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Reconstructive

Innovative Surgical Approaches and Selection Criteria of Large Acne Keloidalis Nuchae Lesions

Sanusi Umar, MD*†‡
Consuelo V. David, MD, MSc‡
Jason R. Castillo, MD‡
Jenna Queller, MD‡
Sophia Sandhu, MD‡

Background: Acne keloidalis nuchae is a debilitating condition mainly affecting the occipital region or nape of the neck. Surgical approaches are limited in aesthetic outcomes. Three innovative surgical approaches based on selection criteria are presented for enhanced and more predictable wound healing and posterior hairline cosmesis.

Methods: "Bat excision" and secondary intention healing are shown for 2 of 37 representative patients and confined to the area between the occipital protuberance superiorly and posterior hairline inferiorly. Lesions with ≤3 cm vertical width were required to be in the lower one-half portion of this zone. The same procedure was aided by the use of tension sutures for lesions with >3 cm vertical width area within the defined zone. It was also suitable for breaches of the 2 horizontal lines defined above but generally located in the nuchal area. Debridement of premature epithelizing granulation tissue is shown in 2 additional patients.

Results: Use of these procedures with debridement in selected patients allowed fine control over the hairline shape and resulted in narrower scars. The mean maximum sagittal width of excised lesions was 5.4 cm. Excised lesion width ≥6.5 cm was highly predictive of >2.5 cm wide scar ($P = 0.001$).

Conclusion: Innovative procedures based on selection criteria can extend the approach of acne keloidalis nuchae excision with secondary intention healing to better control the final hairline shape and minimize scarring. *(Plast Reconstr Surg Glob Open 2019;7:e2215; doi: 10.1097/GOX.0000000000002215; Published online 16 May 2019.)*

INTRODUCTION

Acne keloidalis nuchae (AKN) is a scalp condition in which follicular-based papules and pustules form hypertrophic or keloid-like scars almost exclusively in the occipital region or nape of the neck. While typically affecting men of color, AKN can also affect women and whites.[1,2] The trigger of AKN is the presence of ingrown hairs due to natural curl as the hair shaft tip grows inward toward the scalp when hair is cut short. Skin injuries arising from irritation, occlusion, trauma, and friction are also risk factors in the development of AKN.[3–6]

*From the *Division of Dermatology, Department of Medicine, University of California at Los Angeles, Calif.; †Dr. U Hair and Skin Clinic, Redondo Beach, Calif.; and ‡Division of Dermatology, Department of Medicine, Harbor-UCLA, Torrance, Calif.*

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Left untreated, AKN can impact the quality of life due to pruritus, pain, abscess, and sinus tract formation. Social isolation and depression may result in some patients. Although mild AKN can be treated medically, surgery offers the best long-term benefit.[7–11] Laser epilation is also potentially curative, especially with small papular lesions.[11] Nevertheless, a systematic review of the literature noted that 17 of 41 patients with AKN treated by surgical excision still had mild recurrence.[11] The authors also expressed significant concern about scarring.[11]

A favored surgical approach, with mixed results, has been deep excision that includes the posterior hairline followed by secondary intention healing (SIH).[9,12–14] In this context, the goal is not a classical SIH involving the formation of new epithelium over a large granulated area to ultimately result in a wide scar. Rather, the wound is expected to spontaneously contract until the superior and inferior wound margins join to form a thinner horizontal linear scar that defines a new posterior hairline. In one report, 4 of 6 males achieved good cosmesis with horizontal elliptical excision that included the posterior hairline; recurrence occurred in 2 other men.[9] In another series of 5 patients, there was no AKN recurrence, but scarring

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was significant despite patient acceptability.[12] In contrast, 2 other case studies involving 3 patients with AKN lesions of limited sizes reported excellent cosmetic results with no recurrence.[13,14] None of these reports describes patient selection criteria for the procedures. Most studies of AKN excision and SIH have reported a 6–12-week time frame from excision to wound closure.

We believe that selecting optimal candidates for AKN excisions involving the posterior hairline and SIH and more innovative surgical approaches can improve outcome. We report here 3 novel procedures to address these issues.

METHODS

We conducted a preliminary study that retrospectively analyzed data of 37 patients presenting for AKN lesion excision who received bat excision with or without tension suture-assisted SIH. Patients were excluded from the analysis if they had used isotretinoin in the previous 12 months or had a history of keloids elsewhere. Selection criteria were used to determine the applicable procedure depending on the size and location of the lesion (Fig. 1). Charts and photos of all qualifying patients with AKN who underwent the procedure between May 23, 2012, and May 16, 2018, were reviewed for maximum sagittal width of excised lesions, associated dissecting cellulitis or folliculitis decalvans; scar shape, hypertrophy, or stretching; and insufficient wound contraction resulting in the failure of secondary joining of inferior and superior wound edges. Scar stretching was defined as wounds that contract to complete secondary edge closure only to widen later. A satisfaction survey based on the question "On a scale of 1–10 where 1 is not satisfied at all and 10 extremely satisfied, what number would you use to rate your overall satisfaction after your AKN surgery?" was also mailed to patients. All patients received standard of care and provided written consent for the surgical procedures.

Study variables were summarized as mean, ± SD, and range for continuous variables. Categorical variables were presented as counts and percentages. For categorical variables, chi square and Fisher's exact tests were performed to test for statistical differences. P values <0.05 were considered statistically significant. PASW 25 (IBM, Chicago, IL) was used to perform statistical testing.

The Bat Excision and SIH Procedure

This procedure is recommended for AKN lesions confined to the area between the occipital protuberance superiorly and the posterior hairline inferiorly. Lesions with ≤3 cm vertical width should be in the lower one-half portion of this zone to qualify (Fig. 1A). The procedure began with hair clipping in the general area of the lesion. The operation field was then cleaned with povidone-iodine. Next, the incision line to outline a generally boat-shaped inferior margin was made to include the existing posterior hairline. An extra concave recess can be added in the middle one third of the base, if desired. The superior margin was then defined by 2 dome-shaped lines occupying roughly the 2 lateral one third of the superior margins, both of which meet in the middle one third to form an inverted dome (Fig. 2A). Symmetry can be ensured by removing normal tissue, if necessary (Fig. 2A). Far-flung outlying or satellite lesions were ignored to be revisited with appropriate treatments later.

Following marking of the incision lines (Fig. 2A), margins of the incision line were injected with a lidocaine HCl

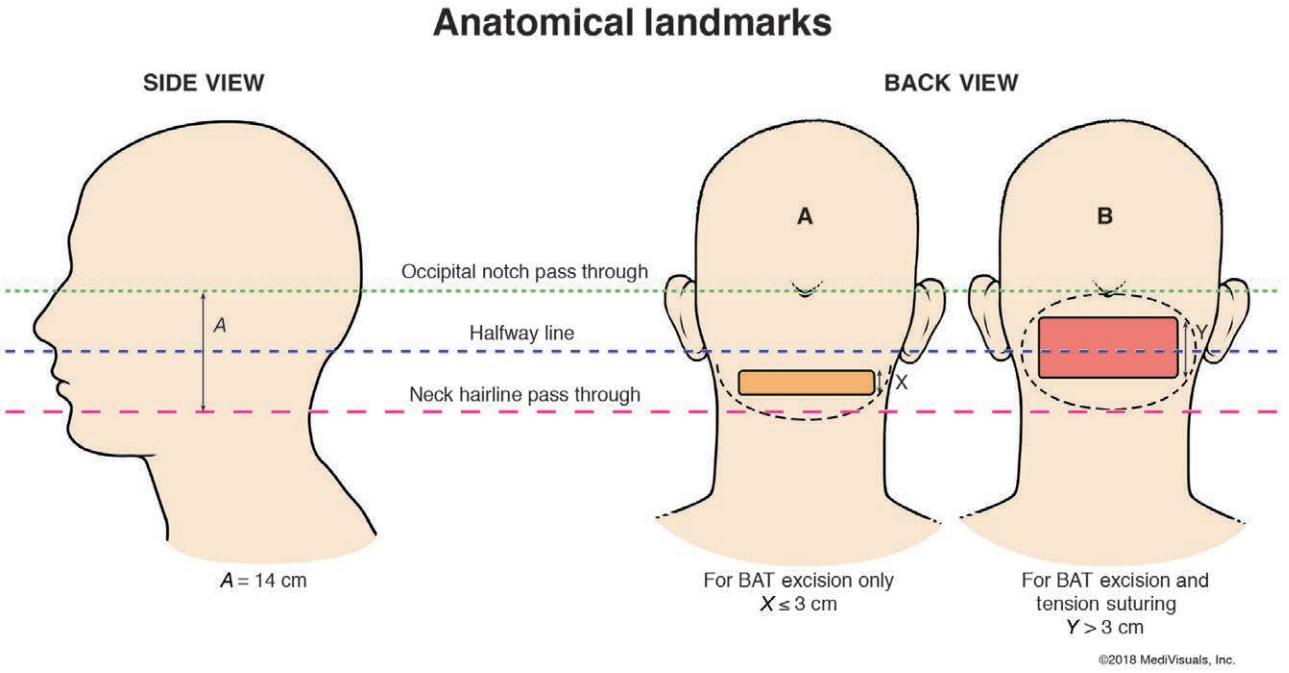

Fig. 1. Anatomical landmarks. Side and back views of the head showing anatomical landmarks and posterior scale, with indication for bat excision alone (A) and bat excision and tension suturing (B).

1% and epinephrine 1:1,000,000 mix injection. Next, the entire lesion and a zone 2–3 cm outside the incision line were injected in the subcutaneous level with the same lidocaine/epinephrine mix further diluted 10:1 with normal saline. After a period of 15 minutes, the lesion was excised to the level of galea using an electrosurgical tip capable of cutting and coagulating (Covidien SurgiStat Electrosurgical Generator II, Medtronic, Minneapolis, MN). The result is a wound shape resembling a bat in a spread-eagled position, termed the "bat excision" method (Fig. 2B).

Small bleeders were cauterized, whereas larger bleeding vessels were tied off using a figure-8 knot and 3–0 polyglactin sutures. Once hemostasis was achieved, the wound was packed with bacitracin ointment followed by a layer of petrolatum-impregnated gauze, Telfa pad, 4×4 sterile gauze, self-adhering Kerlix bandage, and Coban tape. Wound dressings are changed daily following cleansing with normal saline or acetic acid. The wound typically closed in approximately 8 weeks, although it may be less (6 weeks) or more (as high as 12 weeks) depending on certain variables.

After bat excision, SIH resulted in a linear scar, which defines a new posterior hairline with a substantially inferior concave peak that was formed by the inverted dome of the superior margin of the outline incision margin (Fig. 2C).

Bat Excision and SIH With the Aid of Tension Sutures

This procedure is recommended for AKN lesions with a vertical height of >3 cm and confined to the area between the occipital protuberance superiorly and the posterior hairline inferiorly (Fig. 3A). It is also suitable for breaches of the 2 horizontal lines defined above but generally located in the nuchal area.

The procedure is described for one representative patient (Fig. 3A) and began with the previously described bat excision (Fig. 3B). Once hemostasis was achieved, tension sutures were initiated using size 0 polydioxanone suture in an interrupted horizontal mattress fashion between the inferior and posterior margins of the wound in 3 positions (middle one-half and then right and left lateral one-half positions) along the horizontal length of the wound. Horizontal mattress sutures can also be exteriorized in pairs 1–2 cm away from the superior and inferior wound edges (Fig. 3C). Alternatively, a half-buried horizontal mattress can be used with exteriorization of the sutures only performed in an area 1–2 cm superior to the wound edges (Fig. 3D). Next, povidone-iodine-soaked 4×4 gauze pads were folded into quarters and inserted underneath the cutaneous entry and exit points of the sutures on either side of the wound margins to minimize direct suture tension on the skin, ischemia, and suture cut through of the skin (Fig. 3C, D). The sutures were tied with sufficient tension to bring the inferior and superior wound edges to within 1–3 cm of each other. The distance between the superior and inferior wound margins was manipulated to impact the desired wound shape and further influence final scar morphology (Fig. 3D).

Tension was applied during the knot-tying process. When extensive lesions were present (Fig. 3A) with superior wound margins superior to the occipital notch and outside the concave terrain of the nuchal area (Fig. 3B). This procedure ensured that the superior margin of the wound was brought below the level of the occipital notch and well within the general concave terrain of the nuchal area. Bringing the wound margins within 3–5 cm of each other will generally achieve this aim (Fig. 3D).

Next, the final defect (after approximation by tension sutures) was packed with bacitracin ointment followed by a layer of petrolatum-impregnated gauze, a Telfa pad, 4×4 sterile gauze, self-adhering Kerlix bandage, and Coban tape. The tension sutures were removed when they were observed to have lost their tautness, typically at week 4. The wound was typically closed in 8 weeks. Removal of tension sutures before they have lost their tautness may result in stalled progression of wound contraction and ultimately a wide scar (Fig. 3E). The operator also has the option of using a multifilament absorbable such as size 0 polyglactin tension sutures in a horizontal mattress fashion that is buried on both sides. Because these sutures would dissolve in 60–70 days, a follow-up visit to remove sutures is unnecessary. The combination of the bat excision and tension sutures in extensive AKN lesions that are allowed to heal by SIH typically results in a more predictable wound contraction and esthetically pleasing posterior hairline shape (Fig. 3F).

Debridement of Maturing Granulation Tissue and Neoepithelium With or Without Tension Suturing

In AKN excision surgeries that rely on SIH, premature epithelization will occur occasionally. This is when the vertical width of the granulation tissue is considered too wide (≥2 cm) at the onset of epithelial tissue formation in the wound margins (Figs. 3E, 4A). Unaddressed this would

Fig. 2. Examples of Bat excision and SIH procedure. A, Patient 1, a Hispanic man, age 59 years, with a ≤3 cm vertical width acne keloidalis nuchae lesion in the lower half of the area between the posterior hairline and occipital protuberance showing the outline for a planned bat excision. B, Patient 1, after bat excision, the wound assumes the shape of a bat in a spread-eagled posture. C, Patient 1, 8 weeks postoperative.

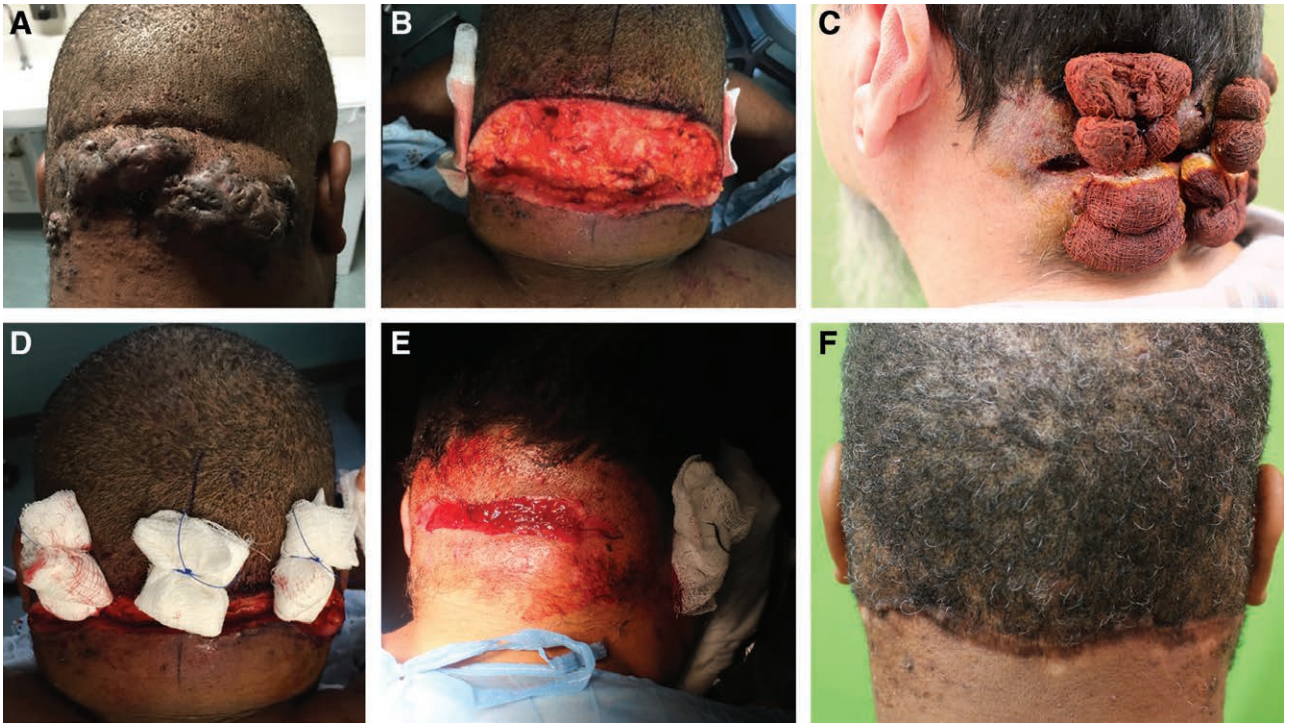

Fig. 3. Examples of Bat excision and SIH with the aid of tension sutures. A, Patient 2, an African American man, age 44 years, with acne keloidalis nuchae tumors whose spread breaches the level of the occipital protuberance superiorly and the posterior hairline inferiorly. B, Patient 2, after bat excision, the wound assumes a shape of a bat in a spread-eagled posture. C, Patient 4, a Hispanic male, age 40 years, immediately after aggressive debridement of granulation tissue and wound margin epithelial tissue followed by application of horizontal mattress tension sutures exteriorized on both sides and padded by folded gauzes soaked in povidone-iodine solution. The wound edges are brought to within 1–1.5 cm of each other. D, Patient 2, after the application of tension sutures to bring the superior wound margins into the concave fold of the nuchal area. A half-buried horizontal mattress with exteriorization of the sutures is performed in an area 1–2 cm superior to the wound edges. Wound edges are approximated to within 2–3 cm of each other. E, Patient 4. 15 weeks after bat excision of acne keloidalis nuchae and tension suturing, which had been prematurely removed after 1 week, showing an open wound that has ceased to contract any further in the prior 4 weeks. The noncontracting wound shows marked epithelization especially in the lateral margins. In this state of wound healing, the myofibril activity has ceased and the wound width and size are set to define the final scar dimensions. F, Patient 2, 14 months postoperative.

cause a cessation of wound contraction to result in a wide scar whose width is determined by the width of the wound at the onset of epithelization. The authors have addressed this problem by debridement of the granulation tissue along with its neoepithelium.

The procedure is described for one representative patient and began with cleaning of the area, infiltrated with lidocaine/epinephrine mix, and debridement of granulation tissue by curetting to a level just below the vertical wound edge level using a 15-blade scalpel or curette. Neoepithelial tissue forming in the margins was also excised to create a better-defined wound margin (Fig. 4B). Hemostasis was achieved either by electrocautery or by aluminum chloride. A layer of bacitracin was then applied, and the patient advised to continue daily dressings with saline-soaked gauze on a bacitracin-layered base.

With the removal of premature epithelial tissue and debulking of granulation tissue, contractile forces are expected to continue unabated, ultimately resulting in a smaller width scar (Fig. 4A–C).

In instances where the wound contraction has already stalled (Fig. 3E), the debridement procedure was accompanied by the use of tension sutures using already described methods (Fig. 3C, D). Although it would have been possible to primarily close the resulting wound, the tension sutures were used to bring the superior and inferior wound margins to within 1–3 cm of each other (Fig. 3C). The purpose of the tension sutures was to bring about a cascade of changes that would favor wound contraction. Closing the wound primarily would have resulted in a scar that would initially heal well only to stretch to undesirable widths.[12,13] Tension sutures were removed after they had lost their tautness after 2 weeks.

In stalled wound contraction, it is expected that debridement of mature granulation tissue and excision of its neoepithelium causes a resetting of the wound healing cascade, similar to a new wound. Adding tension sutures in this setting encourages the wound to resume contraction in its cascade of activities with the ultimate result to create a scar whose vertical width is considerably smaller than the width set at the time of granulation tissue maturation before the procedure (Figs. 3E, 5A, B).

RESULTS

The mean age of the 37 patients was 33.6 years (range: 25.0–58.2). The mean maximum sagittal width of excised

Fig. 4. Example of debridement of maturing granulation tissue and neoepithelium without tension suturing. A, Patient 3, a Hispanic man age 22, 4 weeks after acne keloidalis nuchae oval excision showing a 2-cm-wide granulated wound with premature epithelization in wound margins at 4 weeks after oval excision (not bat excision). B, Patient 3, immediately after debridement of granulation tissue and wound margin epithelial tissue. C, Patient 3, at 8 weeks showing that a cosmetically pleasing scar line holds.

lesions was 5.4 cm (SD: 1.83; range: 2–11 cm). Three patients underwent bat excision alone, whereas the remaining 34 patients had bat excisions and tension suturing. Four patients required debridement, 3 of whom had a secondary application of tension suturing.

Open wounds spontaneously contracted in 35 patients, resulting in secondary joining of the upper and lower wound edges to define a new esthetically desirable M- or U-shaped posterior hairline (Fig. 3F; Table 1). The exceptions were two patients whose open wounds did not contract sufficiently enough to cause secondary fusion of the inferior and superior wound edges because of large lesion sagittal widths (8 and 11 cm) and nearly nonexistent scalp laxity. Of the 35 patients with fully contracted wounds, 12 (32%) patients had mildly stretched scars with width <2.5 cm (Fig. 5B; Table 1). Two patients, both with severely diminished scalp laxity, had more significantly stretched scars (2.5–3.5 cm width).

Excised lesion width ≥6.5 cm was predictive of development of a stretched scar >2.5 cm in width ($P = 0.042$) or insufficient contraction with failure of the inferior and superior wound margins to secondarily merge ($P = 0.042$). In addition, an excised lesion width of ≥6.5 cm was also highly predictive of occurrence of the above events ($P = 0.001$); odds ratio: 59 (95% CI: 2.7–1,290.9). Four of 8 (50%) patients experienced a wide scar when the excision width was ≥6.5 cm compared with no patients with an excision width of <6.5 cm.

Two patients had hypertrophic scar sequelae, which completely resolved with steroid injections (Fig. 7). Minor suture track marks (Fig. 5b) were noted in 21 patients (57%); in 2 patients, 1 of 3 pairs of suture marks cut through to the wound margin. None of the 23 patients with suture marks including cut through considered it cosmetically significant. Most patients received a steroid injection, topical steroids, antibiotics, or other procedures before bat excision with tension suturing (Table 1). No recurrence of excised lesions was observed in any patient.

Twenty-five patients who underwent these procedures responded to the mailed questionnaire and reported high levels of satisfaction, with a mean Likert score of 7.7 (SD 2.64). The mean follow-up time was 1.9 years (SD 1.52).

DISCUSSION

Large AKN excisions with SIH are generally favored over other surgical approaches such as primary closure[10] and skin grafting.[15] These latter two procedures have a risk of recurrence and large scars,[2,3,9,12–14] whereas skin grafting can create cosmetically dismal bald atrophic areas mismatched in color, texture, and thickness.[2,10,13,14]

Table 1. Additional Information on Current Procedures and Complications, Past Medical Treatments for AKN, and Satisfaction with Current Surgical Procedure

Parameter	Percentage	N
Procedure type		
Bat excision	100	37
Tension suturing	92	34
Debridement	11	4
Debridement with second tension suturing	8	3
Complications		
Mild stretched scar (≤2.5 cm)	32	12
Minor suture track marks*	57	21
Failure of edges to join secondarily†	5	2
Hypertrophic scar‡	5	2
Significant suture track marks (cut through to wound margin)§	5	2
Significant stretched scar (>2.5 cm)¶	5	2
Recurrence of excised lesions	0	0
Disease conditions associated with AKN		
Clinically visible dissecting cellulitis or folliculitis decalvans	11	4
Past AKN surgery	5	2
Past medical treatment for AKN		
Topical steroids	8	3
Steroid injection	68	25
Antibiotics	43	16
Others	41	15
Patients with desirable M- or U-shaped posterior hairline	95	35
Satisfaction score,‖ mean (SD)	7.7 (2.64)	25

*Suture track marks noted in photos but not a concern to any patient.
†Both patients had >8-cm-wide lesions removed and no scalp laxity. In one patient, extensive folliculitis decalvans in the area above the excised lesion contributed to poor scalp laxity.
‡Both hypertrophic scars resolved permanently with intralesional steroid injections.
§Track marks with suture cutting through to wound margins noted on photos but was not of significant concern to these two patients, both of whom reported satisfaction scores 7 and 9 out of a 1–10 Likert scale, respectively.
¶Both patients with significant stretching had scars <3.5 cm width. Both had very poor scalp laxity, and one had an 8-cm-wide lesion excised.
‖Based on survey question: on a scale of 1–10, where 1 is not satisfied at all and 10 is extremely satisfied, what number would you use to rate your overall satisfaction after your AKN surgery?

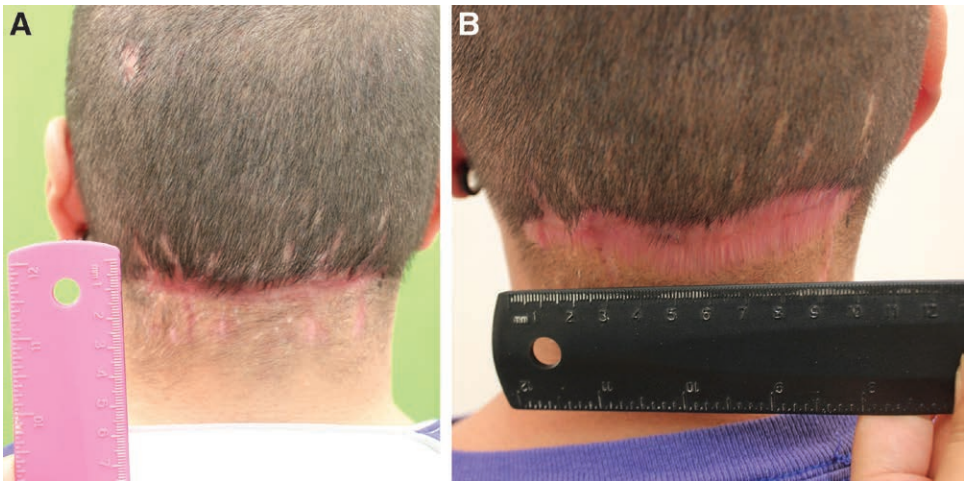

Fig. 5. Example of delayed stretched scar A, Patient 4, 4 weeks after debridement of mature granulation and neoepithelial tissue and SIH assisted by tension sutures. The wound shows an ideal M-shaped scar and posterior hairline. B, Patient 4, 16 months after the debridement of mature granulation and neoepithelial tissue and SIH assisted by tension sutures. The wound shows a mildly stretched M-shaped scar and posterior hairline with a maximum vertical width of nearly 2 cm as well as suture track marks.

Excised large AKN wounds that heal with second intention tend to form an inverted U- (fish-mouth) shaped posterior hairline contrary to the natural state, which consists of a straight or gentle U outline with the occasional M-shaped wave form with V- or U-shaped peak. This can result in an unaesthetic posterior hairline and scar that is misshaped and markedly hypertrophic, with possible AKN recurrence (Fig. 6).[12]

The bat excision approach is advantageous by offering an ability to manipulate the shape of the excised wound to influence the final configuration of the scar line (Figs. 2C, 3F, 5A). Combining bat excision and tension suturing can provide several benefits. Using tension sutures increases the chance of wound closure by contraction and the spontaneous coming together of the inferior and superior wound margins, instead of by epithelization. The use of tension sutures can also tilt the scale in favor of these contractile forces and linear scar formation; studies have shown that manipulation of tension on the wound inside the first 48 hours of wounding influences fibroblasts to become proto-myofibroblasts that further transform (buoyed by mechanical tension) into differentiated myofibroblasts. Differentiated myofibroblasts are pivotal to the contractile ability of the wound.[16] Additionally, increasing resistance in the tissue surrounding wounds induces the differentiation of myofibroblasts to initiate and enhance wound contraction.[17]

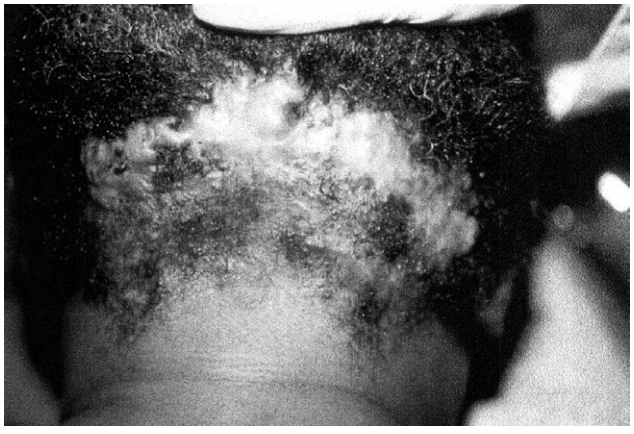

Fig. 6. Example of an unacceptable scar shape. Reprinted with permission from *Arch Facial Plast Surg* 1999;1:308–311; Copyright © 2000 American Medical Association.

Fig. 7. Example of post- operative hypertrophic scarring. Patient 2, showing formation of an M wave–shaped hypertrophic scar at 6 months after bat excision and SIH assisted by tension sutures.

By manipulating the tension at different points of the tension sutures, one can further manipulate the ultimate shape of the wound to a preferred M-shape line that ultimately defines the ideal posterior hairline (Figs. 3F, 5A): Primarily, contractile forces generated by these sutures bring about the deposition of collagen and cellular fibronectin-rich extracellular matrix (ECM). The newly formed collagen and ECM, as well as the fibroblasts themselves, are layered in particular patterns, oriented parallel to the wound bed and along expected lines of stress.[18,19]

In more extensive lesions distributed in areas beyond the occipital notch superiorly (Fig. 3A, B), the surgeon can use tension sutures to forcefully bring the superior margins of the wound to well below the occipital notch, which will align the wound margins within the concave topography of the nuchal area (Fig. 3C). Wounds confined to concave terrains heal better by SIH compared with similar wounds that are disposed in flat or convex terrains.[20] In concave terrains, these contractile wound healing forces always have an advantage over healing by the epithelization of granulation tissue beds.[21]

It is important to debride the premature epithelization of wounds when epithelization occurs in granulated wound margins while the wound is still too wide and insufficiently contracted. In addition, use of debridement combined with tension sutures allows contraction even in wounds that have ceased shrinking for periods of 4 weeks or more (Figs. 3C, E, 5A).

We have observed that sagittal width of the excised lesion is the most significant determinant of the occurrence of significant scar stretching (>2.5 cm width) and wide scars caused by insufficiently contracted wound and failure of the inferior and superior wound edges to unite to form a linear scar as expected. Based on our results, we expect that patients with excision lesions ≥6.5 cm will be at greatest risk for these events, with approximately 50% likely to experience a wide scar. Another factor is severely constricted scalp laxity, the role of which warrants further study.

Other possible complications include hypertrophic scarring in predisposed patients (Fig. 7), easily resolved with intralesional steroids (Fig. 3F). Furthermore, the presence of extensive folliculitis decalvans in areas above the excised AKN lesions could be predictors of insufficient wound contraction. This effect may be due to reduction in scalp laxity that this cicatricial scalp disease mitigates. Tension sutures commonly form track marks (Fig. 5A, B), which is not a problem for patients.

In summary, our new techniques enabled better control over wound contracture with improved cosmesis and better aesthetics of the hairline in AKN. This improved outcome is based in part on comparison with previous reports of outcomes after surgical removal of large AKN lesions, including the example shown in Figure 6. We cannot, however, exclude the possibility that other factors may influence the incidence of scar complication besides width of excision margins. Although our report includes the largest cohort of patients with large AKN excisions to date, a prospective well-controlled study with a larger number of patients can best evaluate predictors of scar formation and the techniques reported here.

Sanusi Umar, MD
Dr. U Hair and Skin Clinic
510 N. Prospect Avenue, Suite 209
Redondo Beach, CA 90277
E-mail: drumar@dru.com

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