 31% lower for minigraft procedures compared with standard graft procedures and 29% lower for micrograft procedures compared with minigraft procedures. The complication rate was 59% lower for strip harvesting procedures compared with punch harvesting procedures.

Conclusions: Newer hair replacement techniques have improved aesthetic results, with lower morbidity and complication rates. These improvements are responsible for the increase in the level of satisfaction of patients undergoing hair replacement surgery today.

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The origins of hair transplantation can be traced to as early as 1804 to 1822, when Baromio demonstrated the possibility of successful transplantation of hair-bearing transplants in animals. Since the 1930s, major contributions to hair transplantation techniques in humans have been reported by Sasagawa, Okuda, and Orentreich and Orentreich. In the past 10 to 15 years, newer techniques of hair replacement have revolutionized the field of hair replacement surgery. Innovative techniques have improved not only the aesthetic results but many facets of the entire hair replacement process. Minigrafts and micrografts, which produce an improved and more natural result, are now more frequently performed than standard grafts. The use of linear punches and laser technology has replaced the use of round punches to minimize complications, increase efficiency, and maximize the aesthetic result. Laser hair transplantation was initially viewed as more of an advertising gimmick than an area of facial plastic medicine with potential benefits for patients. Strip harvesting procedures that improve the aesthetic result of the donor site and maximize the use of available donor hair are now used more often than punch harvesting procedures. Scalp reduction and scalp flap procedures continue to evolve and provide physicians with a wider range of surgical options.

Because laser hair transplantation is a new technique, it is subject to a learn-
METHODS

Three hundred surveys were mailed randomly to patients who had undergone hair replacement surgery over the last 3 decades. The questionnaire asked former patients to rate aesthetic factors and the level of postoperative complications they experienced during different periods according to the type of surgical technique that was used for their hair replacement procedures. The aesthetic factors and complications compared in our study were categorized as follows: itching, pain, swelling, scarring, bleeding, altered sensation, poor growth, color and texture, infection, hairline, and natural appearance. Each complication was rated by patients on a scale of 0 to 3: 0, none [best]; 1, minimal; 2, moderate; and 3, worst [severe]). The mean was calculated for each factor by the corresponding period and type of hair replacement surgery. Hair replacement procedures were compared for 3 different periods (before 1980, 1981-1990, and 1991-1996). Rates of complications were compared for standard grafts procedures vs minigrafts and micrografts. Complication rates for strip and punch harvesting, scalp reductions, and scalp flap procedures were also compared for these periods. A χ² test was conducted for each of the survey questions to determine if the trend and response were statistically significant. In this report, the χ² test compared a patient’s actual response for each factor (the observed response) with the expected response. Because of the varying number of patients responding to each question, it was necessary to calculate a weighted arithmetic mean for the expected response for each factor. A hypothesis was also formulated for each survey question based on the general trend in patient responses; this is called the null hypothesis. We accepted the null hypothesis as true or rejected it as false by comparing the χ² results for each factor (χ²) with a corresponding critical figure in the χ² distribution table, commonly referred to as the critical X value. We used P≤.05 for all hypotheses when comparing the χ² value (χ²) with its critical X value to determine if we accepted or rejected the null hypothesis as true.

RESULTS

Of the 300 surveys mailed, 66 were returned, a 22% response rate. A total of 399 procedures were performed among the 66 respondents during the 3 periods surveyed. The age of the survey respondents ranged from 23 to 72 years, with a mean age of 43.7 years.

There was a change in the number of procedures performed in the last 2 decades. Between 1981 and 1990, 70% of the patients responding to our survey underwent standard hair graft procedures and 52% had micrografts; none had micrografts performed during this time. Between 1991 and 1996, 32% (a decrease of 38 percentage points) underwent standard graft procedures, 83% (an increase of 31 percentage points) had minigrafts, and 48% (an increase of 48 percentage points) had micrografts. Between 1981 and 1990, 30% of patients had scalp reductions and 13% had scalp flap procedures. Between 1991 and 1996, 35% (an increase of 5 percentage points) had scalp reductions and 12% (a decrease of 1 percentage point) had scalp flap procedures (Figure 1).

Before 1980, patients who responded to our survey underwent a mean of 3.30 hair replacement procedures. Between 1981 and 1990, these patients underwent a mean of 2.85 procedures, and between 1991 and 1996, a mean of 2.14 procedures. The results of our comparison of hair transplantation procedures for the 3 periods appear in the Table, including the mean response for each factor in the patient survey, calculated expected response, χ² value, and critical X value. Figure 2 and Figure 3 illustrate the mean response for each factor and the overall response.
SURVEY QUESTION 1

Null Hypothesis

Patients who underwent hair replacement surgery over the course of the 3 periods experienced the same level of postoperative complications and aesthetic results. This may indicate that there was no discernible difference between the older and newer techniques used during the 3 periods.

Analysis of Null Hypothesis Test

Based on the $ \chi^2 $ values in the Table, we rejected the null hypothesis for 10 (83%) of the 12 factors assessed and accepted it as true for 2 factors (17%). This rejection of the null hypothesis for the majority of the factors indicates a statistically significant level of postoperative complications.

The rate of reported complications was 48% lower between 1981 and 1990 (mean response, 1.2) compared with before 1980 (mean response, 2.3) and 38% lower between 1991 and 1996 (mean response, 0.8) compared with between 1981 and 1990 (mean response, 1.2).

Thus, the rate of reported postoperative complications was lowest in the most recent period.

Figure 4 and Figure 5 illustrate the mean responses for complications and aesthetic results by type of procedure. For all factors, the mean was better for micrografts than for minigrafts and better for minigrafts than for standard grafts.

SURVEY QUESTION 2

Null Hypothesis

Patients who chose hair transplantation as their hair replacement surgery procedure generally experienced a level of postoperative complications and aesthetic results at or less than the 1− minimal rating for each factor.

Analysis of Null Hypothesis

Based on the $ \chi^2 $ values, we accepted the null hypothesis as true for 11 (92%) of the 12 factors assessed and only rejected it once (8%). This demonstrates that, for
most of the factors assessed, postoperative complications and aesthetic results were at or less than the 1−minimal rating.

Although in general the patients’ ratings were low, there was a noticeable difference by type of procedure. More patients reported hairline improvement with mini-grafts compared with standard grafts (mean response, 0.5 vs 1.4) and with micrografts compared with minigrafts (0.3 vs 0.5). The reported complication rate was 31% lower for minigrafts compared with standard grafts and 29% lower for micrografts compared with minigrafts. **Figure 6** shows preoperative and postoperative photographs of the frontal hairline of a patient who underwent a combination of minigraft and micrograft procedures.

**Figure 7** and **Figure 8** illustrate the mean and overall responses for complications and aesthetic results for punch harvesting vs strip harvesting.

**SURVEY QUESTION 3**

**Null Hypothesis**

Patients who underwent hair transplantation using the back of the head as the donor site experienced the same level of postoperative complications and aesthetic results whether they underwent punch harvesting (an older technique) or strip harvesting (a newer technique). Therefore, the newer techniques may be viewed as having no advantages over the older techniques.

**Analysis of Null Hypothesis**

Based on the $\chi^2$ values, we rejected the null hypothesis for 8 (73%) of the 11 factors assessed and accepted it as true for 3 factors (27%). Overall, we rejected the null hypothesis and determined that there was a difference in the level of postoperative complications between the 2 techniques. This difference is reflected by the lower means for those patients who underwent strip harvesting vs punch harvesting. Patients reported lower rates of scarring (mean response, 2.2 vs 0.9), itching (mean response, 1.6 vs 0.9), pain (mean response, 1.9 vs 1.1), bleeding (mean response, 1.9 vs 0.6), swelling (mean response, 1.5 vs 0.6), and overall complications (mean response, 1.5 vs 0.6) for strip harvesting compared with punch harvesting. **Figure 9** shows the postoperative scars and cobblestoning or checkerboard appearance of the donor site of a patient who underwent a punch harvesting procedure.

**Figure 10** illustrates the mean and overall responses for complications from scalp reduction (hairline advancements or scalp lifts) for patients who underwent scalp reduction procedures between 1981 and 1990 and between 1991 and 1999.
SURVEY QUESTION 4

Null Hypothesis

Patients who underwent scalp reduction procedures between 1991 and 1996 experienced the same level of postoperative complications and aesthetic results as patients who underwent the same procedures between 1981 and 1990.

Analysis of Null Hypothesis

Based on the $\chi^2$ values, we accepted the null hypothesis as true for 9 (75%) of the 12 factors assessed and rejected it for 3 factors (25%). This indicates that except for a few factors, there was no significant difference reported between the 2 periods in the level of postoperative complications. Even though the overall rate of complications reported for scalp reduction procedures was lower (mean response, 0.9 vs 0.8) during the most recent period, there was no statistically significant difference. Figure 11 illustrates the mean overall responses for complications from scalp flap procedures for patients who underwent scalp flap procedures between 1981 and 1990 and between 1991 and 1999.

SURVEY QUESTION 5

Null Hypothesis

Patients who underwent scalp flap procedures between 1991 and 1996 experienced the same level of postopera-
Analysis of Null Hypothesis

Based on the $\chi^2$ values, we accepted the null hypothesis as true for 8 (67%) of the 12 factors assessed and rejected it for 4 factors (33%). Although the rate of complications reported for scalp flap procedures was lower (mean response, 1.1 vs 0.9) during the most recent period, there was no statistically significant difference. Figure 12 shows the preoperative and postoperative frontal hairline of a patient who underwent a scalp flap procedure (ie, temporoparietal-occipital flap).

We surveyed men who underwent hair transplantation procedures during 3 decades and compared the subjective responses of patients about levels of complications and aesthetic results for the old and new techniques. Although the participants all came from a single practice, we believe their responses represent those of a broad range of patients seeking hair transplantation.

Patients reported a lower rate of complications and improved aesthetic results for the procedures performed between 1991 and 1996 compared with procedures performed during the previous 2 decades. Although this suggests that the newer procedures are significantly better, the types of procedures that were compared require additional evaluation.

We also compared the level of complications and aesthetic results for micrografts compared with minigrafts and standard grafts. Patients reported a lower rate of complications and improved aesthetic results for micrografts compared with minigrafts and for minigrafts compared with standard grafts. More patients reported improvement in the hairline and natural appearance with micrografts compared with minigrafts and for minigrafts compared with standard grafts.

Patients reported a significantly lower rate of complications for strip harvesting compared with punch harvesting. For the scalp flap and scalp reduction procedures, there was basically no difference in the results reported for the 3 periods. A more detailed comparison of the different scalp flap and scalp reduction techniques would require additional studies with selected patient populations matched to specific procedures. New techniques and instruments will continue to develop and may modify the techniques used for hair replacement in the future. According to the results of our survey, patients who undergo hair replacement procedures today have an increased level of satisfaction.

Newer hair replacement techniques have evolved and improved with regard to aesthetic results, morbidity, and complications. These improvements are undoubtedly responsible for the increase in satisfaction among patients undergoing hair replacement surgery today.

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