Chapter 1

Wound Healing and Care

Abnormal Healing—Hypertrophic Scars and Keloids

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The science of basic wound healing is covered well in basic surgical textbooks. It is imperative that surgeons everywhere have a solid understanding of the principles of wound healing. The surgeon is constantly confronted with the difficult task of wounds in a variety of stages within the healing process. This chapter will help one better understand the abnormal wound healing processes that lead to hypertrophic scarring and keloid formation and give one basic steps in preventing and treating these conditions in remote areas. Other chapters will deal with chronic wounds and ulcers and Vacuum Assisted Wound Closure and skin grafts.

There are many causes of abnormal healing. Some of the more common causes in Africa are:

1. Anemia—though the hemoglobin must be below 5 grams before it will directly affect wound healing, it frequently coexists with chronic malaria, worm infestation, general malnutrition, immunocompromised conditions and poverty.

2. Diabetes is common and uncontrolled diabetes leads to impaired fibroblasts and collagen deposition and epithelialization.

3. Untreated AIDS is a major cause of delayed wound healing. The first sign of immunocompromised state maybe a chronic wound

4. Atherosclerosis is seen more than expected.

5. Venous stasis affects wound healing and lack of elevation is a common cause of slowly healing wounds.

6. Aging

7. Malnutrition with deficiency of
   A. amino acids and a low serum albumin
   B. vitamin C and A deficiency
   C. trace elements

8. Infection

9. Sickle Cell Anemia

10. Drugs, tobacco, beetle nut use

11. Environment—excessively wet or dry climates may contribute to poor wound healing
With any slowly or non-healing wound, a reasonable workup to exclude the above factors and conditions should be carried out. The most likely causes are diabetes or other immunocompromised state, stasis, sickle cell, malnutrition, and aging. The chapter on chronic wounds discusses management of the subacute or chronic wound.

Excessive scar formation

There are two types of excessive cutaneous scar formation. They are hypertrophic scarring and keloid formation. Though both result in an overgrowth of scar with excessive collagen formation, it is important to differentiate between the two.

Hypertrophic scars

Hypertrophic scars are self-limited, raised, excessive scar tissue that remains within the border of the wound. They can occur within weeks after the original wound injury. Hypertrophic scars occur in persons of any age and at any wound site, either surgically created or by traumatic injury. They tend to spontaneously regress in size over time and are generally more responsive to treatment compared to keloids. Tension at the site of the wound is often responsible for the formation of hypertrophic scars. Though hypertrophic scars may be found anywhere, there is a higher propensity for them to occur on the chest, the upper back, or the deltoid regions. Other factors contributing to hypertrophic scar formation are a prolonged inflammatory response, infection, foreign body (e.g. suture material) and wound orientation different from the direction of skin tension lines. Patients tend to complain of their appearance and pruritic sensation. Small hypertrophic scars generally respond well to a steroid injected into the lesion like triamcinolone acetonide (Kenalog). A dose of 10-40mg (usually comes in 40mg/1ml) is injected into the scar using a 25-27 gauge needle. Unlike keloids, hypertrophic scars normally may be excised and closed primarily in a tension free manner in the direction of relaxed skin tension lines without fear of recurrence. This is most effectively performed by excising a linear scar in a fusiform fashion with a 4:1 length to width ratio of the wound to assist in closure. Scars not oriented along relaxed skin tension lines, can be reoriented in a more tension free direction using a one or more simple z-plasties. Compression therapy with Spandex or other elastic material can be used in garments to apply pressure. (See chapter 33.) These garments maybe used for treatment and also for prevention of hypertrophic scar in acute wounds with a tendency for hypertrophic scars. Silastic gel sheeting may also be used if available. When special garments are not
available, bandages such as an Ace or Crepe may be used to apply pressure. When primary closure is not possible, a split thickness or full thickness graft can be used. Once the wound has healed pressure may be applied to prevent recurrence.

Often burns are associated with hypertrophic scarring and with contractures if over joints. These can also be excised with skin grafting or a local flap transfer. It is best to wait 12 months for the scar to mature especially if some of the scarred skin will be used in a local flap. There may be a place for serial excision in large hypertrophic scars. One must be sure that it is a hypertrophic and not a keloid before proceeding with this treatment option. Rarely after complete surgical excision there may be recurrence. Waiting for these recurrent scars to mature before any further surgery is advised. If one is close to a large city, low dose irradiation may be helpful in the control of recurrent hypertrophic scars. Cocoa butter is often available and has been found by some to help control itching. (See Chapter 15 Burn Reconstruction)

**Keloids**

Clinically, keloids are identified by continued excessive growth of the scar beyond the border of the actual wound. Keloids are less common than hypertrophic scars and appear to have a genetic component that primarily affects African and Asian populations. This abnormal proliferation of scar tissue with immature collagen synthesis up to 20X normal, as compared to 14X in a hypertrophic scar, can form either from a surgical incision, burns or from a simple and sometimes forgotten traumatic injury to the cutaneous tissue. Compared to hypertrophic scars, keloids do not naturally regress in size, but may continue to enlarge over time. They are also predominantly in high-tension areas of the skin such as the shoulder, anterior chest and neck. Keloid formation generally begins within a year after injury. Other significant risk factors, similar to hypertrophic scarring, are wounds that heal by secondary intention and wounds with chronic inflammation as in earring sites. Patients complain of the keloid’s unsightly appearance as well as pruritic and burning sensation at or around the keloid.

The treatment of keloids can be frustrating. The most important consideration is prevention in those that are at a high risk for keloids. Great care should be taken in closing wounds in a tension free manner, paying attention to the direction of the scar and with an appropriate soft tissue layer closure. Monofilament suture may be helpful in causing less reaction and sterile technique should be followed in minimizing the risk of subsequent infection.
No readily available modality is effective to completely prevent keloid formation. Hypertrophic and keloid prone areas should be carefully closed, especially with long lasting deep dermal sutures.

In large cities low dose irradiation is usually available and can be administered within a few days of keloid excision. There are different treatment regimens but irradiation is often given daily over 3-4 days. The results are outstanding on the smaller keloids as those around the ear. Irradiation should not be used in children. The injection of steroid into the keloid is generally the best first line treatment for small keloids. The corticosteroid of choice is triamcinolone acetonide (Kenalog). The goal is to inject the body of the keloid scar with 10-40 mg/ml using a 25-27 gauge needle at 6-8 week intervals. The triamcinolone is mixed half and half with a local anesthetic. This not only provides anesthesia for the injection but gives increased volume for the injection. The author will penetrate just beneath the skin with the needle and then make multiple radial sticks throughout the keloid prior to injection of the steroid. The needle is then withdrawn to just beneath the skin and the steroid injected. This allows the solution to fill the keloid in every direction. Oftentimes, a larger gauge needle is needed with larger keloids. Some feel the internal pressure from within the keloid by the injected fluid is significant in the resolution of the keloid. It may be impossible to inject very hard keloids and these require surgical removal. Care should be taken not to inject the steroid into the subcutaneous tissue that may result in atrophy and loss of pigmentation in the surrounding tissues. The results of steroid injections in small keloids can vary from partial flattening to nearly complete or complete resolution. Large keloids cannot be effectively treated with triamcinolone.

As with hypertrophic scars, compression therapy has been effective as an adjunct to treating keloids after steroid injection and after keloid excision. Patients should be encouraged to massage keloids regularly after steroid injections. Keloids resulting from earrings can often be helped by creating special large earrings that apply pressure after steroid injection. These are commercially made but it may be possible to create a device to apply pressure. Garments made of spandex, fabricated to provide consistent pressure may be of help in the treatment of keloids occurring on the trunk, extremity or even face and neck. If one has Spandex or a similar elastic material, a seamstress may be able to custom-make a garment to apply constant pressure. Often these can be worn for at least 12 hours at night and sometimes all day. Silastic gel can also be applied to the area if it is available. (See Chapter 32)
If it is decided to proceed with excision of a keloid, the patient should be informed preoperatively of the high rate of recurrence. Excision with primary closure has recurrence rates in keloids of 50% and often with recurrence of equal or larger size. Steroid injection should be administered at the time of excision into the superficial dermal edges of the wound. This can be repeated at two to three week intervals postoperatively. Incisions should be made in relaxed skin tension lines whenever possible. If a tension free closure is not possible, a split thickness or full thickness skin graft may be best. Additionally, methotrexate can be given as a single oral dose, 15-20 mg. in an adult, one week before keloid excision and then continuing for three - four months after surgery. This may be helpful in limiting keloid recurrence. In younger patients a dosage of 0.3 mg /kg orally is used weekly for at least 6 weeks after surgery. Compression therapy if possible should also be used after keloid excision.

Many other medical therapies, which may not be available to you, have been used with inconsistent results. Patients with keloids will travel many kilometers and pay large sums of money for any help they can get. Unfortunately, complete cure is rare and especially in remote areas with limited treatment modalities.

**Sycosis Barbae and Folliculitis Keloidalis**

Infections in hair follicles can lead to keloid formation. These conditions seen in men, usually of African descent, are sycosis barbae and folliculitis keloidalis. **Sycosis barbae** involves the bearded areas of the face and begins as a folliculitis after shaving. Sycosis is a papulopustular inflammation of the hair follicles. This is also called barber’s itch and folliculitis barbae. It may begin as a superficial staphylococcal infection. Repeated episodes of infection lead deep-seated infections, multiple discharging sinuses and keloid formation. These deep, entrenched infections are difficult to treat and they do not respond well to antibiotics alone. Since these keloids are chronically infected and constantly draining, they should be excised once any acute infection is under control.

**Folliculitis keloidalis** involved the nape of the neck, occipital scalp, and initially may look like a dermatitis or acne. This may be secondary to a haircut but often there are ingrown hairs that irritate the wall of hair follicles and lead to inflammation. Over time keloids may develop in these chronically infected areas.
Both of these conditions may initially respond both oral antibiotics as Doxycycline and topical antibiotics where available. Once the infection is under control, surgery may be performed. With deep, follicular infections, antibiotics will not control the infection that is deep within the sinuses. Complete excision with delayed skin grafting is recommended. Excision must be carried down below the level of the hair follicles in the subcutaneous tissue. In most of these cases, it is important to leave the wound open and take the patient back for one or more “second look” procedures to further débride questionable areas.

Surgical technique: surgery is performed under general anesthesia with Xylocaine/Lidocaine with adrenalin infiltration in the skin to decrease the bleeding and also help with visualization. This is often diluted when dealing with large keloids as shown in the case below. Electrocautery is useful in minimizing bleeding, but one must be careful not to damage vital structures within the area of surgery. Repeat débridements are carried out every other day. In subsequent débridements the Weck or Humby knife blade is used for tangential excision. Since important structures maybe nearby in sycosis barbae, especially the marginal mandibular branch of the facial nerve, the author feels that tangential excision down to viable, non-infected tissue is the safest method of débridement. As soon as the bed is clean without evidence of residual infection, it is skin grafted. Complete and adequate débridement may require 7-10 days. Thick split thickness sheet grafting is ideal, but a meshed graft without spreading it out, may be the safest, if one is concerned about residual deep infection. See case below. Where low dose radiation is available, a single dose after skin graft healing may reduce recurrence.
Since infection is usually the cause for the keloid, recurrent keloid formation may be prevented by careful shaving and early antibiotic treatment of any recurrent infection. The patient may need to change from mechanical shaving to using chemical depilatory agents – creams or powders that will be available in city pharmacies and stores.

In the author’s experience, recurrence is not likely if one follows these guidelines. Additional measures to prevent recurrence are: A compression garment maybe placed over the graft, as custom made ones seen in chapter 33 or this could be a dressing with a neck collar or an elastic bandage wrap. Triamcinolone may be injected around the edges of the graft every month for several months if it is available. Triamcinolone 40 mg. is diluted with lidocaine 1:1 or 1:2 for large areas. The lidocaine also offers analgesia during infiltration. If one has access to silicone sheets, these maybe placed on the healed wound under a neck collar or pressure garment. The silicone should be used continuously for several months and then at night time for a year to reduce recurrence.

This patient had bilateral severe sycosis barbae and keloid formation. He was draining from multiple deep sinuses. Multiple secondary tangential excisions with the Weck blade were required to completely excise all of the deep infected follicles. Fig 2 shows the wound after the first excision. If cultures can be obtained, appropriate antibiotics should be used. Otherwise broad spectrum antibiotics are used for these chronic deep infections. Staphylococcus is often the predominant organism. Skin grafting is carried out only when there is no evidence of residual infection.
After a period of oral antibiotic intake and local antibiotic cream application, complete excision of the keloids, skin grafting and postoperative single-low dose radiation therapy was carried out. The patient then used silicone sheets for a year, and has not had any recurrences. He uses depilatory powder for his beard. (Editor’s note: The keloids around the ears in the above patient are not the typical sycosis barbae keloids. They are not in the heavy beard area and deep-seated folliculitis is less of a problem and the response to local and oral antibiotics would typically be better. Low dose preop irradiation, where available, is an excellent way of preventing keloid recurrence in such cases. The neck keloid is still in the beard.)

Excision and skin grafting of folliculitis keloidalis in the occipital scalp may create an additional problem in a male of African descent—a bald area which is cosmetically disfiguring. In such a case, after the skin graft has healed, either serial excision of the graft or tissue expansion in normal hair-bearing scalp may be done. Then the unsightly graft may be excised. If either of these measures is performed, care must be taken not to close the wound under tension as this may lead to keloid recurrence. Deep sutures must be taken between the galea and pericranium so as to limit and relax tension with closure.

As stated above, when keloids are likely caused by infection, the infection should be controlled with antibiotics, then excised and closed with flaps and/or skin grafts. When tension and infection can be eliminated postoperatively, these keloids are likely not to recur as in the case below.
Current algorithms for the treatment and prevention of hypertrophic scars and keloids by Rei Ogawa, M.D., Ph.D. are shown below. No one will have all the modalities mentioned but this gives one a guide for possible treatment.

Conclusion

Understanding the basic phases in the normal wound healing process is necessary in managing wounds at various stages of healing. Recognizing that abnormal healing may lead to excessive scar formation and ultimately hinder function, the surgeon should be alerted to use preventive measures prior to or after surgery and soon after injury or burns. It is important to distinguish the two kinds of abnormal scars and to proceed carefully in their treatment in order that a bad scar is not made worse. Many keloids should not be excised unless one has the availability of postop low dose radiation. The author has also used low dose methotrexate systemically after keloid excision but its efficacy has not yet been proven. Other methods have been used but are either too expensive or there is not yet good evidence for their widespread use. As in other wound care, dedicated physician care as well as patient compliance is required for the best results.

Other chapters will deal with chronic wounds and ulcers and Vacuum Assisted Wound Closure and skin grafts.

The Most Current Algorithms for the Treatment and Prevention of Hypertrophic Scars and Keloids by Rei Ogawa, M.D., Ph.D. are shown below. No one will have all the modalities mentioned but this gives one a guide for possible treatment.

Ogawa, Rei M.D., Ph.D.

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(Algorithms used by permission from Lippincott Williams and Wilkins)
(A) Exclusive diagnosis of similar diseases and differential diagnosis of hypertrophic scars and keloids

Hypertrophic Scars (HSs)

HSs with severe scar contractures including joint contractures

HSs with mild scar contractures

HSs without scar contractures

Large / Wide HSs

Small / Linear HSs

(B) Partial surgical contracture releasing

a. Skin grafting
b. Local flap transfer

(C) Complete surgical resection

Effective

Recurrence

(D) Non-surgical multimodal therapy

a. Compression therapy
b. Gel sheets
c. Corticosteroid injection
d. Laser
e. External agents
f. Internal agents
g. Make-up / camouflage therapy
h. Others

(E) Surgery + adjuvant therapy

a. Surgery + radiation
b. Surgery + corticosteroid injection

Effective

Recurrence

(F) Long-term follow-up + conservative therapies

a. Gel sheets
b. Taping fixation
c. Compression therapy
d. External agents
e. Internal agents
f. Make-up / camouflage therapy

(G) Conservative multimodal therapy

Effective

Recurrence

Satisfactory improvement

Unsatisfactory results

Repeat
(A) Exclusive diagnosis of similar diseases and differential diagnosis of hypertrophic scars and keloids

Keloids

Small / single keloids

Large / multiple keloids

(B) Radical treatments

(D) Surgery + adjuvant therapy
  a. Surgery + radiation
  b. Surgery + corticosteroid injection

(E) Non-surgical monotherapy
  a. Corticosteroid injection
  b. Cryotherapy
  c. Laser
  d. Antitumor / immunosuppressive agents

(Satisfactory mass reduction)

(Effective)

(Recurrence)

(Repeat)

(F) Mass reduction surgery

(G) Symptomatic non-surgical multimodal therapy
  a. Corticosteroid injection
  b. Cryotherapy
  c. Laser
  d. Antitumor / immunosuppressive agents
  e. Compression therapy
  f. Gel sheets
  g. External agents
  h. Internal agents
  i. Make-up / camouflage therapy
  j. Others

(Satisfactory results)

(Unsatisfactory results)

(H) Long-term follow-up + conservative therapies
  a. Gel sheets
  b. Taping fixation
  c. Compression therapy
  d. External agents
  e. Internal agents
  f. Make-up / camouflage therapy

(Satisfactory symptom improvement)

(Unsatisfactory results)

(Repeat)

(Consider)

(F) Mass reduction surgery