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Using the follicular unit extraction technique in treatment of male androgenetic alopecia

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Abstract

Background The incidence of androgenetic alopecia in males is on the rise annually, with hair transplantation using follicular unit extraction (FUE) gaining increasing acceptance as an appropriate treatment for these individuals.

Methods A retrospective study was undertaken, involving 158 male patients diagnosed with androgenetic alopecia, who underwent treatment between January 2016 and December 2020 at the Medical Cosmetology Department of the First Affiliated Hospital of Xi'an Medical University. Demographic data and treatment characteristics were documented and analyzed. Clinical efficacy, operation-related complications, patient satisfaction rates, and quality of life scores were assessed and analyzed.

Results Following FUE hair transplantation, over 90% of the hair follicles survived in 158 patients, with more than 85% of patients achieving a hair follicle survival rate exceeding 95% at 12 months post-operation. Patient satisfaction rates exceeded 98%, while the complication rate was below 6%.

Conclusion Our findings demonstrate that FUE is a minimally invasive hair transplant technique associated with a high hair follicle survival rate and optimal hair density. This approach proves effective in treating male androgenetic alopecia and merits further clinical application.

Keywords Androgenetic alopecia, Hair follicle unit extraction, Hair transplantation, Hair follicle, Hair density

Introduction

Androgenetic alopecia (AGA), also known as sebaceous alopecia and premature alopecia, is a form of alopecia characterized by progressive and minimal hair follicles.It belongs to non-cicatricial alopecia and can occur in both men and women, representing one of the most prevalent clinical forms of alopecia [1]. Typically initiating at puberty, AGA's prevalence escalates with age [2]. Clinically, it presents as progressive thinning of hair diameter, reduction in hair density, and eventual balding to varying extents, often accompanied by heightened sebum secretion on the scalp [3]. Studies indicate that AGA affects up to 80% of genetically predisposed males [4]. In China, the incidence of androgenetic alopecia stands relatively high, at about 21.3% [5]. Although AGA does not impact

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physical health, its implications on mental well-being and quality of life for affected individuals are profound.

Medical interventions for male AGA comprise topical application of minoxidil 5% once or twice daily, and oral administration of type II 5-α-reductase inhibitor finasteride (1 mg/day) for a minimum duration of six months [6]. Advances continue in hair restoration technique ranging from surgical approach to instrumentation and ways to enhance growth. According to Rose PT, since Dr. Norman Orentreich found that hair follicles taken from an area of nonbalding scalp could be implanted into an area of male pattern hair loss and continue to grow terminal hair, surgeons began to create undetectable results in cases of androgenetic alopecia and well as other conditions associated with hair loss used hair transplants [7]. Surgical approaches, particularly hair transplantation methods like Follicular Unit Extraction (FUE), have gained increasing acceptance among male AGA patients [8]. The pioneering work in FUE was actually conducted by Dr. Ray Woods from Australia, who has been recognized for his innovative techniques since 1989. FUE represents a surgical technique involving the drilling, extraction, and collection of hair follicle units via a small-diameter perforator, currently standing as one of the most widely employed methods for hair transplantation [9, 10].

For over two decades, our department has been conducting autogenous FUE hair transplantation procedures. This study entails a comprehensive review and analysis of pertinent clinical data from male AGA patients who underwent FUE surgery at the medical cosmetology department of the First Affiliated Hospital of Xi'an Medical University between January 2016 and December 2020. Through this analysis, we aim to discuss and evaluate the clinical application of FUE in the management of male AGA.

Table 1 Patient characteristics and demographics

Characteristic /Variable	Value
Number	158
Age(year)	
range	19–68
mean	44.8
Duration(year)	
range	0.5–42
mean	19.2
Positive family history (%)	74.6
Brainworker (%)	80.4
Alopecia Level	II-V
Alopecia area(cm^2)	
range	14–168
mean	112
Initial hair density (FU/cm^2)	
range	0–40
mean	23.2

Methods

Research object

Participants selection

This study received approval from the Ethics Committee of the First Affiliated Hospital of Xi'an Medical University(No: XYYFY2021LSK-034), and all participants provided written informed consent before enrollment in the study. Funding for this study was provided by the Natural Science Basic Research Program of Shaanxi Province in 2021 (2021JQ-784), the Shaanxi Science and Technology Program of Xi'an City in Shaanxi Province (21YXYJ0129), Natural Science Basic Research Program of Shaanxi Province (2022JM-528), and the 2021 University-level Scientific Research Innovation Team of the Medical College (2021TD14).

A total of 158 male patients with androgenetic alopecia (AGA) were enrolled in this study. These patients were diagnosed and treated between January 2016 and December 2020 in the Medical Cosmetology Department of the First Affiliated Hospital of Xi'an Medical University. Patient characteristics and demographics, including age, duration of alopecia, family history, occupation (brainworker or non-brainworker), Hamilton-Norwood grading of alopecia, alopecia area, and initial hair density, were recorded and analyzed (Table 1).

Inclusion criteria

Individuals meeting the following criteria were eligible for inclusion, based on standard guidelines [11]: (1) Male patients with AGA, (2) Patients classified as Hamilton-Norwood grades II-V, (3) Patients with no or minimal response to medical treatments for at least 6 months, (4) Absence of scalp infection or other hair-related disorders.

Exclusion criteria

Patients meeting any of the following criteria were excluded [12]: (1) Hamilton-Norwood grade I or grade VI and above, (2) Presence of scar constitution, scalp infection, ulceration, or other dermatological conditions, (3) Systemic illnesses such as cardiovascular, hepatic, pulmonary, or renal diseases, (4) Endocrine or psychiatric disorders.

Methods

Operative design

Operative plans were tailored to individual patients based on scalp hair follicle examination results and aesthetic considerations. The location and extent of the donor area were determined based on hair density and follicle quality [13]. The emphasis was placed on the hairline as a critical component of facial aesthetics, with consideration given

to gender-specific hairline characteristics. Designs aimed to preserve an aesthetic hairline shape while maximizing follicle utilization, adhering to the principle of positioning the hairline as close to the natural position as possible, avoiding a low forehead [14]. Before a hair transplant surgery, we use the following methods to assess initial follicular density and calculate the number of follicles needed:

1) Measurement of the Area with Hair Loss: First, we take photos of the patient from multiple angles, including a full-face front view, a head-down view, and close-ups of both the recipient and donor areas. We then design the transplantation area based on the patient's specific situation and outline the transplant recipient area with a marker. Next, we cover the patient's head with a plastic film that has counting grids, trace the outlined recipient area on the film, and calculate the area of hair loss using the grids on the film.
2) Measurement of Follicular Density: Within the area of hair loss, we select five different representative locations (e.g., the hairline, both sides of the forehead, the top of the head, etc.) and mark out a 1 square centimeter area at each location with a marker. Using a dermatoscope, we count the number of follicles in each marked area and record the follicular density per unit area, while also taking photos to preserve the data.
3) Estimation of the Number of Follicles Needed for Transplantation: Based on the area of hair loss and the initial follicular density, combined with the expected outcome after transplantation (50–60 follicular units per square centimeter), we can estimate the number of follicles needed to be extracted from the donor area.

Preoperative preparation

Prior to surgery, preoperative laboratory tests were conducted, including complete blood count, coagulation profile, blood glucose, and screening for infectious diseases (hepatitis B, hepatitis C, syphilis, and HIV). Patients were instructed to discontinue vitamins, aspirin, hormones, and other medications two weeks before surgery, and cessation of hair growth agents was advised. Smoking and alcohol consumption were prohibited [12]. Hair in the donor and recipient areas was trimmed to a length of 1.0–2.0 mm using clippers to facilitate follicular unit (FU) extraction and preparation of follicular unit grafts (FUG). Thirty minutes before surgery, patients received an intramuscular injection of 1 unit of haemocoagulase (manufactured in China), followed by another 1 unit via intravenous injection at the beginning of the operation.

Procedure

Follicle extraction

Occipital follicular units (FU) were extracted with the patient in the prone position, while temporal FU extraction was conducted with the patient in the lateral position. A tumescent solution comprising 250 ml normal saline, 15 ml 2% lidocaine, and 1.5 ml 0.1% epinephrine was utilized. Local anesthesia was achieved with a solution consisting of 30 ml tumescent solution, 25 ml 2% lidocaine, and 0.5 ml 0.1% epinephrine. Following conventional skin preparation and draping, the donor area received a ring nerve block anesthesia, followed by the application of local anesthesia solution and tumescent solution to optimize space and minimize follicular damage during extraction [15]. A motorized follicular unit extraction (FUE) device (LeadM-FUEPK-7000, Korea) equipped with either a 0.8–1 mm sharp punch was employed. In accordance with the Alt and Cole's study, success in follicular unit extraction requires an understanding of hair, device, operating physician and individual patient variation [16, 17]. Careful attention was paid to the angle, depth, and density during extraction, ensuring alignment with the natural hair growth direction. Extraction depth typically ranged between 2.5 and 3.0 mm, with extraction density dispersed evenly across the designated area to preserve postoperative aesthetic integrity. Extracted FUs were promptly stored in normal saline at 4 °C to facilitate subsequent separation, processing, and transplantation, promoting enhanced graft survival. Following FU extraction, the donor area underwent sterilization and compression.

FUG preparation

FUG preparation, a pivotal and meticulous phase of the surgery, involved the microscopic removal of skin and adipose tissue surrounding extracted FUs to create grafts containing single or double hair follicles. Ensuring a moist environment for both extracted FUs and operating tools was paramount throughout to prevent follicle damage.

FUG graft

For FUG grafting, patients were positioned supine, with the recipient area undergoing local infiltration and swelling anesthesia using pre-configured anesthetic solutions. FUG insertion was followed by the creation of implantation holes, typically utilizing a 1.0 mm gem knife for single follicle grafts and a 1.2 mm gem knife for double follicle grafts. Drilling depth ranged between 3 and 5 mm, with FUG placement aligning with the natural growth direction and angle of the original hair. Graft density, typically ranging from 30 to 60 FUs per square centimeter, was determined and allocated based on preoperative design. Post-grafting, gentle saline rinsing removed

blood clots from the recipient area, and a sterile cap was applied without bandaging.

Postoperative care

Following successful FUE transplantation, meticulous postoperative care was essential to optimize FUG survival rates. Immediate attention focused on preventing compression and collision in the recipient area. Measures to prevent or reduce edema included oral prednisone or spironolactone administration for 2–3 days and sleeping in a semi-upright position. Prophylactic antibiotic use, such as cefradine for 3–5 days, was recommended. Removal of the sterile cap and dressing occurred after 3 days, with hair washing advised after 6 days and the option for a haircut available after 20 days.

Evaluation

Clinical efficacy

Assessment of hair growth occurred at 1 month, 3 months, 6 months, and 1–2 years post-treatment, with efficacy evaluated through photography. Clinical efficacy was determined by calculating the hair follicle survival rate and measuring recipient area hair density. The methodology is as follows: We take photos of the patient from multiple angles using the same photographic requirements as before the surgery. We compare the pre- and post-surgery photos, select five different locations within the transplant area to assess follicular density, and use the same method as before. Calculation of Follicular Survival Rate: Using the formula (Number of follicles after transplantation − Number of follicles before transplantation) / (Number of follicles transplanted during surgery)×100%, we can calculate the follicular survival rate. It should be noted that the data obtained may be subject to subjective errors during the counting process and should be viewed as an estimate.

Four efficacy levels were defined: very good (>90% survival rate), good (70-90% survival rate), general (50-70% survival rate), and poor (<50% survival rate).

Complications

Previously reported complications were observed and recorded, including general complications [18] (e.g., adverse reactions to anesthesia, intraoperative bleeding), donor area complications, and recipient area complications.

Satisfaction rate

A self-designed satisfaction rate questionnaire categorized satisfaction into four levels based on percentages: very satisfied (91–100%), satisfied (71–90%), dissatisfied (51–70%), and invalid (less than 50%). The total satisfaction rate was calculated as the sum of very satisfied and satisfied rates.

Quality of life score

Quality of life was assessed using the GQOLI-74 scale, measuring physical, psychological, social, and material well-being. Scores ranged from 0 to 100, with higher scores indicating improved quality of life.

Statistical analysis

Statistical analysis was conducted using SPSS 22.0 software. Measurement data were expressed as mean ± standard deviation, with the t-test used for comparison. Enumeration data were presented as percentages, with statistical significance set at $p<0.05$.

Results

Patient demographic

Tables 1 and 2 present the general characteristics of 158 male patients with Androgenetic Alopecia (AGA), aged between 19 and 68 years, with a mean age of (44.8 ± 9.1) years. The duration of illness ranged from 0.5 to 42 years, with a mean duration of (19.2 ± 5.8) years. A positive family history of AGA was noted in 74.6% of patients. Additionally, 80.4% of patients were engaged in occupations requiring cognitive tasks. Most patients exhibited alopecia classified at levels III and IV.

Clinical efficacy

Table 3; Figs. 1 and 2 illustrate the clinical outcomes of follow-up assessments. Among the 158 male AGA patients undergoing Follicular Unit Extraction (FUE) hair transplantation, satisfactory outcomes were observed in the recipient area, with natural growth of transplanted hair. Follow-up examinations revealed a hair follicle survival rate exceeding 90% at 1–2 years

Table 2 Patient Preoperative Assessment

Characteristic /Variable	n	Alopecia area(cm^2)		Hair density (FU/cm^2)		Graft amount (FU)
		range	mean	range	mean	
II	15	10–38	28.8	0–3	1	500–1000
III	63	20–124	101.5	0–18	3	1000–1800
IV	67	30–139	128.7	0–14	6	1500–3300
V	13	100–158	149.2	0–4	2	1500–4000
Total	158					

Table 3 Patient clinical efficacy

Characteristic /Variable	Value
Survival rate (%)	
range	89–95
mean	91
hair density(FU/cm^2)	
range	25–40
mean	35.2
Graft amount (FU)	
range	500–4000
mean	1902.3
Operation time(hours)	
range	4–10
mean	6.3
Transection rate (%)	1

post-transplantation. Initial treatment involved autologous hair transplantation in 151 patients, while 7 patients required secondary intervention due to insufficient hair density in the recipient area. The average density of surviving hair was (35.2±4.3) roots/cm2, ranging from 25 to 40 roots/cm2.

Table 4 Patient complications of FUE hair transplant surgery

Categories	Occurred complication	Proportion (%)
General complications	None	0(0)
Donor area complications	Pinpoint scaring	2/158(1.3)
	Buried grafts	1/158(0.6)
Recipient area complications	Folliculitis	2/158(1.3)
	Swelling /Edema	4/158(2.5)
Total		5.7

Complications

As depicted in Table 4, none of the 158 patients experienced systemic complications. However, donor site complications were observed in three cases. Specifically, two individuals developed pinpoint scarring, which, while not visible to the naked eye, may become apparent with close inspection under conditions of short hair growth. This scarring was attributed to the transplantation technique, where the hair follicles were not properly aligned during the punch procedure, resulting in the grafts being inadvertently buried within the dermis. The resolution entailed the use of a needle to extricate the buried grafts. Additionally, six patients encountered recipient site complications. Among these, two cases of mild folliculitis were reported in the postoperative period at the donor site, which promptly resolved following the topical

Fig. 1 **A**. Preoperative, **B**. Immediately after FUE transplantation, and **C**. 12 months Postoperatively

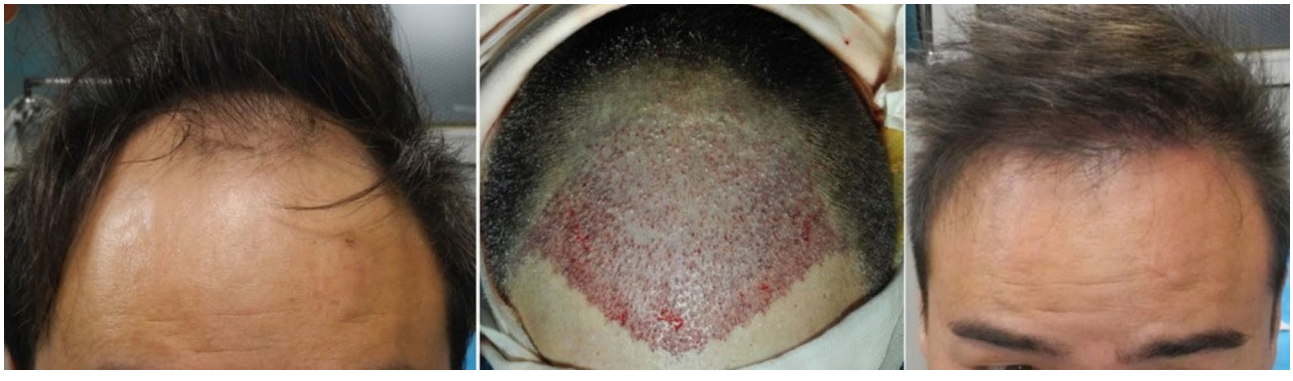

Fig. 2 **A**. Preoperative, **B**. Immediately after FUE transplantation, and **C**. 6 months Postoperatively

Fig. 3 **A**. Preoperative, **B**. Ten months after the first FUE transplant, **C**. 18 months after the second FUE transplant

Table 5 Patient satisfaction of FUE hair transplant surgery

Patient satisfaction	n	Satisfaction rate (%)	Total satisfaction rate (%)
Very satisfied	141	89.2	95.5
Satisfied	10	6.3	
Dissatisfied	7	4.4	
Invalid	0	0	
Total	158		

Table 6 Preoperative and postoperative QOL (quality of Life) Assessment

Characteristic /Variable	Physical dimension	Psychological dimension	Social dimension	Material life dimension
Preoperative scores	76.35 ± 5.42	75.27 ± 5.78	75.95 ± 6.02	73.28 ± 6.19
Postoperative scores	89.64 ± 6.58*	87.98 ± 6.21*	86.88 ± 6.34*	89.47 ± 6.38*

Data presented as mean ± standard deviation, * $P<0.05$ vs. Preoperative scores

application of an antibiotic ointment as prescribed. Furthermore, four patients exhibited transient tissue edema post-surgery, which was self-resolving and required no further intervention. Collectively, these findings indicate that the overall complication rate associated with FUE hair transplantation was below 6%.

Patient satisfaction

Follow-up evaluations revealed a high satisfaction rate among the 158 patients who underwent FUE hair transplantation, with 141 patients expressing high satisfaction and 10 patients reporting satisfaction. Seven patients initially dissatisfied due to extensive hair loss experienced improved satisfaction following secondary procedures (Fig. 3). None of the patients deemed the operation ineffective (Table 5).

Quality of life assessment

Post-transplantation, patients demonstrated significantly improved scores across all dimensions compared to preoperative assessments (Table 6).

Discussion

Androgenetic alopecia (AGA) is a multifaceted condition now recognized as a polygenic recessive genetic disorder with a genetic predisposition. It is undeniable that genetic susceptibility is the main influence on androgenetic alopecia.The interplay of genetic factors, alterations in the hair follicle growth cycle, and the local microenvironment contribute to its pathogenesis [2, 19]. As societal standards for beauty evolve alongside improvements in quality of life, the incidence of AGA rises due to heightened stress, anxiety, unhealthy lifestyle choices such as excessive alcohol consumption, smoking, and irregular sleep patterns [20].

Our clinical observations suggest that chronic stress and unhealthy lifestyle habits do contribute to hair loss. In patients with androgenetic alopecia, increased stress may lead to a more amplified manifestation of androgenetic alopecia regional hair loss. In the study of Liu et al., family history of AGA, cigarette smoking and unhealthy dietary habits were the reported risk factor for early-onset AGA and young men with AGA tend to suffer from psychological issues compared to those without hair loss [21, 22].In our investigation involving 158 individuals, approximately 75% of patients exhibited a positive family history of AGA, with 127 of them being engaged in mentally demanding occupations. Over 80% of these individuals perceived high levels of work-related stress and habitual sleep deprivation, factors significantly associated with the onset or exacerbation of hair loss.

Hair transplantation, a surgical procedure utilizing microscopic technology to extract healthy hair follicle tissue from the patient, meticulously process it, and subsequently transplant it into areas of hair loss, offers

a comprehensive solution to the distress caused by hair loss [23]. Widely adopted as the primary clinical intervention for AGA, current hair transplantation techniques predominantly encompass Follicular Unit Transplantation (FUT) and Follicular Unit Extraction (FUE) surgery [24]. Both FUT and FUE are established methods in hair transplantation, differing primarily in the method of follicle extraction. FUT involves the removal of a strip of scalp, while FUE involves the direct extraction of follicles using a punch tool.

In our clinical practice, we have observed that FUT is well-suited for patients with extensive hair loss, allowing for the extraction of a large number of follicles in a single session. However, it is not without its drawbacks, such as the requirement for a scalp strip harvest, which can result in significant tension and scarring at the donor site. Additionally, patients may be limited in their hairstyle choices post-surgery, and the procedure is associated with greater trauma, potential vascular damage, increased bleeding, and a longer recovery period. The harvest site may also result in discomfort such as pain and tightness, and there is a risk of follicle wastage due to the difficulty in identifying all follicles within the strip.

On the other hand, FUE is noted for its minimally invasive nature, resulting in less trauma to the donor area and a more aesthetically pleasing outcome for patients who value a natural look. The procedure is less painful, has a quicker recovery time, and requires fewer personnel to perform. However, it does entail a longer extraction time and may be less comfortable for patients with certain physical conditions, such as back problems.However, we acknowledge that FUE has its own limitations, such as the longer duration of the extraction process and the need for patients to remain in a supine position, which can be challenging for those with lower back issues.

FUT, characterized by its extensive tissue trauma and propensity for complications, often faces patient resistance [25]. Conversely, FUE surgery, as evidenced by clinical practice and our study findings, exhibits the following attributes [26–28]:1) Minimal donor area sensory impairment, numbness, or scarring, obviating the strip scars typical of traditional FUT procedures. Moreover, the donor area's expansiveness allows for reduced or even elimination of surgical intervals through incremental, partitioned, or multi-stage surgeries. 2) Negligible trauma, minimal bleeding, and exceptionally low infection risk in both donor and recipient areas. 3) Swift recovery, broadened eligibility criteria, and enhanced patient comfort during follicle extraction, facilitated by rapid unit extraction. 4) Enhanced follicle unit preservation, expedited unit separation and preparation, and reduced postoperative unit damage, leading to higher follicle survival rates. 5) Elevated planting density and more natural aesthetic outcomes, coupled with simplified operating room requirements and procedural simplicity achievable with a small medical team.In comparing the two methods, we intended to convey that although FUE may result in a larger overall area of micro-trauma, each individual site experiences less trauma compared to the linear incision made in FUT. The presence of normal tissue between the micro-trauma sites in FUE potentially allows for faster healing and a quicker recovery. Moreover, because FUE does not involve the removal of a strip of skin with follicles as in FUT, patients may find the FUE's trauma more cosmetically acceptable, despite the larger overall area affected.

Our study, with 1–2 year follow-ups, consistently recorded follicle survival rates exceeding 90% among patients, with a notably high efficacy rate. FUE transplantation significantly augmented hair coverage in bald areas, eliciting higher patient satisfaction rates and lower complication incidences. Post-transplant, patients exhibited markedly improved quality of life across all dimensions of AGA assessment.

Transection refers to the damage or severing of hair follicles, which can occur during the extraction process. If the damage affects the dermal papilla region of the follicle, the follicle is typically discarded as it cannot be successfully transplanted. However, if the damage occurs above the dermal papilla, the follicle can still be used for transplantation.To prevent follicle transection in donor regions, hair in degenerative stages should be excluded from harvesting. Favorable postoperative outcomes, such as enhanced follicle survival and growth, are associated with the presence of adequate dermal tissue and subcutaneous fat around the hair follicles, intact sebaceous glands, minimal excess epidermis, and pear or teardrop-shaped follicles [29, 30]. Our institution's decade-long commitment to this approach, marked by seamless collaboration, yielded a mere 1% transection rate in our study. Additionally, Civas et al. discovered that advancements in punch technology, such as serrated and trumpet punches, can enhance follicle extraction and improve graft survival rates. Consequently, the adoption of these innovative punch techniques is recommended for broader application in the field [31].

Conclusion

Follicular Unit Extraction (FUE) hair transplantation demonstrates the potential to enhance the viability of transplanted hair follicles, thereby substantially enhancing patients' quality of life, alleviating negative affective states, mitigating stress, and thus merits consideration for clinical utilization in male androgenetic alopecia cases.

A 48-year-old man experiencing Androgenetic alopecia due to over 15 years of high work pressure and unhealthy living habits. Specialist physical examination showed that

the anterior hairline and both sides of the frontal horn were backward, the hair on the top of the head was obviously sparse, and the oily scalp was visible. The area of hair loss was about 160 square centimeters. The average density of the surviving hair was (60±5) FU/cm2. The patients were very satisfied after 12 months.

A 33-year-old man had been dealing with hair loss for over 9 years, mainly because of stress from work. He presented with receding anterior hairline, sparse hair loss on both sides of the forehead and the top of the head, and exposed oily scalp. Androgenetic alopecia was diagnosed. Specialist physical examination showed that the anterior hairline and frontal horn on both sides receded, and the area of hair loss was about 136 square centimeters. The average density of the surviving hair was (43±3) FU/cm2. The patients were very satisfied after 6 months.

A 43-year-old man had been experiencing for over 7 years as a result of significant work-related stress. He had obvious receding of his forehead and hairline on both sides. Androgenetic alopecia was diagnosed. Specialist physical examination showed that the anterior hairline and bilateral frontal horns were significantly receded, and oily scalp was visible. The area of hair loss was about 162 square centimeters. The first operation was transplanted with about 3800 FU, but the patient was not satisfied with the effect and requested a second operation. In the preoperative assessment for the patient's second hair transplantation procedure, we conducted a thorough examination. These studies clearly revealed that the majority of the hair at the patient's frontal hairline and temporal regions were the surviving follicles from the first transplantation, indicating a high survival rate from the initial surgery. However, it was also evident that hair loss was significant in the non-transplanted areas of the scalp.The patient reported experiencing significant life events and substantial changes in their work environment after the first transplantation. We believe that these factors may have contributed to the variability in the overall aesthetic outcome following the first procedure. It is well-documented that stress and environmental changes can have an impact on hair growth and the health of the scalp.The second operation was performed after one year with about 2900 FU. The average density of the survived hair was about (62±4) FU/cm2 at the follow-up of one and a half years. Upon the second surgery, with the patient's improved mental state and more stable environmental conditions, we were able to achieve a markedly better outcome. The patient has expressed a high level of satisfaction with the results of the second procedure.

Author contributions

Fang Wang contributed to literature searching, designing, and writing the manuscript. Fang Wang, Ying Chen, Huibin Lei, Huifeng Zhang, Jie He, Meng Li and Ting Lei contributed to surgical procedures and data collection. Fang Wang and Ying Chen contributed to substantial contributions to conception, design, and interpretation of data. Wei Zhang contributed to editing, revising, and final approval of the manuscript. Wei Zhang, Fang Wang, Chao Li, Chen Yang and Bei Liu contributed to the revision of the article.

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Data availability

The data are available under request.Those who would like to know the further details about the raw data analyzed in our study can contact us with wangfang1956@163.com or doctorzhw@163.com.

Declarations

Ethics approval and consent to participate

The Ethics Committees of the First Affiliated Hospital of Xi'an Medical University approved this study. Patients provided informed consent.

Consent for publication

Not applicable.

Competing interests

The authors declare no competing interests.

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