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Postburn Scar Contractures: Formation, Anatomy and Classification

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Abstract

Background: Anatomy of postburn scar contractures is insufficiently researched. A commonly accepted anatomic classification, serving as a guide for reconstructive surgery, is not developed. Existing scar contractures names (linear, wide, long and other) do not highlight particular anatomic features. Classifications of separate joints contractures are confusing and are not used in clinical practices. The true anatomical cause of the contracture has not been explored.

Methods: More than three thousand patients with postburn scar contractures, in different locations and of various severities, were operated on personally. Unsatisfactory functional results after the use of classical local-flap techniques (Z- and Y-V plasty and their modifications) urged us to investigate the anatomy of contractures depending on their location and severity, and ultimately categorize the anatomic and clinical features of contractures into distinguished several types.

Results: All postburn scar contractures are anatomically divided into three types: edge, medial, and total, regardless of their location and severity. Burns and scars of joint's flexion lateral surface cause edge contractures; burns of joint's medial flexion surface form medial contractures. After burns of joint's flexion surfaces or circularly, a total contracture is formed. Every type has specific anatomic features and clinical signs allowing an easy diagnosis of the contracture type and thus an easy indication of a surgical technique to be used. New data on contractures' anatomy laid grounds for the development of new, more effective surgical methods and made surgical rehabilitation of burned patients more effective.

Conclusion: Scars located on joint's flexion lateral surface or flexion medial surface or on both form three contracture types: edge, medial and total. Every contracture form has specific anatomic features and clinical signs. New anatomic data was used as the basis for new effective surgical technique development.

Keywords: *Scar Contractures; Contractures Formation; Anatomy of Contractures; Classification of Scar Contractures.*

Introduction

Inspite of significant achievements in burns treatment, the quantity of scar contractures is high [1]. Among three burn consequences-scar deformity, contracture, and tissue defect contractures most often lead to disability. Therefore, an efficient scar contractures treatment has a paramount meaning in surgical rehabilitation of burned patients. Complete contracture removal significantly improves the appearance of the contracted region. For many years, contracture treatment lied in a classic approach employing local flap techniques. Triangular-flap techniques-Z- and V-Y plasty and their various modifications and combinations continue to be the basis for scar contractures treatment [2-4]. The techniques based on triangular-flaps have known disadvantages; therefore, the results of rehabilitation of burned patients with contractures are far from perfect [5]. According to our experience, the main cause of such limited progress in scar contractures treatment with local tissues lies in the insufficient study of the following aspects: (a) contractures' anatomy, (b) contracture cause (scar surface deficit), and (c) anatomical classification of scar contractures. New data on scar contractures anatomy is presented in this paper.

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Material and Methods

Since 1979, several thousand patients with postburn scar contractures of different joints and body areas were operated on in the specialized Department of Reconstructive and Plastic surgery that contained 55 beds. Different surgical methods were tested and results were compared. The commonly known disadvantages and complications of classic methods (Z- and Y-V plasty) were obvious. This observation of dissatisfactory outcomes led us to conclude that the anatomy of the contractures was not sufficiently researched.

Methods

The anatomic features of contractures were studied before surgery and during operation, noting contractures location and severity, contracture cause, and scars spread. Next criteria were used: (a) scar

location caused contracture in relation to joint surface (flexion lateral, flexion medial, an extension surfaces; (b) is there fold or surface surplus and healthy region (donor site); (c) fold location in relation to joint surfaces; (d) quality of the sheets of the fold; severity of the contracture. The specific features were categorized into distinguished several types. The revealed anatomic and clinical features were classified to determine the true anatomic contracture type. During operations, the contracture cause was explored (scar surface deficit) for understanding of the shape of local flaps necessary for contracture elimination. Anatomy (classification) of contractures and research of real anatomy of contracture cause were used to develop new and more effective reconstructive techniques.

Results

Functional zones of joint and commissural surfaces [Figure 1-3]

Our observations showed, that first one had to determine the contracted scars location in relation to joint's surface which was divided into extension (E) and flexion (F) [Figure 1]; the boundary between them passes along the joint rotation axis level (+ symbol). The flexion surface of big joints and commissures has curvature of nearly 90 degrees; the curvature divides the flexion surface (FL) into flexion medial (FM) surface and flexion lateral (FL) surface [Figure 1 and 2]. The curvature or divided line between them passes along the edges of joint fossa and ankle anterior surface. The round flexion surface of contractures, where the curvature is absent or barely expressed (interphalangeal joints, perineum and lateral trunk) is not divided [Figure 3].

Fig. 1A

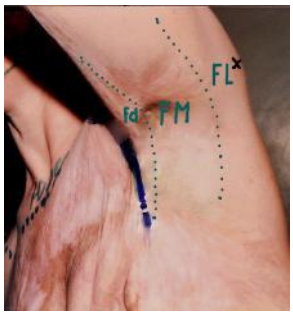

Fig. 1B

Figure 1: Functional zones of joint surface; shoulder and elbow edge contracture. (A and B): E – Joint extension surface above joint rotation axis (symbol "+"); F – joint flexion surface which divided by curvature, causing with fossa's edge in large joints, into flexion lateral (FL) and flexion medial (FM) surfaces; lateral flexion surface is scars, medial flexion surface (joint fossa) is healthy skin; scars formed the fold, crest of fold (Cr) is edge of scars .

Figure 2: J Round surfaces of finger flexion surface, neck, trunk, perineum are considered as flexion medial surface (and contractures)

Specific anatomic features and types of the postburn flexion contractures are the result of the scar location on the joint surface: flexion lateral (one or both joint's sides), flexion medial surface, or on three surfaces (both lateral and flexion) together. Depending on which flexion surface covered by scars, specific anatomic contracture types become obvious.

Edge contracture formation [Figure 3A and 3B]

Burns and scars, covering the joint's flexion lateral surface (FL), commissural zone and neck posterior surface, spread distally on neighboring anatomic segments forming joint, commissure (lips, hand lateral and dorsal surfaces). Growing distally, scars involve the neighboring healthy skin of the joint's fossa (flexion medial surface) and commissural fossa [Figure 3B]. As a result, the fold is formed between the flexion lateral and flexion medial surfaces, along joints' fossa and commissural edge. Therefore, the fold consists of two sheets of different quality (this is the most important anatomic feature and clinical sign): the lateral sheet is scars, and the medial sheet is healthy skin which spreads on undamaged joint's fossa (joint's flexion medial surface, commissural fossa) which becomes the donor site [Figure 3B]. The crest of the fold (Cr) is the scars' edge.

Fig. 3A

Fig. 3B

Figure 3: Joint's edge flexion contracture formation (shoulder joint edge anterior contracture). (A and B)- Scars on joint lateral flexion (FL) surface and neighbor zones spread downward (distally), involving healthy skin of flexion medial surface and connecting joint segments; as a result, a fold FD was formed, located along edge of joint fossa edge, among FL and FM surface. Flexion medial (FM) surface is undamaged; therefore, the fold's sheets have a different quality. Scar sheet has surface deficit in length, between two segments forming the joint (contracture cause) and both sheets have surface surplus in width (from the fold crest to the joint rotation axis) allowing contracture release with local tissue.

In the fold, the lateral scar sheet is continuation of the scars of flexion lateral surface which have a surface deficit in length (distance between two segments forming joint) that causes the contracture. Both fold's sheets have surface surplus in width, which in conjunction with healthy neighboring tissue (joint's flexion medial surface, commissural fossa) allows contracture elimination with local tissues. Thus, in all cases, the scars, located on joint flexion lateral surface and lateral commissural surface (cheek, dorsal and palmar hand surfaces) form the edge contracture.

Medial contracture formation [Figure 4]

Burns of the large joints' fossa, flexion medial surface (FM), ankle anterior surface, finger flexion surface, commissural fossa, lateral and anterior neck, truncal surfaces, and perineum lead to a specific contracture formation. During wound healing, scar's connective tissue undergoes contraction. Attempts to keep joints extended and withstand to flexion the neck and trunk stimulates scar growth. As a result, scars are elevated over joint and commissural fossa and the fold formed, crest of which is located along the middle line of FM

surface (important anatomic feature and clinical sign), central zone of lateral and anterior neck, lateral trunk, and perineum. All flexion medial surfaces of big joints, flexion surface of fingers, anterior or lateral surface of the neck, lateral trunk and perineum became involved in the fold. As a results, sheet of the fold presents significant scar surface surplus, useful for scar surface deficit compensation. As burn damages all FM surface of big joints, all flexion round surface of fingers, and other region of body , both sheets of the fold, causing contracture, are scars, of the same quality (most important anatomic feature and clinical sign), Both fold's sheets have surface deficit in length (real contracture cause), which is maximal at the fold's crest (Cr), and scar surface surplus in width, allowing contracture treatment with local tissue. Flexion lateral surface (FL) of the large joint stays undamaged or covered with scars that do not participate in medial the contracture formation.

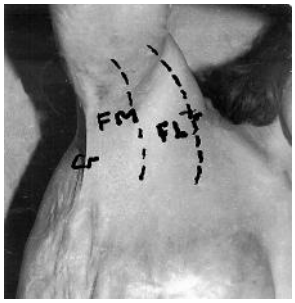

Fig. 4

Fig. 4A

Fig. 4B

Figure 4: Medial flexion contracture formation.(A and B) Burns of the FM surface of large joints, ankle anterior surface, first web space, flexion surface of fingers, fossa commissures, anterior and lateral neck, lateral trunk, perineum cause medial contracture. During the wound healing, scars undergo to traction; attempts to withstand traction stimulates scar grow and contraction. As a result, the scars are elevated over damaged surface and form the fold. The crest of the fold passes along the middle join line, the sheets of the fold achieve edges of large joint fossa, joint rotation axis in small fingers. Length of the fold or distance between two segments forming the joint, and width (from the fold crest to the joint rotation axis), determines contracture severity and possibilities of contracture elimination with local tissues.

Total contracture formation [Figure 5]

Deep and vast burns and scars injure the joint flexion surface or around it, tightly surrounding the joint without a fold. Severe scar surface deficit occurs excluding any possibility for a local-flap technique application.

Figure 5: Total knee joint flexion contracture formation: contracted ulcerous scars tightly surrounded joint without fold (severe scar surface deficit) and caused soft tissue hypotrophy.

Postburn Scar Contractures Anatomy

Knowing the process of scar contractures formation, we were able to explore the anatomy of the contracture deeper, taking in account anatomic features and clinical signs, dividing all scars into separate groups or forms, or types of which there are three: edge, medial, and total.

Edge scar contracture anatomy [Figure 1, 3 and 6A-G]

Edge contractures, making up 70% of total number (our own statistics), are characterized by specific anatomic criteria: (a) scars are located on the lateral joint's flexion surface, commissure, posterior neck, dorsal or palmar hand, lateral surface of ankle joint; (b) a crescent fold is formed located along the joint and commissural fossa's edge, between the flexion lateral and medial surfaces, ankle anterior surface; (c) the fold consists of the two sheets of different quality: scar lateral sheet of the fold is scars (according to joint fossa or flexion medial surface, commissure, neck posterior surface, ankle anterior surface), and the medial fold's sheet and neighboring surface of the joint's and commissural fossa, anterior neck and ankle, remain undamaged; (d) the crest of the fold is the edge of scars. These four anatomic features determined the name for such contractures, edge. The medial fold sheet and adjacent joint fossa, commissural and first web space fossa, ankle and neck anterior surface is healthy skin and serve as donor site. A fold's length and its protrusion differ from case to case, depending on the contracture location and severity. Contracture is caused with scars covering the joint FL surface in conjunction with the lateral sheet of the fold which have a trapezoid scars surface deficit in length which spreads from the fold crest (Cr) to the joint rotation axis. In both sheets there is scar surface surplus in width sufficient for scar surface deficit compensation and contracture elimination without skin grafts, pedicled, and free flaps.

Anatomy of medial scar contractures [Figure 2, and 4, and 7A-I]

Medial contractures, making up 16% of the total number, are caused by contracted scars, covering the joint FM surface and commissural fossa (flexion medial surface of large joints) or joint

Fig. 6A

Fig. 6B

Fig. 6C

Fig. 6D

Fig. 6E

Fig. 6F

Fig. 6G

Fig. 6H

Fig. 6H (2)

Fig. 6I

Figure 6: Anatomy of edge scar flexion/adduction contracture. A- Shoulder edge anterior adduction contracture anatomy; B- edge elbow edge contracture; C- anatomy of edge wrist contracture; D- first web space contracture; E- knee edge flexion contracture; F- ankle edge dorsiflexion contracture; G- edge neck lateral contracture; H- edge interdigital contracture; I- edge mouth angle commissure contracture.

Figure 7: Anatomy of scar medial flexion/adduction contracture. (A) shoulder medial adduction contracture anatomy; (B) anatomy of medial elbow flexion contracture; (C) wrist medial flexion contracture; (D) medial first web space contracture; (E) medial knee flexion contracture; (F) ankle medial dorsiflexion contracture; (G) neck lateral medial contracture; (H) truncal medial flexion contracture; I- medial perineum contracture.

flexion surface of the fingers, first web space, anterior ankle, perineum, lateral neck and truncal surfaces, and nose. Medial contractures, regardless of their location and severity, have specific anatomic features and clinical signs. (a) Scars cover flexion medial surface of large joints, first web space, all flexion surface of fingers, lateral and anterior neck, trunk surfaces, and perineum; (b) scars from the crescent fold; the fold's crest is located along the middle line of the joint's flexion surface, ankle anterior surface, perineum, lateral trunk and neck surfaces; (c) both sheets of the fold are scarred and spread from the fold's crest to the joint fossa's edges (large joints), joint rotation axis level of interphalangeal joints. These three anatomic features determined the name for these contractures, medial. Both scar sheets of the fold have a trapezoid surface deficiency in length (cause of contracture) and surface surplus in width which allows contracture treatment with local flaps alone or in combination with skin transplants. The fold can be small and short or may spread on the neighboring areas and joints.

Total contracture anatomy [Figure 5, 8A-D]

After deep vast burns, scars cover the flexion surface or tightly surround the joint and phalanges, creating severe scar surface deficit without a fold, which does not allow contracture treatment with local tissues. These anatomic criteria characterized the contracture as total (14% of the total number). Because of severe tension and traumatization while walking, the scars become pathologic (solid, rough, and thick), prone to necrosis and ulceration. Along with the scar contracture, deep burns could injure solid articular structures, making the contracture more severe and treatment more complex.

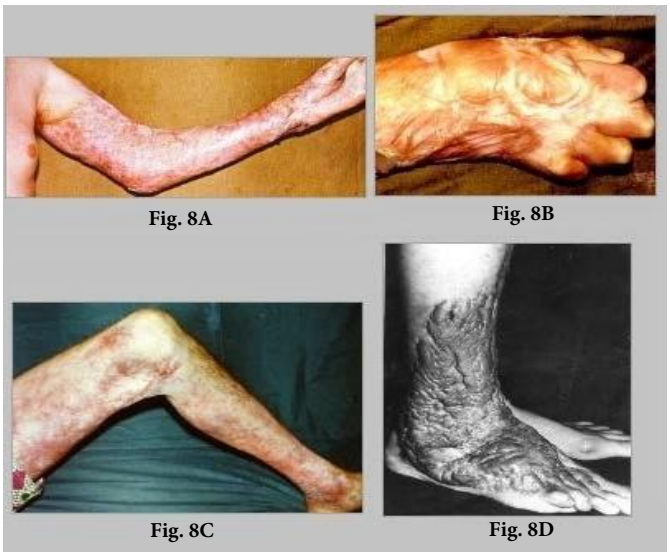

Figure 8: Anatomy of total scar flexion contractures. (A) Elbow medial total contracture; (B) total knee contracture C- total ankle contracture; (D)- total knee contracture.

Severe scar surface deficit excludes local-flap techniques' use; this deficit can be compensated and contracture can be treated with skin grafts, regional pedicled or free flaps.

Particular anatomic features and clinical signs are the basis for three contractures forms identification, which is necessary for further planning of the operation, adequate technique choice, and complete single-stage contracture elimination without recurrence, maximally using the local and neighboring tissues.

Discussion

In the literature we did not meet articles, concerning the postburn contractures anatomy in the plane of their surgical treatment with local tissue; the contractures are named according to external scar's form and spreading; separately, there are serial classifications, concerning the concrete joint's contractures. Next contracture names are used: linear [6 -8]; wide [9-12]; wide linear [13]; web straight linear [14]; narrow [15]; long [16]; quadratic [17]; cord like [18]; extended [18]; extensive [19].

There are classification contractures of separate joints. Choi et al. [20] proposed classification of first web space contracture; Stern et al. [21], classification of postburn proximal interphalangeal joint flexion contractures. Ogawa and Pribaz [22] classified contractures in 3 groups: linear, broadband, and circumference; knee flexion contractures divided into 5 forms. Dougherty et al. [23] discern two forms of knee contractures: (a) medially or laterally with unburned skin posteriorly (popliteal fossa) which is successfully treated with local triangular or transposition flaps (the first choice) and (b) contracture of the entire popliteal area which is treated with incisional release and skin grafting.

Many classifications were given for axillary contractures. Yang J-Y [2] pointed out that axillary contractures are characteristically divided into two groups: those involving the hairy dome and those that do not. Several numeric classifications of the shoulder contractures exists [22, 24-31].

Here is only a part of the proposed names and classifications but and listed ones is enough for understanding that they are not based on contractures' anatomy but scar character and spreading; therefore, they cannot have the scientific and practical meaning.

The insufficient anatomy study and absence anatomical classification not allowed to develop anatomically based surgical techniques for scar contractures treatment. Therefore, Z-plasty and Y-V plasty and multiple their modifications and combinations, based on the triangular pointed flaps use, are considered as basic local-flap techniques.

Buis et al. [32] wrote that a conventional Z-plasty on postburn scar tissue frequently leads to varying degrees of necrosis of the tips of the transposed flaps. Van Niekerk and Taggart [33] and Gumus [34] showed that the most disadvantages of Y-V plasty is the restricted displacement of the immobilized flaps. Authors consider that the main cause of the low efficacy of the triangular-flap techniques lies in insufficient study of contractures anatomy [35]. Stekelenburg et al. [36] reported that at present, no consensus exist on when to use what kind of technique; and that due to the scarcity and low quality of the included studies, no definitive conclusion could be reached about the effectiveness of different techniques. After exploring the rehabilitation level of burned patients, Klein [5] concluded that it is apparent that one should expect an evolution in surgical techniques and technologies that can improve the function and appearance of persons with burn injuries.

Our vast experience shows and testifies that cause is concluded in scar contractures anatomy is yet insufficient studied. The understanding of postburn scar contractures anatomy, including the scar surface deficit, is the first and main step in surgical rehabilitation. The rationale surgical techniques are developed, if anatomy is well knower. Technique choice and estimation theirs efficacy impossible without the use common acceptable anatomical classification; therefore, the understanding of postburn scar contractures anatomy as a first and main step in its treatment is the paramount task in success of scar contracture treatment and burned patients rehabilitation Really, there are three types of scar contractures only: edge, medial and total, having specific anatomic features (signs) independent of their location and severity. Specific anatomic features allow easy contracture type diagnosis and indicate which the reconstructive technique is most adequate and yields best outcome. Managing with anatomic principles, presented in our classification, appears possibility to systematize all aspects of surgical rehabilitation more efficacy.

Conclusion

Joint surface is divided into flexion and extension surfaces; in addition, the curvature divides of joint flexion surface (large joints) into flexion lateral and flexion medial surfaces. Round surfaces belong to medial. Anatomically, only three scar contracture types (form) can be categorized: edge, medial, and total. Every contracture type passes a specific way of formation and has specific anatomic features and clinical signs. Scars covering edge flexion lateral surface cause edge contracture: scar located on medial surface large joints and round surfaces cause medial contracture; scars covering the flexion surface or circularly cause total contracture. Our multiple clinical observations showed that new anatomic features and classification is basis for diagnosis construction, operation planning, surgical technique choice and development new reconstructive methods, significant improving surgical rehabilitation of the burned patients.

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