Postburn Contractures of the Elbow and Heterotopic Ossification

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KEYWORDS

• Elbow contracture • Burn contracture • Heterotopic ossification • Surgical intervention

KEY POINTS

- The elbow is among the most common joints to develop contracture following burn injuries and usually becomes contracted in a flexed position.
- Elbow ankylosis reduces the working area that the hand can reach by 90%.
- Functionally limiting elbow contractures most frequently result from deep burns involving the skin, subcutaneous tissue, tendon, muscle joint capsule, and bone.
- The elbow joint is particularly susceptible to heterotopic ossification, especially at the ulnohumeral joint, which causes a rigid block to motion that is recalcitrant to nonoperative intervention.
- Surgical intervention is aimed at releasing or excision of all pathologic structures limiting motion and should include an ulnar nerve transposition to prevent postoperative ulnar nerve palsy and maximize.

INTRODUCTION

As critical care medicine and the survivorship of patients with severe and life-threatening injuries continue to improve, patients and health care providers are faced with the challenge of managing the long-term sequelae of these severe injuries. This challenge is particularly evident in the care of patients with devastating burn injuries, whose mortality has decreased from 24% in the 1970s to 7% in the early 2000s. This improved survivorship is due to the development of dedicated burn centers.[1–3] However, with increased survival come increased substantial morbidity and disability as a consequence of these injuries. Among the most common and debilitating sequelae of burn injuries are joint contractures. They develop in approximately one-third of burn patients[4–6] and limit the joint motion necessary to perform activities of daily living, occupational obligations, and recreational pursuits. Upper extremity contractures constitute most burn contractures (72%), with the elbow being among the most commonly involved joints (34%).[4] Despite appropriate wound care, physical therapy, and early surgical intervention in the acute setting, functionally limiting elbow contractures still occur and often require additional surgical management.

This article reviews the pathophysiology and pathoanatomy of postburn contractures of the elbow as well as the clinical evaluation, treatment, and outcomes of these challenging deformities, with a particular emphasis on elbow contractures resulting from involvement of subcutaneous structures and heterotopic ossification.

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PATHOPHYSIOLOGY OF CONTRACTURE DEVELOPMENT

The propensity of a burn wound to develop a contracture is influenced by several factors, including severity of injury (both depth and extent) and the duration of wound healing.

Severity of Soft Tissue Injury

Depth of tissue injury

The risk and severity of scarring and contracture are in part determined by the depth of the burn injury, which is classified into 4 broad categories (Table 1).[7]

Superficial and superficial partial thickness burns involve the epidermis or the epidermis and papillary (superficial) dermis, respectively. Because the dermal appendages are intact, these injuries are capable of regenerative healing due to the migration of keratinocytes from the dermal appendages as well as collage deposition from the superficial fibroblasts from the papillary dermis. Consequently, these wounds reliably heal with little to no scarring in 5 to 14 days and do not result in contractures.[7,8] By contrast, deep partial-thickness and full-thickness burns injure the reticular dermis (deep dermal layer), including the dermal appendages, and are incapable of skin regeneration.[9–11] In contrast to superficial burns, deep injuries heal by scar formation from deep dermal fibroblasts. In comparison to the superficial dermal fibroblasts in the papillary dermis, the deep dermal fibroblasts from the reticular dermis produce more collagen[12]; proliferate more slowly[13]; have less collagenase[14]; and produce more α-smooth muscle actin compared with superficial fibroblasts.[8] In this regard, deep dermal fibroblasts resemble fibroblasts found in hypertrophic scar, which is observed in 32% to 94% of burn injuries.[11,15–17] Moreover, with increased burn depth, signaling pathways initiating the conversion of fibroblasts to myofibroblasts (associated with wound contracture and hypertrophic scar) are activated.[11] Thus, injuries involving the deep dermis often lead to the development of dense, hypertrophic scarring, which can result in joint deformity, especially when the burned tissue lies directly over a joint.

Fourth-degree burn injuries are those that penetrate into the subcutaneous tissue and underlying structures, including muscles, tendons, joints, and bones. In addition to the contracture resulting from skin involvement, fibrosis of myotendinous structures, scarring of the joint capsule, and formation of heterotopic bone contribute to the development of more severe joint deformity and limitations in range of motion.

Heterotopic ossification, a condition in which mature lamellar bone develops in tissue that does not normally ossify, is an uncommon but debilitating complication of burn injuries, occurring in 1% to 3% of patients.[18] Although the cause and pathogenesis of heterotopic ossification have not been completely elucidated, postburn ectopic bone formation has been associated with greater depth of injury,[19] increased time to wound coverage,[20] the number of ventilator days, the number of trips to the operating room,[21] and greater than 20% total body surface area (TBSA) burned, in particular, arm and forearm burns that require grafts.

EXTENT OF BURN INJURY

Burn injury size has been correlated with contracture development. Both TBSA of burned tissue and TBSA requiring skin grafting are predictors of contracture development.[4] Although greater than 20% TBSA involved by burn injury is often cited as the threshold for increased risk of contracture development, functionally limiting joint contractures have been reported in patients with as little as 8% TBSA involved.[22] In addition to the risk of developing contractures, increased TBSA requiring skin graft is associated with the *severity*

Table 1
Depth of burn injury

Degree	Depth	Layers Affected	Healing Time
First degree	Superficial	Epidermis only	Within 7 d
Second degree A	Superficial partial	Papillary dermis	1–3 wk
Second degree B	Deep partial	Reticular dermis	>3 wk
Third	Full thickness	Full thickness of dermis, may extend into subcutaneous fat	Does not heal spontaneously
Fourth		Subcutaneous fat, muscle, tendon, joint (variable)	Does not heal spontaneously

Modified from Evers LH, Bhavsar D, Mailänder P. The biology of burn injury. Exp Dermatol 2010;19(9):778.