Tangential Excision of Burns

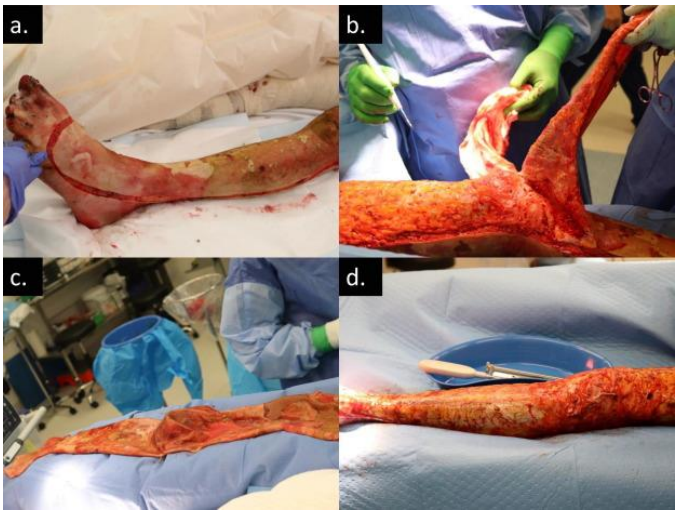
Cassidy A. Muir, Peter Stafford, Goran Jovic, Deepak K. Ozhathil

Introduction:

Where resources permit, early burn excision for deep partial and full thickness burns and skin grafting is recommended. Tangential excision was pioneered by Dr. Zora Janžekovič through her work with burn patients in the former Yugoslavia in the 1960s. Since then, it has become the standard of care in resource-rich settings where there may be ready access to blood products and general anesthesia. In contrast, in resource limited settings, conservative management is pursued, as this is often safer for the patient. This approach consists of wound care until the burn eschar has sloughed off, leaving a granulating wound that can be grafted. However, in many cases (including the examples shown in this chapter) it is safer and more expedient to excise tissue that is clearly burned.

Burn wounds can be excised in a tangential or fascial manner. Tangential excision is performed most often and involves sequential excision of burned tissue until viable tissue is reached. This can be done with a number of different surgical instruments. Most commonly, sharp excision is performed with the Watson knife or the Goulian-Weck blade. Progenitors of these instruments such as the Rosenburg, Thiersch, and Humby knives are still used at some institutions. Powered dermatomes such as a Padgett-Hood or Brown dermatomes or Amalgatome can be used, as well as hydrosurgical dissection using a VersaJet, or mechanical debridement using a TPS Dermabrader. The latter techniques are especially useful on highly contoured surfaces such as the face and hands.

Full fascial excision removes skin and subcutaneous tissue en-bloc down to the anterior fascial plane and is usually performed with diathermy or in combination with sharp dissection. This technique is reserved for deep, large, or severely and invasively infected burns where patients would not tolerate the extensive blood loss of tangential excision. Fascial excision is associated with lymphedema and contour deformities leading to worse functional and cosmetic outcomes.



Full fascial excision removes burned tissue down to the fascia underneath, usually performed with diathermy or a scalpel blade. This technique is not further described here. Source: Greenwood JE et al, *https://doi.org/10.1016/j.burnso.2020.06.003*

The steps of tangential excision and grafting include:

- Preoperative labs and assessment of the need for blood availability
- Determination of area to be excised and positioning of the patient
- Temperature regulation
- Techniques to limit blood loss with excision
- Tangential excision to viable tissue
- Hemostasis
- Immediate autografting or placement of skin substitute
- Dressing placement

Steps:

1. Preoperative hemoglobin or hematocrit levels should be obtained. Depending on the value and the total body surface area planned to be excised, blood may need to be prepared for transfusion.
2. The area to be excised is planned prior to surgery, but the amount excised may change intra-operatively due to the physiologic status of the patient. When performing multiple excisions over the course of several days, large areas, such as the anterior or posterior torso, or large portions of an extremity are excised first, removing as much non-viable tissue as is safely possible. In

cases where the patient may not be stable enough to tolerate excision of all wounds in a single surgery, many surgeons prefer to stage excisions in a proximal-to-distal manner, choosing to minimize mortality risk at the expense of increasing functional morbidity. The patient may be positioned supine, lateral decubitus, or prone as needed to perform the surgery. At times, it may be necessary to reposition the patient intraoperatively to access the necessary sites for excision and grafting.

Patient positioned prone for excision of full thickness buttock burn wounds

3. The burned patient's ability to maintain their body temperature is altered, and it is important to keep the patient warm, between 36-38°C. Uninvolved areas should be covered with blankets and involved areas may be temporarily covered with a surgical drape or a fluid warmer cover. For large surface area burns, a tremendous amount of heat can be lost from the patient during the surgery. Therefore, it is essential to pre-warm the operating theater prior to surgery, make every effort to minimize unnecessary heat loss from the room, and closely monitor the patient's temperature throughout the case. If the patient's temperature deteriorates during the surgery, the surgeon should limit the extent of excision and staging operative goals over multiple surgeries, giving time to rewarm and resuscitate the patient.
4. A major limitation of tangential excision is blood loss, and it is important to take steps to minimize surgical blood loss. Studies have demonstrated standard blood loss of 40-80 cc per 100 cm^2 of excised tissue. For wounds to distal extremities, a tourniquet placed proximally works well. Compression bandages, along with hemostatic dressings if available, or laparotomy pads soaked in epinephrine solution are also useful to apply pressure to minimize bleeding after excision. For the torso, subcutaneous injection of an epinephrine solution at a concentration of 1:200,000 to 1:1,000,000 can be used in combination with the hemostatic efforts described. Diathermy is also necessary in the excision of most large burn wounds, but care should be taken to minimize iatrogenic thermal injury to the wound bed.
5. Tangential excision involves sequential passes with a sharp knife, removing non-viable burned tissue until vascularized tissue is present. It is helpful to start with excision of dependent portions first, as these areas may be otherwise obscured by blood that has run down from non-dependent areas. Excision is facilitated by making the tissue taut. For the extremities this can be obtained by pulling and tightening the tissue from the opposite side. Penetrating clamps can be used to give tension. For the torso, penetrating clamps and subcutaneous injection of epinephrine solution are particularly helpful to provide tension.

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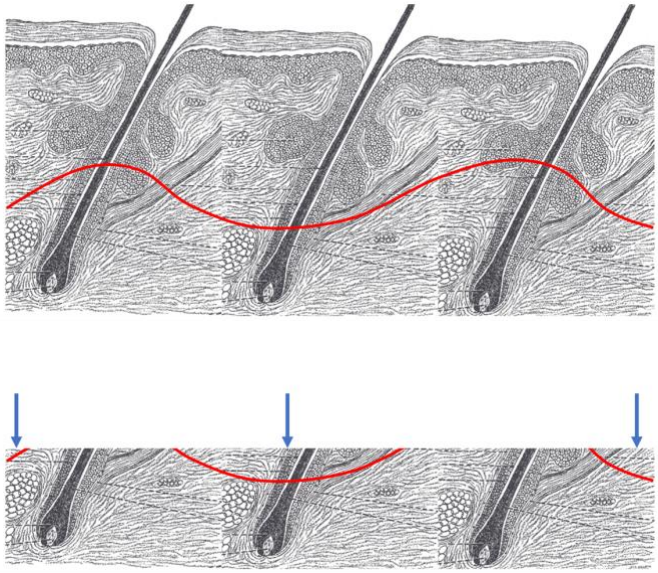
The excision knife is passed back and forth in a sawing motion, with <30 degree downward angled pressure and the knife gradually advancing forward. While the knife has a guard, the depth will vary based upon the angle and pressure applied. Upon completion of the pass, the knife is angled up away from the skin as the back-and-forth movement continues and tissue is excised. It is important to excise the wound down to viable tissue, as leaving non-viable tissue will lead to graft loss, wound infection and further wound deterioration. If time allows, it is possible to exercise a mixture of viable and non-viable dermis in the hopes of tissue preservation. In many cases, dermal preservation can salvage a mixed depth wound with sufficient viable dermal elements. This approach requires a staged return to the operative theater within 2 – 5 days to visualize and possibly excise more tissue prior to pursuing definitive wound closure. Excision for full viability is carried to diffuse punctate bleeding of the dermis. The deeper in the dermis, the larger the vessels and more spread out in appearance.

Tangential excision of a burn wound using a Humby knife with the guard set to maintain a relatively uniform depth. Source: Sharma D et al, [10.18203/2349-2902.ISJ20192374](10.18203/2349-2902.ISJ20192374)



An illustration of Dermal Preservation as described in the text. The Red line shows the depth of the burn. In this strategy, an initial tangential excision is done intentionally shallow, excising most of the burned tissue but leaving behind small "patches" shown by the Blue arrows. These can be excised later, resulting in better preservation of tissue.

When the entire dermis is non-viable, excision is extended until shiny, yellow fat is obtained. Thrombosed vessels within the fat, and brown, gray or orange discoloration are signs of non-viable tissue.

Under tourniquet, excision of the extremities is carried to a white moist surface in the dermis or a bright yellow surface in the fat. Hemoglobin-stained layers of the dermis or gray and brown areas of the fat should be excised.

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Appearance of a full thickness burn eschar prior to tangential excision.

Tangential excision with a Goulian-Weck knife, which allows careful excision of small amounts of tissue. Once bleeding tissue is obtained, excision is deep enough.

Completed excision of a full thickness burn wound, to viable fat. Through careful technique, the extensor tendons, tendon sheaths, and other important structures have been preserved.

6. Prior to tourniquet release of the extremities, gauze soaked with epinephrine solution at a concentration of 1:33,000 to 1:1,000,000 is applied and compression with elastic bandage can be used. This is left in place for several minutes prior to release of the tourniquet. Some prefer to place autograft prior to release of the tourniquet. Any residual areas of bleeding are controlled with sutures or cautery as needed. Care must be taken to keep track of the length of time an extremity is under tourniquet. The longer the restriction of blood flow the greater the risk of deep venous thrombosis, compartment syndrome and reperfusion injury.
7. It is not necessary to immediately place a graft over the excised wound bed, but if this is not done, a moist dressing must be placed. Paraffin or petroleum jelly-soaked gauze is acceptable. This must be changed every 3-5 days.
8. If immediate autografting is planned, the donor site is prepared. Here we briefly describe the technique, which is further described in the chapter Split Thickness Skin Grafting. The site may be injected with an epinephrine solution which helps with hemostasis and in obtaining a uniform graft. Depth of the graft to be taken varies based upon age of the patient, location of donor site and area to be grafted, and amount of donor site available. Often, a depth of 10/1000 to 15/1000 of an inch is chosen (0.25-0.4 mm.) The surgeon should consider the amount of tumescence solution injected. Higher volume injections lead to increased moisture and delayed donor site healing.

   When collecting the split thickness skin graft, the donor site is made taut and mineral oil or lubrication gel mixed with water is used to reduce friction and facilitate gliding of the dermatome. A manual or powered dermatome is used to obtain skin. Frequently, the skin is meshed to expand the graft, increasing the area that can be covered and reducing the risk of seroma and hematoma formation. "Pie-crusting" can be performed by hand or with a mesher and will generally provide less skin. 1:1 meshing will expand the skin back to its original size, 2:1 will expand to ~1.5x, 3:1 to ~1.9x, and 4:1 to ~2.1x the original size. Unmeshed skin grafts are also used, though rarely, to cover small burn wounds on regions of the body where scar contracture should be minimized. Unmeshed graft is at higher risk of failure, from accumulation of

blood or seroma fluid that impairs apposition to the wound surface. The meshing ratio is chosen based on the amount of available donor skin as well as the body region the wound is located.

"Meshing" of the grafted skin allows coverage of a wider area, although cosmesis is worse. This approach would not be suitable for the face. Source: By Giftrapped - Own work, CC BY-SA 4.0, https://commons.wikimedia.org/w/index.php?curid=122835011

Face, hands, feet, neck and forearms generally warrant lower meshing ratios to minimize scar contracture and improve cosmesis. Proximal extremities and the thorax can tolerate higher meshing ratios, but will take longer to heal, leave diamond interstices pattern, and cause more scar contracture. Hemostasis of the donor site is obtained with epinephrine-soaked gauzes. Once hemostasis is obtained, a dressing is applied.

Tumescence of donor site with an epinephrine solution

Tension assisted by penetrating towel clamps. An electric dermatome is being used to harvest skin in this case.

An assistant maintains tension on the skin while a surgeon harvests a skin graft. A manual dermatome is being used to harvest skin in this case.

Harvesting of skin with manual dermatome

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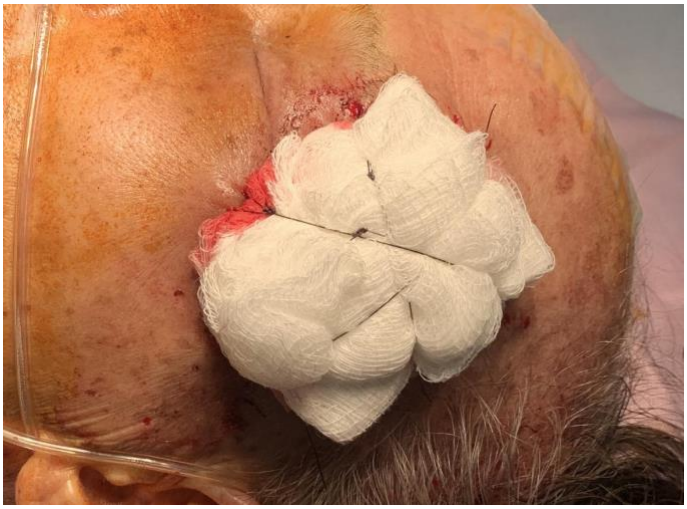
9. The graft is secured to the wound using staples, sutures, or fast-drying skin glue. Negative pressure wound therapy, a tie-over bolster, or layered dressings are used to secure and protect the graft. Regardless of dressing type, a non-adhesive fine-mesh layer of some form should be placed first to prevent maceration of the graft and shearing with dressing changes. A commonly available dressing material is petroleum jelly (Vaseline ®) soaked gauze.

We make our own petroleum jelly gauze by impregnating plain gauze with jelly in a reusable sterilizable container.

Autograft secured with a combination of staples and sutures

Graft over the sacral area secured with negative pressure wound therapy. Note also a rectal tube is being used to divert stool from the area.



A "tie over bolster" dressing can be used to secure small skin grafts.

Pitfalls

- Hypothermia prior to or during the surgery is one of the most dangerous and avoidable challenges the burn surgeon faces. Hypothermia results in increased blood loss, tissue ischemia and markedly worsens peri-operative mortality. The patient's room and the operative theater should be warmed to 74 -95 F (23 – 35 C) depending on the size of injury and the size of the patient. Pediatric patients can deteriorate particularly quickly if normothermia is not maintained.
- Tangential excision is more challenging with a wound that has been treated by the exposure method. An eschar forms over the wound, limiting assessment of its depth and preventing easy passage of the excision knife.
- It is important that the excision knife does not get snagged at the end of the blade. This occurs if the end of the blade runs into tissue as opposed to going over it. If the end does get caught, the knife will not advance forward easily and can

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begin to cut too deeply. Angling the blade to the desired depth of excision is essential.

- If the patient becomes hemodynamically unstable, stop further excision, obtain hemostasis and allow the anesthesia team to catch up with resuscitation. You may not be able to do everything that was planned for that case and need to return at a later time.
- Positioning of circumferential wounds can be challenging. The use of staff to help elevate the extremity can be sufficient for smaller patients with limited posterior wounds. For larger patients or wounds with significant circumferential components, surgeons should consider mechanical assistive devices such as ceiling hooks, bed frames or IV poles with weights added to the base for support. Alternatively, surgical excision can be staged, with only anterior or posterior surfaces being approached at each intervention and avoiding extremity elevation altogether.
- At some institutions cadaveric homograft (allograft) may be available. Allograft affords a number of different applications. It can be used as a temporary wound coverage after excision when sufficient donor skin is not available or the wound bed is not yet appropriate for skin graft application. Autograft can also be used on top of a meshed skin graft to protect the graft. In these circumstances the skin graft is typically meshed at a 3:1 ratio or greater and may itself be a thin or fragile graft (epidermal autograft.)
- Not all full thickness burns need to be excised. Full thickness wounds will heal at a rate of 1 cm per month, and relatively small wounds (<3 cm) can be allowed to heal through secondary intention and good wound care. For this same reason, a skin graft may be placed within 1 cm of the wound edge and allowed to heal-in, rather than extending up to normal skin. During the two weeks it will take for grafted skin to incorporate, the wound edge will heal to meet the graft border. This technique relies on contraction of the wound, so it is not suitable for a wound that crosses a joint, or is otherwise located in a place where adjacent skin can not stretch to fill in the wound.

This small burn across a joint probably would have healed spontaneously elsewhere, for example on the thigh, where adjacent skin could stretch as it contracted. In this case however, as the wound contracted, it pulled the elbow into a contracture. Treatment of burn contractures is addressed in a separate chapter of this Manual.

- Small burns can also be excised primarily if they do not cross a joint and there is sufficient uninjured surrounding skin. Care must be taken to not close a wound edge with injured skin.
- For patients whose burn wound size far exceeds their available donor site, multiple surgeries and repeated harvesting of the available donor site should be anticipated. Thin (epidermal autograft) donor sites taken with the dermatome at <8/1000th of an inch can be expected to heal within two weeks if sepsis is kept at bay, hypermetabolism is managed and the patient receives adequate nutrition.
- Immobilization and activity restriction after graft placement should be considered on a case-by-case basis by the surgeon. Short term restrictions are used to minimize graft loss through shearing or fluid accumulation. Longer periods of restriction are associated with loss of function and limitations in range of motion. To balance these risks, some surgeons will immobilize after skin graft application to the hands or across large joints for a day or two after surgery.

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- The mechanism of burn can significantly affect the extent of full thickness injury. Chemical, electrical and contact burns tend to be predominantly full thickness injuries that can extend beyond the skin and commonly warrant a staged approach to wound closure. Flame and hot oil burns tend to do well with early grafting and wound closure. Scald burns, counterintuitively, tend to heal better with delayed surgical intervention, particularly in children.

Resource-Rich Settings

- For massive burns, an number of epidermal and dermal skin substitutes are available. The most commonly used epidermal replacement is Suprathel, which is the standard of care for partial thickness burns in Europe. The most common and well known dermal replacement product is Integra, which is composed of a matrix of crosslinked bovine collagen and glucosaminoglycan, that provides a scaffold for vascular ingrowth. In addition, Cultured Epidermal Autograft (CEA) can generate a significant amount of skin and is invaluable in the management of patients with large surface-area burns.
- As stated in the text, the availability of blood and blood products for transfusion makes large tangential excision much safer.

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