

Hair transplantation in burn scar alopecia

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Abstract



Treating patients with burn alopecia or hair loss can often be a challenge to both the surgeon and the patient. As with other reconstructive procedures that are required in the post-burn phase, this is usually a multiple stage process often requiring surgery over several years. This is because graft take is not as reliable as in healthy non-scarred skin and may need repeating to achieve adequate density. Also, different areas of hair loss may need to be addressed in separate procedures. There are several limiting factors that will determine whether or not a patient is a candidate for hair restoration which includes but is not limited to the amount of hair loss and the availability of suitable donor hair. Here we discuss how the current surgical technique of hair transplant surgery by follicular unit extraction (FUE) or strip follicular unit transplant (FUT) has become the treatment of choice for alopecic areas that require a more refined aesthetic result. Eyebrow, eyelash, beard and scalp hair loss can all have a negative impact on a burn survivor's self-esteem and even if surgery is not a possibility, there are non-surgical options available for hair restoration and these are also discussed.

Keywords

Burns, hair transplantation, burn scar, alopecia, strip follicular unit transplant, follicular unit extraction, hair loss, hair restoration, scalp, beard, eyebrows, eyelashes

Lay Summary



This article explores the procedure of hair transplantation in the context of general options for hair restoration for individuals that have suffered hair loss due to burn injuries. Treating hair loss due to burns can often be a difficult process for both the surgeon and the patient. As with other surgical procedures that are required in the post-burn phase, hair restoration is usually a multiple stage process often requiring surgery over several years. This is because transplanted hairs are not as reliably successful as in healthy non-scarred skin and many repeat treatments may be needed to achieve adequate density, which is important for a natural look. In addition, different areas of hair loss may need to be addressed in separate procedures. There are several factors that will determine whether or not a patient is a good candidate for hair restoration which includes such things as the amount of hair loss and how much suitable donor hair (the donor is the area from which hair is taken, or donated) is available if the scalp has been affected by scarring. Eyebrow, eyelash, beard and scalp hair loss can all have a negative impact on a burn survivor's self-esteem and confidence. Even if surgery is not a possibility there are non-surgical options, outlined in this article, which may be available for hair restoration. In this article we explain why the current surgical technique of hair transplant surgery has become the surgical treatment of choice for restoring areas of hair loss, especially in areas that require a more refined and natural result such as eyebrows.



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Introduction

Burn injuries, whether caused by chemical (acid/alkali), flame, scalds (including steam, hot water and cooking oils) and rarely electrical injury, may be isolated to the head and neck region or be part of injuries affecting a larger total body surface area. Functional problems are common and include intrinsic and extrinsic contractures resulting in microstomia, upper and lower eyelid ectropion, lip eversion and nostril constriction. After the acute management of life-threatening problems has been concluded, wound healing has been completed, and functional deficits have been addressed attention can be turned to the improvement of the aesthetic concerns of the patient such as partial or complete loss of the nose and external ear. Complete destruction of the hair follicle is usually associated with deep burns, the nature of which also results in severe scarring and which makes hair transplantation more challenging. Although hair loss from previously hair-bearing areas of the head and neck is hard to hide with clothing – specifically the scalp, eyebrows, eyelashes and beard region – it is often seen by clinicians as less important than scar management *per se*. However, hair loss can have an equal or greater impact on the self-esteem and quality of life of patients than the scars themselves and act as a constant reminder of the causative traumatic incident.

Many patients will choose non-surgical options to address their visible difference, but for many patients there are a variety of surgical hair restoration options available that can produce superior results in certain cases.¹ Follicular unit (FU) hair transplantation is an important option for consideration by burns multi-disciplinary teams (MDTs), especially for those areas requiring a more refined outcome rather than simply the presence of hair. The challenge with these techniques is to understand both the characteristics of naturally growing hair and also predicting a realistic outcome for the patient.

Non-surgical options for management

Not all burns patients will be suitable candidates for hair restoration surgery and some will opt not to choose this option. Therefore, the burn MDT should be aware of the non-surgical choices available to the patient. These include:

- Cosmetic camouflage – scalp dyes, coloured hairsprays, keratin microfibrils, eyebrow make-up
- Semi-permanent micro-pigmentation tattooing – particularly effective for eyebrows but can be used to simulate hair stubble or strands of hair
- Scalp hair replacement systems – partial hair pieces or complete wigs
- Hair-bearing adhesive prostheses – eyebrows, false eyelashes
- Scalp hair bearing prostheses combined with Branemark ear prostheses – useful when the hair loss is limited to the post-auricular area

Patients who are not suitable for hair transplantation include those who do not have enough donor hair to cover the non-hair bearing defects, male patients who have advanced male pattern baldness themselves or a significant family history of advanced male pattern hair loss (which limits the size of the safe occipital scalp donor area) and inflammatory dermatological conditions that are contraindications to hair transplantation (for example, lichen plano-pilaris). Patients may also be unsuitable for hair transplantation because there are multiple other reconstructive surgical priorities for functional rehabilitation that are higher on the priority list. The non-surgical options listed above can be used as temporary solutions, and for many patients who are tired of having surgical procedures, they can provide an adequate long-term camouflage. It is worth noting that hair transplantation is not an option for many patients due to cost.

Surgical options for management

The surgical options for treating burn alopecia will depend on the location of the hair-bearing area affected and the size of the defect. These include one or a combination of the following techniques:

- Serial excision with or without tissue expansion
- Hair-bearing flaps with or without tissue expansion
- Hair-bearing full thickness grafts
- Hair transplant surgery

As there is a limit to the hair density achievable per hair transplant procedure, and at least three procedures will be required to simulate the appearance of normal density, large areas of scalp and beard burn scar alopecia (greater than 80–100 cm²) are often best managed initially by

reducing the size of the defect. This is best achieved with serial excision, tissue expansion and hair-bearing flaps leaving hair transplantation as the last stage to refine hairlines, fill in smaller areas of residual burn scar alopecia and cover surgical scars.

Hair-bearing full-thickness grafts are rarely completely successful and hair growth is often not in a natural direction so hair transplantation should be the first treatment of choice for the reconstruction of hair in or around the face. This is especially crucial in producing naturalness in eyebrow and eyelash alopecia.

However, most burns reconstructive surgeons and burns services do not have the skill, training, infrastructure, resources or possibly case load to provide a quality hair transplantation service. Hence, these treatments are commonly unavailable in publicly-funded health systems and patients who can afford the care or can gain public funds through, for example, an Individual Funding Request (IFR) are seen in the private sector. As a consequence, there is little published literature on hair transplantation for burn scar alopecia since private hair transplant providers will rarely see (or be experienced in the treatment of) significant numbers of burns patients. In addition, private providers are generally less likely to be involved in scientific research.

Hair transplant surgery

Historical context

It is universally acknowledged that the era of hair restoration surgery commenced in Japan with techniques developed to treat burn survivors. In the 1930s, Okuda published his technique of transplanting hairs derived from punch grafts into areas of burn scar alopecia in the *Japanese Journal of Dermatology*.² Shortly after, Tamura also published his work using hairs derived from spindle shaped strips of scalp skin.³ These two publications described the fundamentals of the Strip Follicular Unit Transplant (Strip FUT) and Follicular Unit Extraction (FUE) methods used today. There was a delay in these techniques reaching the Western world due to the intervention of World War II. It was not until 1959 that Orentreich from the USA published his technique transplanting 4 mm punch grafts in the *Annals of the New York Academy of Science* and he also described the concept of 'donor dominance', noting that transplanted follicles retained the anatomical and physiological properties of their donor site in the parieto-occipital scalp

which does not go bald. The popularisation of hair transplantation for treating male pattern baldness (MPB) soon followed and the method of obtaining donor hair follicles changed over the following years from extraction with smaller punches to strip excision from the donor area. In 1988, Limmer, working under stereoscopic microscopes in the USA with Strip FUT cases, applied the concept of the follicular unit natural groupings to hair transplantation and suggested better aesthetics and hair survival this way (Figure 1). Headington had previously described that scalp hairs do not grow individually but in small groups and designated these groups as FUs.⁴ Coincidentally in 1988, Inaba from Japan had also published a refined technique of FUE using a 1 mm needle. However, it was Woods from Australia who first demonstrated this technique in the West and it was then first formally described in the Western medical literature in 2002 by Bernstein and Rassman.⁵

General considerations

Hair loss from burn injury falls under the category of a secondary scarring alopecia. While there is a long and extensive global anecdotal experience with successful treatment with hair transplantation, there is little research or publication in this area with regards to the percentage survival of follicles transplanted into burn scars. The authors' anecdotal experience in over 100 cases is that hair follicle graft survival in scar tissue can be in the range of 0–90%.

Prior to embarking on transplantation, the scars should be fully mature, i.e. as pale, soft, flat and as supple as they are likely to become.

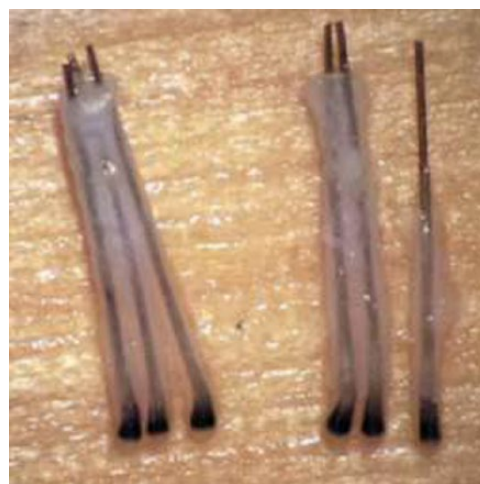


Figure 1. FUs with three, two and one hairs.

Patients are often anxious to proceed with hair restoration as soon as possible but a cautious approach should be advocated in order to ensure the best outcome. If scars remain pink, they are likely to bleed when incisions are made causing inserted grafts to be ejected by the blood flow. The altered architecture of the cutaneous layers means that the natural ‘grab’ of the skin to hold the graft in place is diminished. This decrease in scalp elasticity is also important when considering the method of donor harvesting as there is not always enough scalp laxity to remove a strip of donor hair bearing skin and achieve adequate wound closure. This may restrict the potential of strip FUT and make FUE a better donor follicle harvesting method (see below).

Another consideration is that the vascularity in mature scars is variable and a diminished blood supply will have an impact on grafted follicle survival and over-enthusiastic attempts to pack incisions densely may compromise the blood supply to the scar further, resulting in necrosis. If skin grafts have been previously used in an area there may be a limited amount of subcutaneous tissue and when the skin graft is stuck to the cranium transplantation will not be possible. The authors are aware of anecdotal cases of autologous fat grafting to create enough underlying tissue into which grafts can be inserted through thin scars. Results have been variable but this is an interesting area of development for future treatment. An added benefit to the introduction of multiple fragments of dermis with the transplanted FU may be an overall improvement in the scar quality.

Most follicular unit hair transplants for burn scar alopecia will be performed in private hair transplant clinics and therefore will not have their own MDTs. Ideally, contact should be made with the patient’s burn team not only to

coordinate prioritisation of the hair transplant procedure with other reconstructive surgical needs but also to confirm suitability to have a procedure under local anaesthetic. As these procedures will take a minimum of 2–3 h and a maximum of up to 12 h, local anaesthesia is much safer than general anaesthesia, and remains our preference in most cases.

The consent and patient education process for hair transplantation in burn scars is important and should take into account the variability in follicular unit graft take, the limitation in hair density that can be achieved per procedure, and the likelihood that multiple procedures might be required to achieve a satisfactory density. It is important to understand the patient’s motivation for the procedure and to uncover what their expectations are for short- and long-term outcomes.

Hair transplantation methods

Modern hair transplantation is focused around follicular units being taken from the ‘safe’ donor zone in the non-balding scalp as these provide longlasting, natural results. The donor:recipient ratio concept refers to the number of hairs available in the donor area compared to the number of hairs required to cover a scarred area.

There are two main ways to harvest donor hair – the Strip Follicular Unit Transplant (Strip FUT) method and the Follicular Unit Extraction (FUE) method (Figure 2). Both have advantages and disadvantages for the surgeon and prospective patient to consider.³

In Strip FUT surgery, an ellipse of skin is removed from the donor area leaving a permanent linear surgical scar, the width of which varies depending on the skill of the surgeon and the patient’s scalp healing properties. It is designed to be completely hidden within the patient’s own



Figure 2. Strip FUT (left) vs. FUE (right) donor site harvesting methods.

donor hair. In general, this is a quicker way to harvest grafts compared to FUE but a major disadvantage is that it requires a large team of trained assistants to dissect the grafts into individual follicular units when transferring a large number of grafts (Figure 3).

In FUE surgery, there is no linear scar but instead each extraction site leaves a small round dot scar that can be hidden even with shorter hairstyles compared to a strip scar. The punches vary in size but generally are in the range of 0.75–1.2 mm in diameter attached to either a hand-held manual device, a hand-held mechanised drill device or an automated robotic device. Disadvantages of this technique are that large harvesting sessions require the entire donor area to be shaved and the grafts tend to have less tissue around them and therefore more care is needed in handling them. Only with multiple or ill-planned procedures will there be thinning out of the donor area. One distinct advantage of using this technique in burn alopecia is that the scalp is often very tight in these cases so strip FUT is not advised as only a narrow ellipse can be removed limiting the amount of hair that can be transferred and closure under tension will lead to a widened, or potentially hypertrophic, scar.

The FUE technique can also be applied to the harvesting of beard donor hair for use in beard to beard transplants, or beard to scalp transplants, although the physical characteristics of beard hair are different to scalp hair (beard hairs tend to be of thicker calibre, more ‘bristly’ and may be a different colour) so patients need to be willing to accept the aesthetic difference. Body hair can also be harvested by FUE but the growth characteristics are very different to scalp and beard hair with body hair having a shorter growth phase and a longer resting phase. This means that body hair transplants to the scalp might result in fluctuations in hair density as the body hairs enter their longer hair growth cycle resting phase.

Regardless of the method used to harvest hairs, the implantation is the same and it is the angle and direction of the transplanted hairs along with the hairline design^{6,7} and recipient site density that are responsible for a pleasing hair transplant result, not the method of harvesting. Follicular unit grafts can be implanted into pre-made incisions using forceps or implanters (Figure 4), or the implanters can be used to create incisions at the same time the graft is implanted. The advantage of the former is that the overall design of the transplant is made prior to the onset of graft implantation whereas the



Figure 3. Strip FUT sliver and dissected follicular units.



Figure 4. Follicular units being placed in incisions dyed with methylene blue for ease of identification.

advantage of the latter is that no incision sites are missed.

Complications in hair transplant surgery are mainly related to the aesthetic outcome with density or design as the main area of contention. Infections in the form of folliculitis or cellulitis are rare as is donor or recipient site skin necrosis. Unlike patients with genetic hair loss where the transplanted area can be designed to simulate a naturally occurring thinning pattern, patients with burn scar alopecia often have dense hair adjacent to the areas of alopecia. They therefore require repeated procedures to achieve adequate density and this should be made clear at the time of the original consultation. It can take up to 18 months for transplanted hairs to reach maturation, therefore the ability to assess the results of the transplant. Multiple procedures can take 5 years or more to complete. Camouflage products can be a useful adjunct to hair transplantation to give the illusion of greater density during this period. Likewise micropigmentation tattooing which can give the scars a colour similar to the

hair can reduce the colour contrast of pale scar and darker hair and give the illusion of greater hair density.

Specific areas – scalp

There are several classifications of scalp burns scar alopecia but that by McCauley⁸ is widely accepted (Table 1). Type I and Type II are often best treated with tissue expansion initially, reserving hair transplantation for the refinement of hairlines and sideburns as well as filling in surgical scars created in the tissue expansion process. Historically, the hairline in patients with facial burns has been reconstructed with a temporo-parieto-occipital (Juri) flap but this tends to lead to a harsh straight hairline with the hair exiting at an unnatural angle. Modern follicular unit transplants can provide a much more natural appearance even under close inspection (Figures 5 and 6).

Furthermore, in male patients where hair-bearing advancement or rotation flaps are being considered, either in isolation or as part of tissue expansion, it is important to understand the potential for MPB in the future and warn the patient that flaps taken from areas that are genetically predetermined to lose hair will do so in their transferred location which may lead to

unnatural patterns of balding.^{9,10} In some cases such loss can be prevented by using approved medications for androgenetic alopecia such as oral finasteride¹¹ or topical minoxidil¹² and these should be started as soon as there is evidence of androgenetic alopecia. A classification for male pattern hair loss has been provided by Norwood and is commonly used to classify the degree of baldness.¹³

Where there are localised areas of hair loss adjacent to the loss of the external ear, a Branemark-based prosthetic ear combined with a

Table 1. McCauley's classification of scalp burns scar alopecia.

Type I	Single alopecia segment A Less than 25% of the hair-bearing scalp B 20–50% of the hair-bearing scalp C 50–75% of the hair-bearing scalp D 75% of the hair-bearing scalp
Type II	Multiple alopecia segments amenable to tissue expansion
Type III	Patchy burn alopecia not amenable to tissue expansion
Type IV	Total alopecia

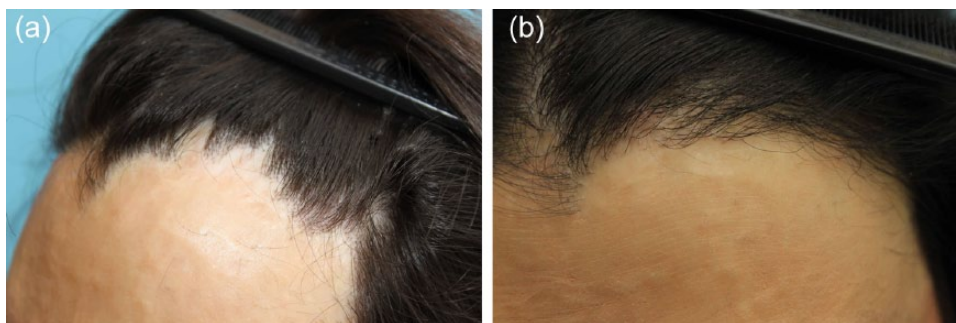


Figure 5. Left hairline burn scar alopecia (a) pre and (b) post hair transplant.

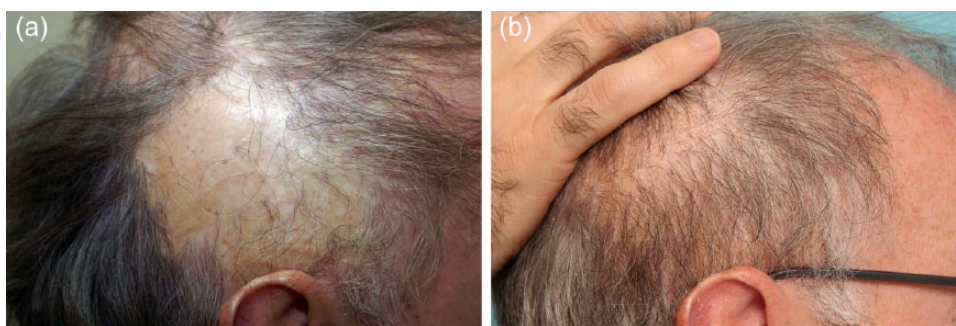


Figure 6. Scalp burns scar alopecia (a) pre and (b) post hair transplant.

hair bearing prosthesis can produce a result that is often superior to attempts at autologous reconstruction especially where the severity of the burn scarring precludes the use of localised skin or fascial flaps for ear reconstruction (Figure 7).

Specific areas – beard

In men, if the roots of the beard or moustache hair have been damaged, scarring alopecia will occur. In hirsute men, especially those with dark hair, this loss of beard or moustache hair can accentuate the post-burn scarring appearance, even with the best quality burns scars that approach normal skin colour and texture. Small areas of beard scar alopecia can be excised, although the resulting surgical scars will still leave residual non-hair bearing scars. Although micropigmentation tattooing can very effectively mimic stubble, beard hair grows quickly and the discrepancy between the tattooed stubble and even short surrounding hairs makes the appearance unnatural. Hence hair transplantation remains the best option for beard and moustache scarring alopecia (Figures 8 and 9). Although scalp hair can be used as the donor, the best match will be from FUE-derived beard hair.

Specific areas – eyebrows

Eyebrows are essential for what we recognise as a ‘human’ face and when they are lost, there is a ‘de-humanisation’ of the appearance. Over-plucking of eyebrows with the resulting permanent hair loss has led many women either to use temporary makeup or more permanent micropigmentation tattooing. This tattooing technique, although commonly applied to eyebrow burn scar alopecia, often produces a harsh appearance (Figure 10).

Modern eyebrow micropigmentation aims to produce a ‘three-dimensional’ appearance, but

this is only effective when viewed straight on and in order for ‘texture’ to be appreciated, hair transplantation is required (Figures 11 and 12).

In the interim period when scars are maturing prior to being suitable for a hair transplant, self-adhesive eyebrow prostheses (Figure 13) can be used and this is particularly the case for men where eyebrow makeup and tattoos tend to be less socially acceptable.

Specific areas – eyelashes

Upper eyelash replacement is possible using either retrograde or anterograde techniques. The retrograde technique is similar to that of a standard hair transplant procedure where follicles are inserted, bulb first, into an incision at the lid margin.¹⁴ The anterograde technique was popularised by Marcelo Gandelman¹⁵ and has the advantage of greater control of the direction of growth of the eyelash, reducing the incidence of inward growth of the eyelash causing corneal abrasions. In this technique a curved French eye needle is inserted 5–10 mm from the lid margin and a long hair is threaded subcutaneously to the lid margin where it is then pulled through until the

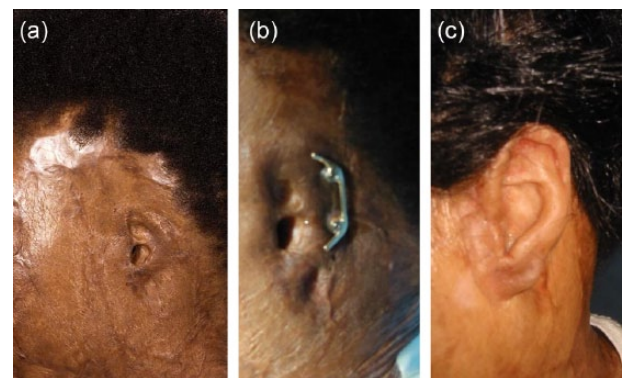


Figure 7. (a) Loss of external ear and burn scar alopecia. (b) With Branemark. (c) Ear and hair-bearing prosthesis attached.

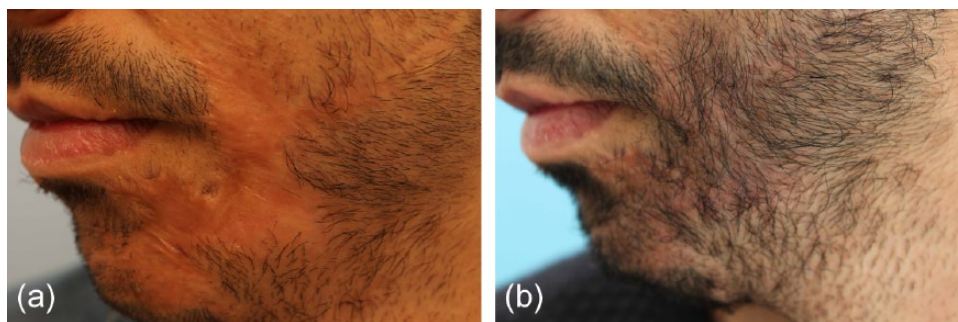


Figure 8. Partial beard scarring alopecia (a) pre and (b) post hair transplant.



Figure 9. Beard and moustache scarring alopecia (a) pre and (b) post full beard hair transplant.

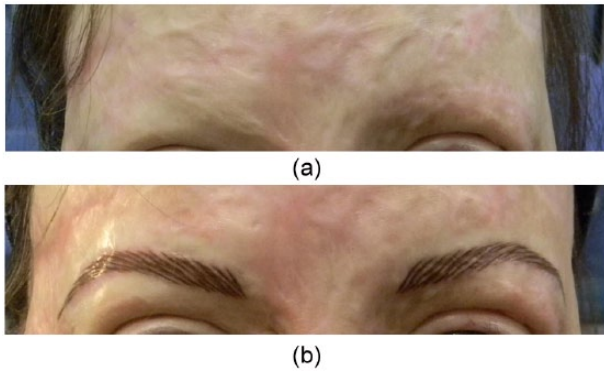


Figure 10. Eyebrow burn scar alopecia (a) pre and (b) post micropigmentation tattooing. Photos courtesy of Marcia Trotter.



Figure 11. Partial right eyebrow scarring alopecia (a) pre and (b) post hair transplant.

bulb is buried under the needle insertion point on the lid (Figure 14). Lower lash replacement is usually not recommended as they are less prominent aesthetically, achieving a natural curl is



Figure 12. Complete right eyebrow scarring alopecia (a) pre and (b) post hair transplant.

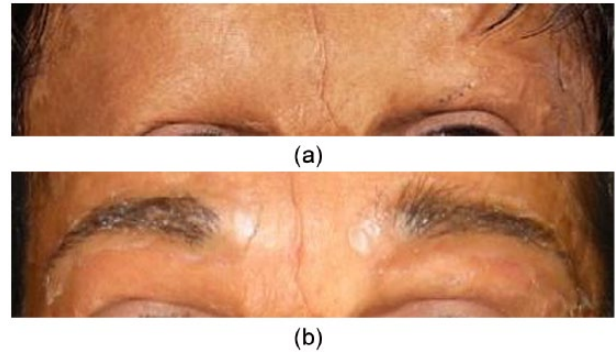


Figure 13. Eyebrow scarring alopecia (a) pre and (b) post eyebrow prostheses application.

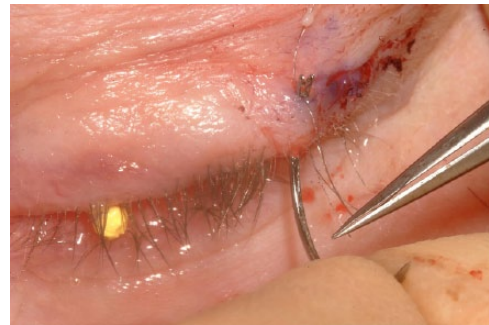


Figure 14. Anterograde technique for eyelash transplantation. Note strand of hair in eye of curved needle – bulb will be positioned under insertion point of needle and distal end of hair will be pulled out through exit point of needle at lid margin.

difficult, and there is a much higher complication rate. For women, false eyelashes are a good alternative to transplantation.

Other hair-bearing areas

Although rarely requested, it is possible to restore hair to other hair-bearing parts of the body. In men, this may involve the chest, axillae, arms and legs. In both sexes, restoration of pubic hair may

be important in regaining a feeling of masculinity or femininity and can contribute to improved rehabilitation of sexuality and sexual function.

Future developments

Hair transplant surgery is currently the only permanent treatment for hair loss, a solution which is limited by the availability of donor hair. The future of alopecia treatment may be in using cell therapy. Culturing of trichogenic cells *in vitro* has been tried in the past with limited success. However, newer culturing methods have shown that hair follicle cells maintain their ability to regenerate hair *in vivo* when re-implanted.¹⁶

Although general patient wellbeing (which may be impacted by hair loss issues) will be captured in burn-specific quality of life and patient reported outcome measures currently, there are no globally accepted outcome measures for hair transplant surgery that can be applied to hair restoration for burn scar alopecia. This, along with the development of more specific patient satisfaction measures for hair transplantation in burn scar alopecia, should be a focus of research in the future.

Conclusion

Burn scar alopecia may add to the appearance issues suffered by burn survivors and contribute to lowered self-esteem and sense of wellbeing. A variety of non-surgical and surgical methods are employed to achieve hair restoration to areas of burn scar alopecia. The suitability of performing a hair transplant procedure is dependent on sufficient availability of donor hair to address the area of hair loss, as well as a receptive recipient area as determined by scar tissue that is sufficiently mature and has adequate subcutaneous tissue to allow the insertion of grafts through the scar.¹⁷ Hair transplantation can restore completely natural looking hairlines, cover small to moderate sized areas of scalp burn scar alopecia, and recreate destroyed beards and moustaches. Eyebrows can be restored, as can upper eyelashes and other hair bearing parts of the body in selected cases. At the present time there are no globally accepted outcome measures for hair transplant surgery that can be applied to hair restoration in burn scar alopecia. This, along with the development of patient satisfaction measures for hair transplantation in burn scar alopecia, should be a focus of research in the future. Engagement and collaboration with health service commissioners would be valuable to

increase availability of hair transplantation for burns survivors.

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Ethical Approval

The authors confirm that the necessary written, informed consent was obtained from patients for this article.

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