Chapter

Surgical Management of Scarring Alopecia

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Abstract

Cicatricial alopecia presents a heterogeneous group of disorders, which are characterized by the destruction of hair follicles, and resulting in scarring and irreversible hair loss. Cicatricial alopecia is classified into two categories depending on the target pathological process. In primary cicatricial alopecia (PCA), the hair follicle is the sole target of a progressive inflammatory process in various skin or systemic diseases. In secondary cicatricial alopecia (SCA), non-specific and generalized disruption of the skin and skin appendages results in fibrotic scarring of the skin and permanent loss of hair follicles due to underlying disease or an external agent. The aim of the treatment of PCA is to reduce inflammation and prevent progression to irreversible alopecia by using immunosuppressive and antimicrobial agents at the earliest phase of the disease. When permanent hair loss occurs in PCA and SCA, scar tissue should be removed or camouflaged by surgical treatment. However, it is difficult to remove the existing scar and treat alopecia. Follicular unit extraction technique hair transplantation is a minimally invasive and alternative treatment with a high success and satisfaction rate in the treatment of cicatricial alopecia.

Keywords: cicatricial alopecia, follicular unit extraction, hair follicle unit, hair transplantation, scarring alopecia

1. Introduction

Head and neck, and body have important hair-bearing aesthetic subunits; scalp, eyebrow, eyelash, mustache, beard, axilla, pubis and other body hairs. They are a fundamental component of facial expression, individual's images, religious beliefs, social and psychological health, personality and sexuality [1–3].

Alopecia is a clinical condition characterized by hair loss of hair-bearing aesthetic subunits and is divided into two main categories; scarring (also described as cicatricial) and non-scarring alopecia (**Table 1**) [3–6]. In non-scarring alopecia, the hair follicles remain intact and their regrowth abilities are preserved [3–6]. However, permanent hair loss may occur in the late stages of non-scarring alopecia, called "biphasic alopecia" [7]. Androgenic alopecia is the most common type of non-scarring hair loss that affects nearly half of men. It is characterized by temporal recession and vertex balding in men, diffuse hair thinning and intact frontal hairline in women [4–6, 8].

Alopecia					
Scarring alopecia					**Non-scarring alopecia**
Primary cicatricial alopecia [North American Hair Research Society (NAHRS) classification]				Secondary cicatricial alopecia	
Lymphocytic	Neutrophilic	Mixed	Non-specific		
1. Lichen plano pilaris (LLP) and variants; • Classic lichen planopilaris (LPP) • Frontal fibrosing alopecia • Graham–Little syndrome 2. Chronic cutaneous lupus erythematosus 3. Pseudopelade of Brocq 4. Central centrifugal cicatricial alopecia 5. Alopecia mucinosa 6. Keratosis follicularis spinulosa decalvan	1. Folliculitis decalvans 2. Dissecting cellulitis	1. Folliculitis acne keloidalis 2. Folliculitis acne necrotica 3. 3- Erosive pustular dermatosis	End stage of scarring	1. Granulomatous; • Sarcoidosis • Necrobiosis lipoidica 2. Inflammatory; • Psoriasis 3. Autoimmune; • Scleroderma • Lichen sclerosus 4. Infections; • Bacterial • Viral • Fungal 5. Neoplastic; • Primary • Metastasis 6. Physical agents; • Trauma • Ionising radiation • Burn • Surgeries 7. Genodermatoses; • Aplasia cutis congenita • Ectodermal dysplasia • Epidermalysis bullosa 8. Connective tissue disease; • Morphea 9. Metabolic; • Amyloidosis • Mucinosis	1. Androgenic alopecia 2. Telogen effluvium 3. Alopecia areata 4. Trichotillomania 5. Traction alopecia 6. Tinea capitis

Table 1.
The classification of alopecia subgroups.

Cicatricial alopecia presents a heterogeneous group of disorders, which are characterized by destruction and fibrous tissue replacing of the hair follicles, resulting in scarring and permanent hair loss. Cicatricial alopecia is classified into two categories depending on the target of the pathological process; primary cicatricial alopecia (PCA) and secondary cicatricial alopecia (SCA) (**Table 1**). In PCA, the hair follicle is the primary and sole target of a progressive inflammatory process in various skin or systemic diseases [4, 6, 7, 9, 10]. In SCA, non-specific and generalized disruption of the skin and skin appendages results in fibrotic scarring of the skin and permanent loss of hair follicles due to underlying disease or an external agent [3, 6, 7, 10, 11]. If scarring alopecia is small, it is not a significant cosmetic problem; however, if it is large, it negatively affects the quality of life, body image, self-image and self-esteem; causes depression, anxiety, psychological burden, social embarrassment, marital and career-related problems [1–3, 7, 11–19].

2. Epidemiology

The cicatricial alopecia constitutes 3.2–7.3% of the hair loss [7, 10, 20]. The majority of cicatricial alopecia is PCA, and lymphocyte-predominant diseases are the most common subgroup of PCA, and female patients are more affected than men [20]. The most common subtypes of lymphocytic pre-dominant PCA are pseudopelade of Brocq, LPP, discoid lupus erythematosus (DLE) [10, 20]. Although it is mostly seen on the scalp, it can involve other facial and body areas [5].

3. Primary cicatricial alopecia

PCA is characterized by increased inflammation around the 'bulge' area of the hair follicle and causes irreversible damage to the epithelial stem cells of the hair follicle. It destroys the remodeling, cycling and regenerative capacity of the hair follicle, and finally causes irreversible hair loss [7, 9, 10].

The NAHRS has classified PCA based on the predominant type of inflammatory cell on hair follicle biopsy; lymphocyte-predominant subgroup, neutrophil-predominant subgroup, mixed subgroup and non-specific subgroup (**Table 1**) [7, 9].

The general characteristics of PCA subgroups are summarized in **Table 2** [4, 6, 7, 9, 10, 21–25].

3.1 Management of primary cicatricial alopecia

Management of PCA is diagnostically and therapeutically challenging due to progression to permanent hair loss. The most important step is informing the patient about the aims of treatment and providing realistic expectations. The successful management of PCA can be achieved with early diagnosis and appropriate treatment to decrease inflammation and progression to scarring alopecia [7, 9]. For this purpose, clinical, histological and laboratory findings should be carefully examined.

3.1.1 Clinical assessment

Patients with PCA may present various distributions of an acute or gradual onset of symptoms. Although some cases are asymptomatic, common symptoms include

	Clinical features	Histopathology	Patient characteristics	Treatment
Lymphocytic cicatricial alopecia				
DLE	Erythematous and scaling plaques, follicular plugging, central hypopigmentation and peripheral hyperpigmentation, telangiectasia and localized on the scalp.	Epidermal atrophy or hyperplasia, early destruction of sebaceous glands, lymphocytic infiltrate at the dermal-epidermal interface, perifollicular scarring.	Middle-aged European woman, systemic lupus erythematosus accompanies in 20% of DLE patients.	Topical and intralesional corticosteroid, hydroxychloroquine, and methotrexate.
LPP	Perifollicular erythematous papules on the vertex and parietal scalp, possible progress to diffuse scarring alopecia, keratotic papules on the trunk and extremities.	Lichenoid band-like perifollicular lymphocytic infiltration, basal vacuolization, Max Joseph spaces along the follicular epithelium.	No age predilection.	Topical, intralesional and oral corticosteroids, hydroxychloroquine, tetracyclines and cyclosporine.
Frontal fibrosing alopecia	Progressive recession of the frontal and temporal hair lines, follicular hyperkeratosis, loss of follicular ostia and eyebrow hair loss about half of the patients.	Lichenoid reaction against miniaturized hair follicles.	Postmenopausal women.	Topical, intralesional and oral corticosteroids, topical minoxidil and oral hydroxychloroquine.
Classic pseudopelade (Brocq)	Rare and slowly progressive cicatricial alopecia, hypopigmentation, atrophic and alopecic plaques resembling “footprints in the snow”.	Perifollicular lymphocytic infiltration, eccentric atrophy of the outer root sheath epithelium, wide fibrous hyalinized tracts, loss of sebaceous glands and follicles.	Middle-aged Caucasian women.	Topical, intralesional and oral corticosteroids, topical minoxidil and oral hydroxychloroquine.
Central centrifugal cicatricial	Tufting, perifollicular hyperpigmentation, progressive scarring alopecia that stars at crown and vertex of scalp and gradually spreads centrifugally.	Premature desquamation of the inner root sheath, perifollicular lymphocytic infiltration and fibroplasia.	Young and middle-aged women of African-American.	Potent topical or intralesional corticosteroids and hydroxychloroquine can be used in the treatment.
Neutrophilic cicatricial alopecia				
Folliculitis decalvans	Multiple hairs emerge from a single follicular orifice, called "tufted hair folliculitis”, erythematous follicular papules or pustules on the crown of scalp. *Staphylococcus aureus* likely triggers the disease.	Follicular plugging, neutrophilic infiltration of the hair follicle, late-stage replacement of hair follicles with fibrous tracts.	Young and middle-aged men.	Tetracycline, doxycycline, erythromycin, and clindamycin; topical or intralesional corticosteroids.

	Clinical features	Histopathology	Patient characteristics	Treatment
Dissecting cellulitis/ folliculitis	Painful and fluctuant nodules, abscesses, sinus tracts with purulent discharge on the occiput or vertex of scalp.	Follicular plugging and neutrophils infiltration at the follicular ostia, extensive abscess formation and dermal fibrosis.	Younger men of African Americans.	Topical, intralesional and oral corticosteroids, isotretinoin, antibiotics.
Folliculitis (acne) keloidalis	Follicular erythematous papules and pustules, hairless keloid-like nodules.	Perifollicular neutrophilic and lymphoplasmacytic infiltration, granulomas or micro-abscess formation around hair-shaft.	African postpubertal males.	Topical and intralesional corticosteroids, oral antibiotics, surgical excision.
Folliculitis (acne) necrotica	Red-brown papules and papulopustules result necrosis and depressed scars.	Fragments of hair shaft, follicular epithelium necrosis.	No age predilection.	Topical and intralesional corticosteroids, oral antibiotics, surgical excision.

Table 2.
The general characteristics of PCA.

itching, pain, burning, irritation and discharge on the affected areas. A complete and careful history should include age, ethnic and family origin, nutrition, psychosocial condition, onset and progression of symptoms, medical disorders including autoimmune and inflammatory diseases, infections, malignancies, trauma, burns, radiation, surgeries and hair care practice (hot combs, excess traction, shampoo, drugs, injections) [5, 7, 9].

Careful physical examination of the affected skin with the aid of a magnifying lens or scalp dermoscopy, also defined as "tricoscopy", in a well-lit environment is essential. PCA is characterized clinically by the lack of visible follicular ostia and the presence of scarring and alopecia. Symptoms of inflammation of the affected area are often indicative of active disease; erythema, scaling, hyperkeratotic plugs, pustules, crusting, scalp bogginess, and different colored dots seen by trichoscopy (**Figure 1**). The epidermal atrophy, irregularly spaced hair shafts, multiple hairs tufts and positive pull test of the anagen hair shaft are other findings of physical examination [5, 7, 9, 26].

During clinical examination, taken digital photography and virtual documentation allows high-speed analysis of prognosis and response to treatment, and facilitates archiving. Additionally, it is like evidence in legal problems.

3.1.2 Laboratory tests

Complete blood count (CBC), serum levels of iron, zinc, folate, vitamin B-12, thyroid-stimulating hormone (TSH) and estrogen should be evaluated. The serum levels of total testosterone, free testosterone and dehydroepiandrosterone sulfate are useful for diagnosis and differential diagnosis of androgenetic alopecia.

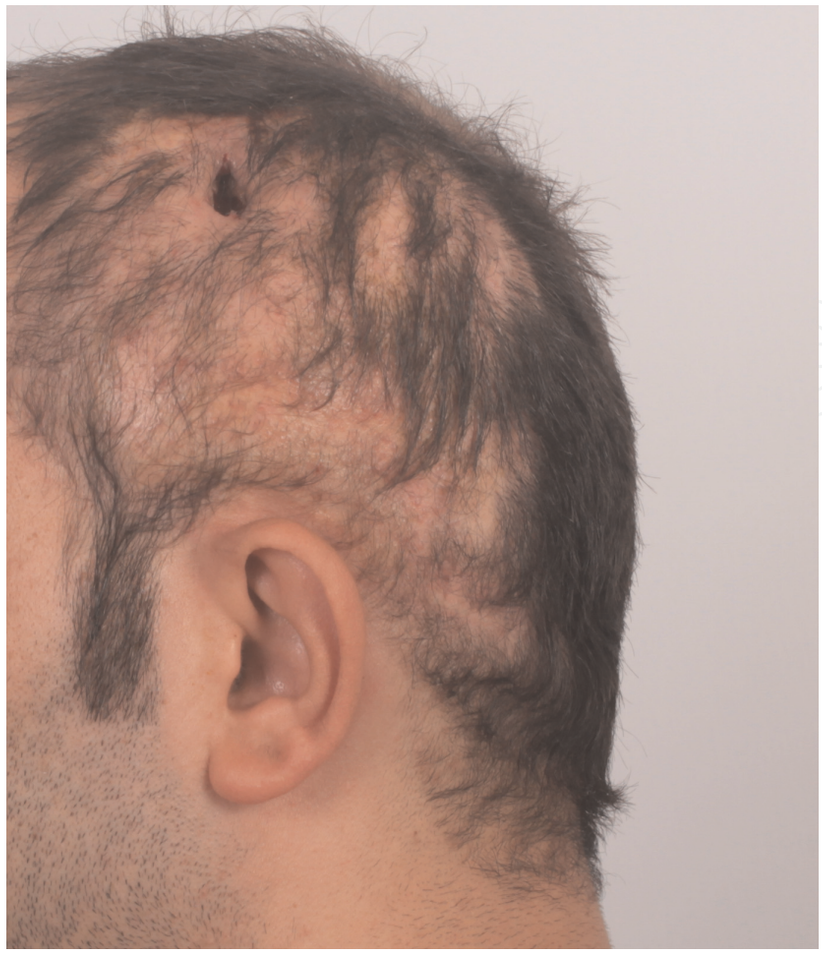

Figure 1.
26-years-old male patient has severe dissecting cellulitis with inflammatory plaques, nodules and discharges purulent material on the scalp.

3.1.3 Histological assessment

A biopsy is always recommended in the assessment of cicatricial alopecia. It can be useful to confirm clinic impression and scarring, identify the underlying pathology and specific type, help guide management and ultimately establishes realistic treatment goals. Samples should be taken using a 4 mm punch biopsy orientated parallel to the angle of the hair shaft growth and deep enough to include the entire HF at the margin of the active disease. Two biopsies are recommended for horizontal and vertical sections. PCA is characterized histopathologically by variable degrees of inflammation of hair follicle epithelium, the replacement of hair follicle structures with scar-like fibrous tissue and hyalinization of surrounding collagen [5–7, 9].

3.2 Treatment

The principal aim of the treatment of PCA is to reduce symptoms and inflammation, slow down and if possible stop the progression of the disease at the earliest phase, and prevent irreversible alopecia [4, 7, 9].

A clear consensus on successful treatments has not yet been achieved in clinical practice. However, immunosuppressants such as potent topical, intralesional and oral

corticosteroids and antimalarials drugs (hydroxychloroquine) are useful for lymphocyte-predominant lesions; antimicrobials (tetracyclines) and dapsone are useful for the neutrophil predominant lesions [4, 7]. Additionally, it is very important to monitor the course and activity of the disease, and response to treatment with regular dermoscopy and clinical examination [26].

Some pharmacological agents such as topical minoxidil and oral finasteride are also used in the treatment. Although controversial and with several side effects including minoxidil-induced telogen effluvium, skin irritation and itching; topical minoxidil can be useful by stimulating vascularity of hair follicles for growth in some patients. Oral finasteride inhibits the enzyme 5-alpha reductase, which is involved in the conversion of testosterone to the more potent dihydrotestosterone, and provides to increase in the ratio of anagen to telogen hairs. However, it can cause erectile dysfunction, decreased libido, impotence and anxiety in men [4, 7, 10, 20].

When severe hair loss occurs, hats, hairpieces and prosthetic wigs may be useful for cosmetic camouflage. The scalp reduction surgeries by primary excisions, local flaps and tissue expansion, and hair transplantation can be used in the surgical treatment of PCA. The stability of PCA is the most important parameter for surgical hair restoration. In the presence of clinically unstable cicatricial alopecia, surgical treatment is not recommended due to the high risk of recurrence of the disease. A 2-year disease-free period is recommended before surgery to minimize the risk of disease recurrence and to increase treatment success [7]. Surgical applications in scarred alopecia are discussed in detail in the section of "secondary cicatricial alopecia".

3.3 Follow-up

PCA can be reactivated after a quiet of one or more years. Thus, close follow-up is needed for the course of the disease, its severity, response to treatment, treatment-related side effects and the patient's psychological and social problems with regular dermatoscopic and clinical examination [26].

4. Seconder cicatricial alopecia

SCA develops due to the result of an underlying process or an external agent. The destruction of the hair follicle is not the primary pathological event, generalized disruption of the skin and skin appendages results in scarring and irreversible hair loss [1, 3, 7, 18, 27].

Potential etiological factors are granulomatous and autoimmune diseases, infections, neoplastic processes and physical agents (physical trauma, ionizing radiation, burn, previous surgeries) (**Table 1**, **Figures 2** and **3**) [1–3, 11, 13–19, 27, 28].

4.1 Management of seconder cicatricial alopecia

The most important step in treatment for SCA is the selection of the right patient and mature scar. The patient's expectations should be investigated, and the patient should be informed about procedures, complications, and follow-up period [16].

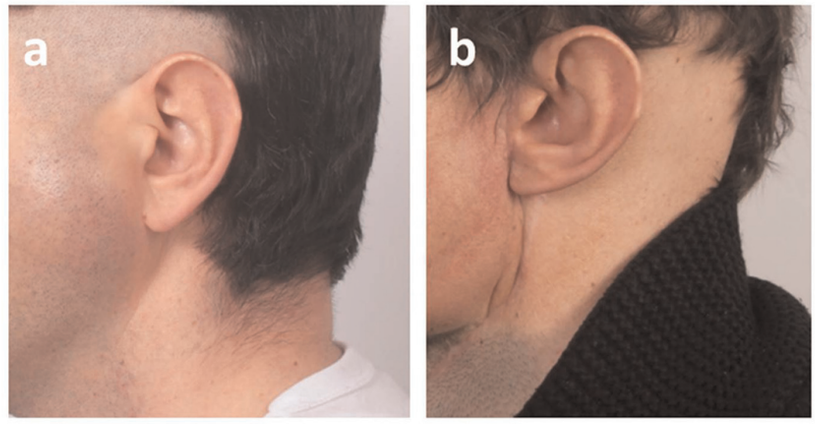

Figure 2.
A 33-years-old male patient presented with malignant head and neck tumor (a). After 1 year of radiotherapy, radiation-induced irreversible scarring alopecia observes on the left face and scalp areas.

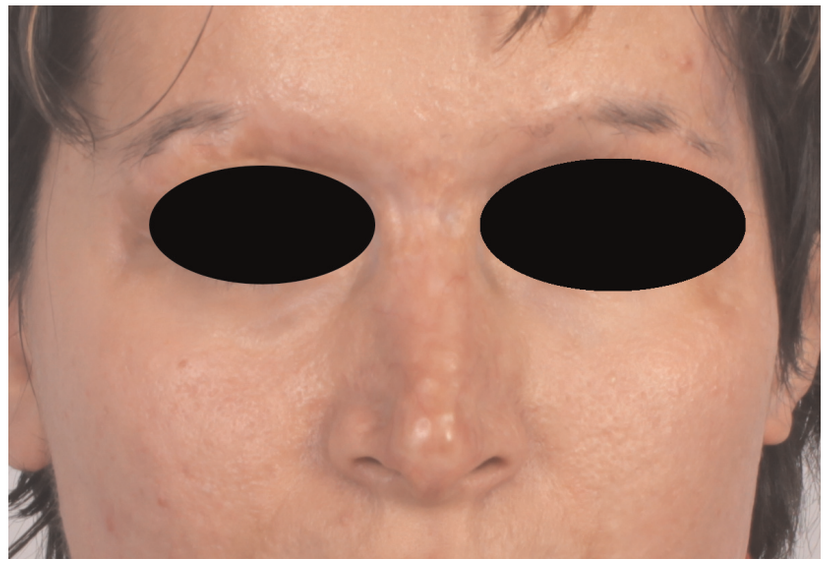

Figure 3.
A 31-years-old female patient presents post-burn scarring alopecia on the bilateral eyebrows.

4.1.1 Clinical and laboratory assessment

The patients should be evaluated for age, sex, etiology, previous medical and surgical treatment, medical conditions with laboratory tests including CBC, blood chemistry panel, coagulation panel, viral serology, localization and dimensions of scarring alopecia, scar characteristics and availability of donor hair for restoration.

Evaluation of scar characteristics is also very important for the management of SCA. The scars should be fully mature that pale, soft, flat, and flexible with sufficient subcutaneous soft tissue and vascular supply [14–16]. If the scar is immature, hypertrophic or excessively atrophic, and located on directly muscle, bone or tendon with not enough subcutaneous tissue, various approaches including preoperative fat grafting, stem cell and laser treatment and combinations could be used to increase the quality, pliability and vascularity of scar tissue [2, 12, 15, 29–32].

4.2 Treatment of seconder cicatricial alopecia

Various medical and surgical procedures have been determined to camouflage and reconstruct scarring alopecia depending on size, location, type of alopecia; laxity, quality, vascular supply of recipient skin and donor hair availability [1–3, 11–14, 16, 28, 29, 33, 34].

4.2.1 Non-surgical camouflage and medical treatment

Prosthetic wigs, tattoo micro-pigmentation, colored spray, dye and make-up can be used for non-surgical camouflage of scalp cicatricle alopecia, but not natural and available for facial scarring alopecia [14, 28, 29, 33].

Some medical management that scar-less ointment, silicone pomade and sheeting, laser treatment, fat injection, *platelet-rich plasma* (PRP) and stem cells can be used for scar treatment and maturity, but alopecia cannot be treated [15, 28–31].

4.2.2 Surgical treatment

Reconstruction of post-burn scarring alopecia is challenging because of permanent hair loss, scar stiffness and poor vascularity, so need to camouflage and removing by surgical procedures [13, 14, 16, 35].

4.2.2.1 Surgical excision

The primary and staged scar excisions are simple methods for correcting small scarring alopecia, but not available for large defects, and scar widening due to secondary tension can be cause relapse [3, 14, 16, 28, 33].

The scar reduction with tissue expansion can be used to avoid relapse and reconstruction of large scarring alopecia. However, increases surgical stage and treatment period, expander-related complications that tissue necrosis, seroma formation, nerve damage and infection; unnatural hair growth direction, facial disfiguring during balloon expansion and a visible scar on expander margins are the main disadvantages [3, 13, 14, 16, 17, 28, 33, 36].

Composite scalp grafts, pedicle and free scalp flap can be used for scarring alopecia, but graft failure in the poor vascular recipient area, increased hair density, unnatural direction of hair, surgery-related scar and complications, microvascular dissection and anastomosis are the main limitations of these techniques [13, 14].

4.2.2.2 Autologous hair transplantation

Otology hair transplantation, that redistributes existing hair follicle units (FUs) to recipient areas, seems to be the most effective technique for scarring alopecia [2, 3, 11–16, 19, 28, 29, 34, 35, 37]. However, poor vascularity and scar stiffness are challenging problem for graft viability [2, 14, 15] and increases post-transplantation complication such as infection, tissue ischemia and necrosis [1, 3, 12, 14–16, 28]. Thus, mechanical and vascular characteristics of scar tissue can be improved by laser, fat injection and stem cell treatments, and combination of them to obtain successful result before hair transplantation [2, 12, 14, 15, 29–32].

Adipose tissue has a volume-increasing effect and includes adipose-derived stem cells (ADSCs) that have a primary role in the regenerative purposes of skin and

subcutaneous tissue by increasing angiogenesis and new collagen deposition [15, 18, 29, 31]. Using autologous fat grafts increase pliability, vascularity and maturity of scar tissues, and fills the loss of volume in depressed scars [2, 12, 14–16, 29–31]. In addition, fat grafts can be prepared rich in stem cells and combined with laser, PRP and other treatments [15, 18, 30].

The FUs can be harvested in ellipse tissue strips from donor areas that follicular unit transplantation (FUT) technique or individually FU with micro-punch that FUE technique. FUT technique has some disadvantages. It causes a permanent scars in donor areas, it is not usefull for patients with tight scalp tissue and other body parts (beard, chest, axilla, pubis), it is not available to harvest only single-hair FUs, and it needs more assistance for procedures [3, 14, 16, 19, 35, 37, 38].

FUE is a strategy for graft harvest with different kind's punches with quick healing donor areas without a linear and conspicuous scar [12, 14–16, 29, 34, 35, 37, 38]. It is first-choice method for hair transplants due to the ability to individually choosing of desirable FUs, with minimal spot scarring and no suturing [11, 14, 16, 34].

4.2.2.2.1 Technique detail of FUE hair transplantation

Care should be taken to plan implantation with the correct direction and shaping of hair graft to achieve a good cosmetic result. FUE hair transplantation can be performed under local anesthesia with or without sedation. The number of implantation channels and density of FUs (grafts/cm^2) for scar camouflage should be determined by the environment unaffected hair-bearing area or opposite healthy face before surgery.

a) Selection of donor side

Post-auricular and occipital scalp are the most common donor areas for hair transplantations, due to genetically stable and most resistant to hormone-related alopecia [16, 28]. Hair follicles in the scalp grow in groups of one to four hairs, so it is important to choose single-haired follicles for restoration of scarring alopecia on the eyebrows, eyelashes, mustache, beard and hairline of the scalp (**Figure 4**) [35]. Two to more hair-FUs grafts may be used toward the center of the mustache and beard alopecia to improve density but can result in unnatural aesthetic appearances,

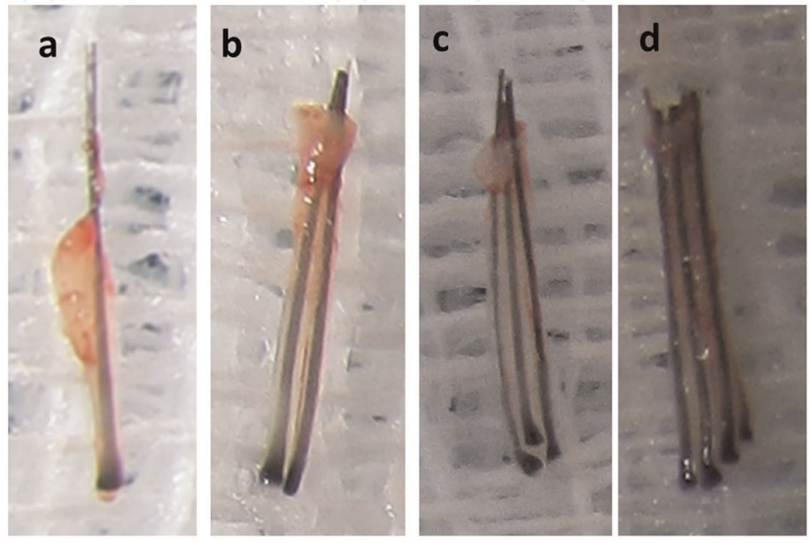

Figure 4.
The image shows 1, 2, 3 and 4-hair follicular units on the right to left (a, b, c, d). While each follicular unit has a single hair in hair-bearing aesthetic subunits of the face, it has one to four hairs on the scalp.

especially with a short beard and mustache [16]. Additionally, single-hair FUs have a small size with low metabolic requirements [13, 19], thus, it is also a good option for graft viability in scarring alopecia.

The submandibular beards are the best donor areas with the natural caliber and density for mustache, beard and side-burn scarring alopecia, which have similar hair characteristics. The availability of submandibular beard hair is sometimes a limiting factor, but FUE offers the advantage of harvesting different body hair such as the occipital and post-auricular scalp, suprapubic and other body [2, 14, 16, 37]. However, heterotopic hair transplantation can cause different regrowth duration and physiological cycle, color change by aging, and different calibration and density due to different anatomic and physiological characteristics [14, 28].

b) Anesthesia and harvesting hair follicles

The donor's hairs are cut to 2–3 mm lengths before procedures. With the patient in the supine position, on the operating table, donor and recipient sites are anesthetized by infraorbital, supraorbital, supratrochlear, mental, cervical, post-auricular or occipital nerve block. Then donor area infiltration anesthesia is performed by the tumescent solution that a mixture of 0.9% saline, 2% lidocaine, and 1:1000 epinephrine. Tumescent with low concentration or without epinephrine is injected in the recipient area, to avoid decreased subdermal blood supply due to vasoconstriction [14, 15, 19, 28, 34].

The FUs are harvested from the donor area individually by using handled or low rotational speed electronic micro-motor powered 4–5 mm-length and 0.6–1.2 mm-diameter circular micro-punch to avoid transection of follicles. Single-hair FUs are selected from the occipital and post-auricular scalp for restoration of scalp hairline and facial hair. The micro forceps are used to apply gentle pressure on the skin around the FUs graft, elevating it lightly to allow the top part of the graft to be grasped. The extracted FUs are handled gently and kept moist in sterile petri-dish with 0.9% saline or special solutions at 4°C until transplantation [14–16, 28, 34].

c) Implanting hair follicles

Single channels are opened for each graft and FUs are synchronously implanted into the pre-made channel by using micro forceps. Channeling in fibrotic scar area is performed by using 0.75–1.2 mm width and 4–5 mm length classic micro blade or sapphire blade to make incisions perpendicular parallel to the growth direction of existing hair with similar density of opposite side or environment of scarring alopecia [11, 14, 15, 19, 34].

Attention must be paid for making true channeling and hair transplantation with surrounding facial hair without neurovascular injuries.

d) Discharge

Oral antibiotics and analgesics are administered for 5 postoperative days. Recipient and donor areas left open without occlusive dressing, with daily antibiotic ointment and washing with hair lotion or shampoo after the third postoperative day. Patients should be followed for at least 12 months. Folliscope examination is useful to evaluate the condition and density of transplanted FU [3, 15]. After transplantation, PRP injection can be used to improve graft viability [18].

4.2.2.2.2 Post transplantation complications

The most important complications of cicatricial alopecias include graft failure, infection, tissue ischemia and necrosis after surgery because of additional vascular injury during close and deep channel opening and graft implantations [14].

4.2.2.2.3 Survival rate and density of transplanted follicle units

The most important determining factor of surgery success is the survival rate of transplanted FUs in scarring alopecia. The survival rate of transplanted FUs grafts is over 90% in healthy vascularized areas [16, 19], but there is confusion about various survival rates (0–90%) for scarring alopecia [14].

In the scarring alopecia, Shao et al. [3] obtained a mean of 78.96% (ranged from 64.29 to 95.00) surviving FU density. Meyer-Gonzalez and Bisanga [37] considered more than 80% graft survival successful. Yoo et al. [1] obtained a mean 80.67% (ranged from 70% to 90%) survival rate with significant satisfaction. In the literature, an average 80% or over of graft viability has been accepted as success in scarring alopecia [1, 19, 37].

Low graft viability is a challenging problem due to poorly vascularized and fibrotic recipient areas [1, 2, 12, 14, 16, 28]. Various treatment methods are used to increase scar vascularity and maturity before hair transplantation. Akdag et el. [2] transferred fat grafts and FUs to scarring alopecia after cleft lip surgery at 3 months intervals, and an average of 82% (73.6–88.6) graft viability was obtained. Agaoglu et al. [15] combined non-ablative fractional laser and cryopreserved microfat grafting multistage before hair transplantation, and obtained a mean of 85.04% (76–95) graft viability. Podda et al. [32] performed cold-ablative Er:YAG Laser-Assisted hair transplantation and obtain apparent 95% graft survival. Autologous fat grafting, includes adipose-derived regenerative cells that have a primary role in the regenerative purposes by secreting a number of growth factors, increasing local neovascularization, collagen and elastin synthesis, and improving texture, thickness, pliability and angiogenesis of scar tissues [2, 15, 29, 30, 39].

During the treatment of scarring alopecia, one of the most difficult decisions is to determine the density of FUs. Because low blood supply is limited to high-density transplantation in scarring alopecia. While average follicle density for normal scalp alopecia is accepted over 30–35 FU grafts per cm^2 [1, 16], but there was no consensus about scarring alopecia.

Barr and Barrera [16] recommended 20–30 FUs/cm^2 scarring alopecia according to scar characteristics. Unger et al. [28] recommended a transplantation density of 30 FU/cm^2 or less to prevent the development of postoperative complications; 15–20 FU/cm^2 for scarring alopecia with poor blood supply; 20–30 FU/cm^2 for scarring alopecia with better perfusion. Wang et al obtained 30–34 grafts/cm^2 graft density and averaged 97% graft survival (range 87–100%) in scarring alopecia at 1-year follow-up. Civas et al. transplanted about 24.9 FU/cm^2 in scarring alopecia with 86.7% satisfactory result of the patient. As a general rule, there is a decrease in graft survival when the graft frequency exceeds 30 FU/cm^2 in scarring alopecia areas. While small and mature scars can be transplanted in a close to normal number (30 FUs/cm^2) since nutrition will be good; however, low-density transplantation and if required staged transplantation is recommended for large and problematic scars [16, 28].

4.2.2.3 Staged hair transplantation

After hair transplant in scarring alopecia, normal perfusion and oxygenation during the ischemia-reperfusion period and re-vascularization of hair follicle grafts mainly affect graft viability. If transplanted grafts are not re-vascularized within a few days after surgery, the graft will go failure [15, 16]. Additionally, the number of transplanted FUs determines the rate of graft survival. If too many grafts are transplanted in a small area, they compete for reduced blood flow through the scar

tissue and low blood flow cannot meet grafts' nutrition. Assuming that there is acceptable blood perfusion, it is recommended that this number does not exceed 30 grafts/cm^2 when performing a hair transplant in scarring alopecia. For this reason, it is better to perform multistage hair transplantation than running the risk of complications [16].

4.2.2.4 Advantages of FUE technique hair transplantation

FUE technique hair transplantation is the safe, effective and repeatable method in cicatricial alopecia including several advantages; provides a large amount of individual FUs harvesting on donor area with minimally invasive, less pain, less discomfort, less-complication method, high FUs graft survival rate, small implantation hole without formation of a linear scar and neurovascular damage, well accepted by patients with natural-looking hair growth and high level of satisfactory results. Additionally, transplantation of hair FUs to cicatricial alopecia carries epidermis, dermis, hair follicle, skin appendages that sebaceous and sweat glands, neurovascular bundles, piloerectile muscles, surrounded by a sheath of collagen and hair follicle stem cells increases the quality of the scar. FUE has led to improved graft survival and better cosmetics. Moreover, FUE needs less manpower, less equipment and minimal graft preparation period. All patients can be treated at an out-patient clinic with short hospitalization and a faster recovery period without general anesthesia (**Figure 5**) [16, 19, 28, 29, 34, 35, 37].

4.2.2.5 Disadvantages of FUE technique hair transplantation

FUE technique hair transplantation is time-consuming procedure and needs to technique skills. Because it is difficult to keep the punch parallel to the follicles to avoid transactions that result inflammation, cyst formation and inability to harvest all the hair from the mid portion of the donor area [35]. Multistage procedures need to obtain satisfactory hair density in poor vascular scars. Wide donor area and spot scar formation on the punched-out sites are other limitations [1, 14, 28, 35].

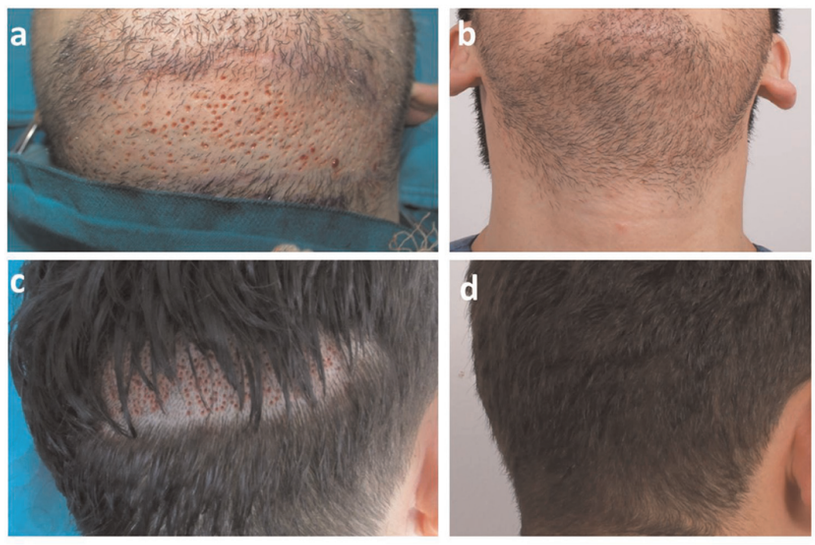

Figure 5.
The intra-operative images of the submandibular (a) and scalp (c) donor areas of follicular unit extraction (FUE) technique hair transplantation. After 1 week of hair transplantation, submandibular (b) and scalp (d) donor areas heal uneventfully.

4.2.2.6 Scalp restoration

The scalp is the most common area of scarring alopecia with its large surface. Several well-established treatment modalities have been used for the reconstruction of scarring alopecia on the scalp, including primary excision, local flaps, tissue expander and hair transplantation. The defects affected 50% of the scalp can be reconstructed by aesthetically and homogeny redistributing of remaining scalp tissue with excellent cosmetic density [16, 17, 33, 36]. It is very important to determine the hairline and exit angle of FUs during scalp hair transplantation. The anterior hairline should reconstruct approximately 8 cm above the glabella in males, approximately 5.5 cm in a female by using single hair FUs. Two or more hair FUs can be used for central scarring alopecia to increase density [16].

4.2.2.7 Beard and mustache restoration

Beards and mustaches are important hair-bearing aesthetic subunits for hirsute men. Especially male patients who underwent cleft lip surgery suffer from bilateral philtrum scars and prolabial alopecia. Hair transplantation is the best treatment option for scarring alopecia on the beard and mustache. The submandibular beard is the best match donor area for beard and mustache (**Figures 6** and 7). The single-hair FUs from the scalp can be used for beard and mustache restoration in beardless man [2].

4.2.2.8 Eyebrow restoration

Hair loss in the eyebrow causes de-humanization of the appearance (**Figure 3**). Modern makeup and micropigmentation techniques provide a 3-dimensional eyebrow appearance close to normal [14]. The exit angle and growth direction of the transplanted hair should be determined for the aesthetically pleasing result, that the medial hairs are oriented vertically, followed by the upper marginal hairs angled down and the lower marginal hair angled up. The donor hair can be taken from the opposite eyebrow, single-hair occipital and post-auricular scalp and nasal vibrissae [16].

4.2.2.9 Eyelash restoration

The eyelash restoration can be performed by retrograde or anterograde techniques with the single-hair occipital and post-auricular scalp. In the retrograde technique, hair FUs are implanted in the lid margin with classical techniques [19]. In the anterograde technique, the distal end of long hair is pulled out by a curved needle at the lid margin and provides better control of the growth direction of the hair [14, 16].

4.3 Future

It is a well-established fact that scarring alopecia has lower graft survival rates as compared to non-scarring alopecia. Tissue engineering studies need to develop scar-less wound healing and increase scar maturation similar to normal tissue. Perhaps in the near future, alopecia will be treated routinely by in-vitro culturing of

hair FUs [2, 14]. However, nowadays otology redistribution of existing hair FUs is the most commonly performed treatment for scarring alopecia [16].

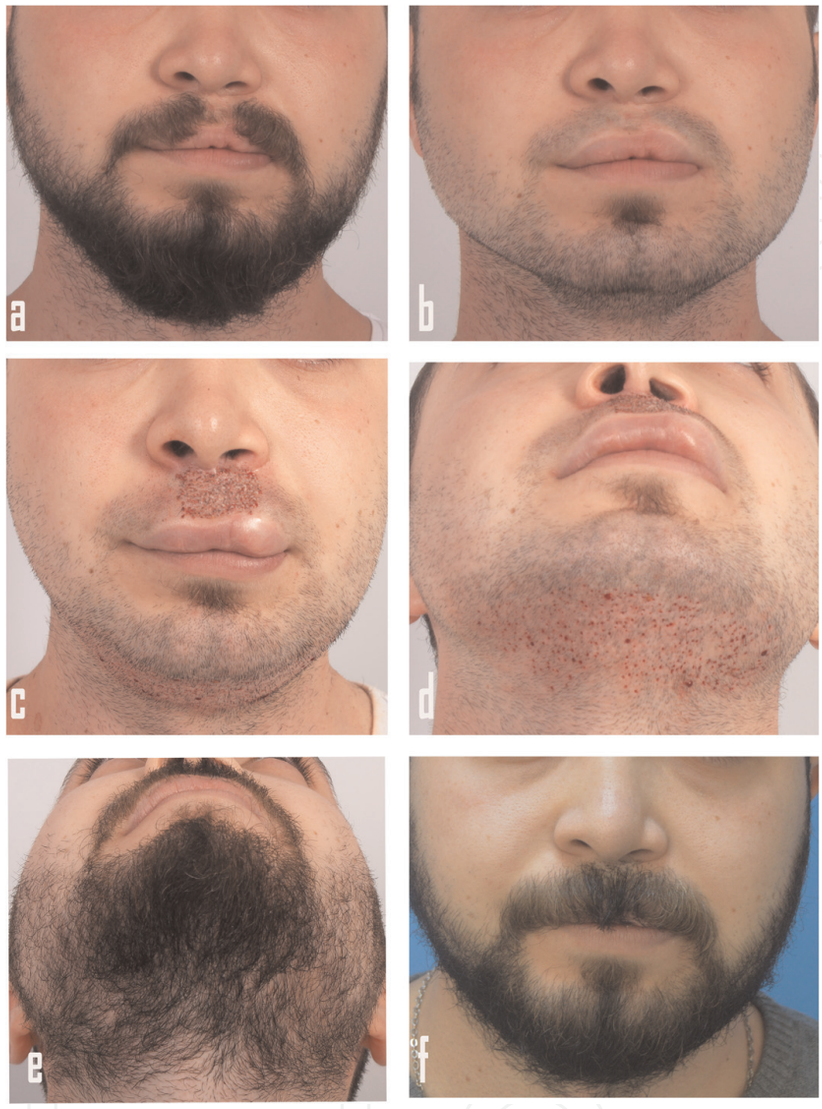

Figure 6.
A 22-years-old male patient had serious scarring alopecia after cleft lip surgery (a, unshaved image; b, shaved image). The patient underwent single-stage FUE hair transplantation from the submandibular area (c, d). After 3 years of hair transplantation, lip scarring alopecia has been successfully camouflaged (e, f).

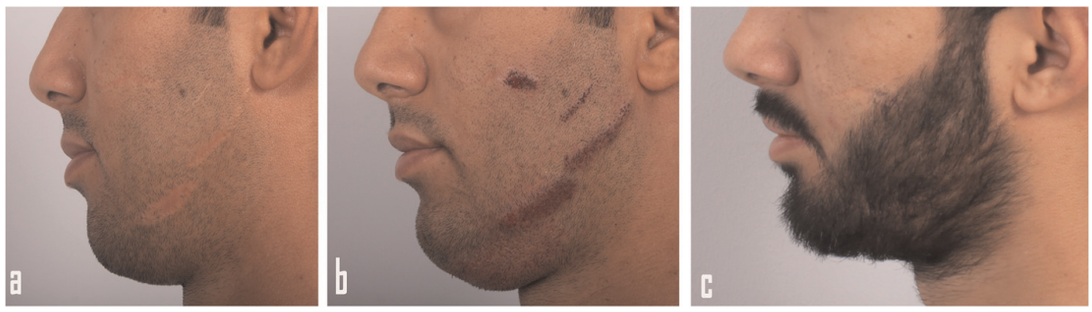

Figure 7.
A 27-years-old male patient had multiple scarring alopecia on the face after trauma (a). The patient underwent single-stage FUE hair transplantation from the submandibular area (b). After 24 months of hair transplantation, scarring alopecia has been successfully camouflaged (c).

5. Conclusions

Cicatricial alopecia forms a group of disorders that destroys hair follicles and replaced them by fibrous tissue. Treatment of cicatricial alopecia is challenging because of permanent hair loss. However, in primary scarring alopecia, early diagnosis and treatment can limit or even prevent the progression of hair loss. In contrast to classical techniques including scar excision, local flaps, and tissue expansion, follicular unit hair transplantation offers an innovative and effective treatment option for stable primary scarring alopecia and mature secondary scarring alopecia with several advantages; safe, minimally invasive and aesthetically pleasing results, even after a single session.

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References

[1] Yoo H, Moh J, Park JU. Treatment of postsurgical scalp scar deformity using follicular unit hair transplantation. BioMed Research International. 2019; **2019**:3423657

[2] Akdag O, Evin N, Karamese M, et al. Camouflaging cleft lip scar using follicular unit extraction hair transplantation combined with autologous fat grafting. Plastic and Reconstructive Surgery. 2018;**141**: 148-151

[3] Shao H, Hang H, Yunyun J, et al. Follicular unit transplantation for the treatment of secondary cicatricial alopecia. Plastic Surgery (Oakville, Ont). 2014;**22**:249-253

[4] Cardoso CO, Tolentino S, Gratieri T, et al. Topical treatment for scarring and non-scarring alopecia: an overview of the current evidence. Clinical, Cosmetic and Investigational Dermatology. 2021;**14**: 485-499

[5] Mubki T, Rudnicka L, Olszewska M, et al. Evaluation and diagnosis of the hair loss patient: part I. History and clinical examination. Journal of the American Academy of Dermatology. 2014;**71**:415. e411-415.e415

[6] Stefanato CM. Histopathology of alopecia: a clinicopathological approach to diagnosis. Histopathology. 2010;**56**: 24-38

[7] Rongioletti F, Christana K. Cicatricial (scarring) alopecias: an overview of pathogenesis, classification, diagnosis, and treatment. American Journal of Clinical Dermatology. 2012;**13**:247-260

[8] Manabe M, Tsuboi R, Itami S, et al. Guidelines for the diagnosis and treatment of male-pattern and female-pattern hair loss, 2017 version. The Journal of Dermatology. 2018;**45**: 1031-1043

[9] Sundberg JP, Hordinsky MK, Bergfeld W, et al. Cicatricial Alopecia Research Foundation meeting, May 2016: progress towards the diagnosis, treatment and cure of primary cicatricial alopecias. Experimental Dermatology. 2018;**27**:302-310

[10] Whiting DA. Cicatricial alopecia: clinico-pathological findings and treatment. Clinics in Dermatology. 2001; **19**:211-225

[11] Martinez D, Sodré JL, Regis JR, et al. Hair transplantation in uncommon secondary cicatricial alopecias. Dermatologic Therapy. 2022;**35**(8):e15592

[12] Kwon OS, Kim MH, Park SH, et al. Staged hair transplantation in cicatricial alopecia after carbon dioxide laser-assisted scar tissue remodeling. Archives of dermatology. 2007;**143**:457-460

[13] Barrera A. The use of micrografts and minigrafts for the treatment of burn alopecia. Plastic and Reconstructive Surgery. 1999;**103**:581-584

[14] Farjo B, Farjo N, Williams G. Hair transplantation in burn scar alopecia. Scars, Burns & Healing. 2015;**1**: 2059513115607764

[15] Agaoglu G, Özer F, Karademir S, et al. Hair transplantation in burn scar alopecia after combined non-ablative fractional laser and microfat graft treatment. Aesthetic Surgery Journal. 2021;**41**:Np1382-np1390

[16] Barr L, Barrera A. Use of hair grafting in scar camouflage. Facial

Plastic Surgery Clinics of North America. 2011;**19**:559-568

[17] Jiang W, Chen L, Jia L, et al. Corrective strategies for poor appearance after tissue expansion for temporal and sideburn cicatricial alopecia. Journal of Cosmetic Dermatology. 2021;**20**:4001-4004

[18] Evin N, Tosun Z, Aktan TM, et al. Effects of adipose-derived stem cells and platelet-rich plasma for prevention of alopecia and other skin complications of radiotherapy. Annals of Plastic Surgery. 2021;**86**:588-597

[19] Barrera A. The use of micrografts and minigrafts in the aesthetic reconstruction of the face and scalp. Plastic and Reconstructive Surgery. 2003;**112**:883-890

[20] Tan E, Martinka M, Ball N, et al. Primary cicatricial alopecias: clinicopathology of 112 cases. Journal of the American Academy of Dermatology. 2004;**50**:25-32

[21] Cummins DM, Chaudhry IH, Harries M. Scarring Alopecias: Pathology and an Update on Digital Developments. Biomedicines. 2021;**9**(12):1755

[22] Imhof RL, Cantwell HM, Proffer SL, et al. The spectrum of pediatric scarring alopecia: a retrospective review of 27 patients seen at Mayo Clinic. Pediatric Dermatology. 2021;**38**:580-584

[23] Villablanca S, Fischer C, García-García SC, et al. Primary scarring alopecia: clinical-pathological review of 72 cases and review of the literature. Skin Appendage Disorders. 2017;**3**:132-143

[24] Harries MJ, Paus R. The pathogenesis of primary cicatricial alopecias. The American Journal of Pathology. 2010;**177**:2152-2162

[25] Porriño-Bustamante ML, Fernández-Pugnaire MA, Arias-Santiago S. Frontal fibrosing alopecia: A review. Journal of Clinical Medicine. 2021;**10**

[26] Mubki T, Rudnicka L, Olszewska M, et al. Evaluation and diagnosis of the hair loss patient: part II. Trichoscopic and laboratory evaluations. Journal of the American Academy of Dermatology. 2014;**71**:431.e431-431.e411

[27] Severs GA, Griffin T, Werner-Wasik M. Cicatricial alopecia secondary to radiation therapy: case report and review of the literature. Cutis. 2008;**81**:147-153

[28] Unger W, Unger R, Wesley C. The surgical treatment of cicatricial alopecia. Dermatologic Therapy. 2008;**21**:295-311

[29] Tesauro P, Trivisonno A, Gennai A, et al. Hair transplantation in cicatricial alopecia: the role of autologous fat transfer. International Journal of Regenerative Medicine. 2020:1-11

[30] Onur Erol O, Agaoglu G, Jawad MA. Combined non-ablative laser and microfat grafting for burn scar treatment. Aesthetic Surgery Journal. 2019;**39**:Np55-np67

[31] Klinger M, Klinger F, Caviggioli F, et al. Fat grafting for treatment of facial scars. Clinics in Plastic Surgery. 2020;**47**: 131-138

[32] Podda M, Spieth K, Kaufmann R. Er: YAG laser-assisted hair transplantation in cicatricial alopecia. Dermatologic Surgery. 2000;**26**:1010-1014

[33] Leedy JE, Janis JE, Rohrich RJ. Reconstruction of acquired scalp defects: an algorithmic approach. Plastic and Reconstructive Surgery. 2005;**116**:54e-72e

[34] Civas E, Aksoy H, Aksoy B, et al. Clinical experience with hair

transplantation for secondary cicatricial alopecias. 2019;**27**:160-166

[35] Rassman WR, Bernstein RM, McClellan R, et al. Follicular unit extraction: minimally invasive surgery for hair transplantation. Dermatologic Surgery. 2002;**28**:720-728

[36] Guzey S, Alhan D, Şahin I, et al. Our experiences on the reconstruction of lateral scalp burn alopecia with tissue expanders. Burns. 2015;**41**:631-637

[37] Meyer-Gonzalez T, Bisanga C. Body-hair transplant for cicatricial alopecia. Actas dermo-sifiliograficas. 2012;**103**: 163-164

[38] Umar S. Use of beard hair as a donor source to camouflage the linear scars of follicular unit hair transplant. Journal of Plastic, Reconstructive & Aesthetic Surgery. 2012;**65**:1279-1280

[39] Klinger M, Marazzi M, Vigo D, et al. Fat injection for cases of severe burn outcomes: a new perspective of scar remodeling and reduction. Aesthetic Plastic Surgery. 2020;**44**:1278-1282