THE SQUARE FLAP TECHNIQUE FOR BURN CONTRACTURES: CLINICAL EXPERIENCE AND ANALYSIS OF LENGTH GAIN

DOUBLE LAMBEAU RHOMBOÏDE POUR BRIDE SÉQUELLAIRE DE BRÛLURE: EXPÉRIENCE PRATIQUE ET ANALYSE DE LA LONGUEUR GAGNÉE

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SUMMARY. Post-burn contractures, affecting the joints especially, are demanding problems. Many surgical techniques have been designated for burn contracture release. The aim of this study is to investigate the efficiency of the square flap technique to release a post-burn scar contracture, and assess the post-operative length gain that can be achieved by simple mathematical calculation. In this study, sixteen patients with linear contracture bands were treated with the square flap technique. The anatomical distribution of the contractures was: axilla, cubital fossa, flank, perineum and popliteal fossa. Scar maturity ranged from 4 months - 9 years. Square flap width and contracture band length before and immediately after surgery were recorded by simple mathematical calculation. Flap complication was assessed. Patient satisfaction was also assessed during the follow-up period. All square flaps were effective in lengthening the contracture bands. The length of the contracture that was released ranged from 2 to 6 cm. The gain in length provided with this technique ranged from 212 to 350%, average 247%, and adequate contracture release was achieved in all cases postoperatively. All square flaps healed uneventfully except for one (6%), which demonstrated limited epidermolysis that healed by secondary intention. The follow-up interval ranged from 6 months to 1.5 years. Patients or their parents were satisfied with the results of the operations in terms of skin tightness and aesthetic results. The square flap method was shown to be a simple technique and easy to replicate. It has good lengthening potential and is effective in releasing contracture bands on long-term follow-up.

Keywords: square flap, burn contracture, burn scar

RÉSUMÉ. Les brides séquellaires de brûlures, en particulier celles qui atteignent les régions articulaires, sont une cause fréquente de consultation. De nombreuses techniques chirurgicales sont utilisables dans cette indication. Le but de cette étude est d’évaluer l’efficacité du double lambeau rhomboïde (DLB) dans cette indication et d’évaluer le gain d’extension obtenu, après un calcul pré opératoire simple. Seize patients ont bénéficié de cette technique, pour traiter des brides linéaires simples. Elles étaient situées dans la région axillaire, la fosse cubitale, le flanc, le pépin et le creux poplité. La maturation cicatricielle s’étendait de 4 mois à 9 ans. La largeur du DLB et la longueur de la bride, en pré comme en post opératoire, ont été objectivées par un calcul simple. Les complications ont été répertoriées, ainsi que la satisfaction du patient (suivi de 6 à 18 mois). Nous avons toujours observé un gain de longueur satisfaisant, évalué entre 2 et 6 cm soit 212% à 350% (moyenne 247%). Un seul patient (6%) a vu sa cicatrisation retardée par une épidermolys se partielle. Les patients étaient satisfaits des résultats fonctionnel comme esthétique. Le DLB apparaît comme une technique simple et reproductible. Son bon potentiel de libération le rend efficace dans le traitement des brides linéaires.

Mots-clés: double lambeau rhomboïde, bride, séquelle, brûlure

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Introduction

As a result of a high prevalence of burn injuries and possible insufficient management, contractures are commonly encountered during the late stages. Burn contractures are routinely seen by plastic surgeons across their careers. Post-burn contractures crossing the joints especially are demanding problems that can provoke functional impairments.¹

Many surgical techniques have been reported for burn contracture release.

The Z-plasty technique is the traditional treatment approach, and is a reliable method for breaking down the straight line, increasing length and restoring joint normal range of motion.² There are also a number of variant Z-plasty techniques that can be used, including the 4-flap Z-plasty, the 5-flap Z-plasty and the 7-flap plasty, that when exerted in distinct angles and lengths can aid scar contracture release.³

The square flap method was introduced by Hyakusoku and Fumiiri and is an effective way to release post-burn contractures in many anatomic regions, such as the axilla, cubital fossa, neck, digital contractures, perineum and popliteal fossa.⁴ Despite its superb surgical characteristics in burn contracture release, it is not widely used by plastic surgeons.

In our study we present a clinical case series of patients with post-burn contractures in multiple anatomic regions in which the square flap method was used. We investigate the efficiency and versatility of the technique to release a post-burn scar contracture, and analyse the actual length gain that can be obtained by simple mathematical calculation.

Patients and methods

This clinical study was conducted between October 2016 and May 2018. We treated 16 patients who had linear contracture bands with the square flap technique.

The patients were selected from the plastic surgery outpatient clinic after approval from the ethics committee of the Faculty of Medicine. Patient recruitment in this study was conducted according to the guidelines established in the Declaration of Helsinki.

Every patient or child’s parents were informed about the study objective and written consent was obtained. Patient age distribution was between 3.5 - 35 years old, with an average of 9 years old. There were 6 males and 10 females. The anatomical distribution of the contractures was as follows: axilla = 5; cubital fossa = 8; flank = 1; perineum = 1; popliteal fossa = 1. In all patients, burn was the cause of the contracture, and scar maturity ranged from 4 months to 9 years (Table I). The width of the square flap, contracture band length before surgery and immediate lengthening of the contracture band after surgery were recorded in centimetres.

In the early postoperative period, complications related to the flap, such as wound dehiscence, seroma, hematoma or skin necrosis were assessed. Patients were followed up for at least 6 months. Patient or parent satisfaction in terms of skin tightness, aesthetic results and re-contracture were assessed during the follow-up period.

Surgical technique

A square was marked on one side of the contracture band and two triangular flaps were designed on the other side of the contracture.

The lengths of the sides of the square and triangular flaps were kept equal. The angle of the first triangular flap and the second flap were kept at 45 degrees and 90 degrees respectively (Fig. 1).

A full thickness skin incision was made along the marked flap design, followed by incision of the subcutaneous tissue. After the incisions were made, all contracted scar tissue was released.

Fig. 1 - Schematic diagram of square flap described by Hyakusoku, the first triangular flap at an angle (angle A) of 45° and the second triangular flap at an angle (angle B) of 90°
Table I - Patient clinical data

<table>
<thead>
<tr>
<th>Patient no.</th>
<th>Age (yrs.)</th>
<th>Gender</th>
<th>Cause of burn</th>
<th>Time since injury (months)</th>
<th>Site of C.B*</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>4</td>
<td>Female</td>
<td>Scald</td>
<td>18</td>
<td>Cubital fossa</td>
</tr>
<tr>
<td>2</td>
<td>5</td>
<td>Female</td>
<td>Scald</td>
<td>48</td>
<td>Cubital fossa</td>
</tr>
<tr>
<td>3</td>
<td>5</td>
<td>Female</td>
<td>Scald</td>
<td>36</td>
<td>Flank</td>
</tr>
<tr>
<td>4</td>
<td>20</td>
<td>Female</td>
<td>Scald</td>
<td>63</td>
<td>Cubital fossa</td>
</tr>
<tr>
<td>5</td>
<td>12</td>
<td>Male</td>
<td>Flame</td>
<td>108</td>
<td>Cubital fossa</td>
</tr>
<tr>
<td>6</td>
<td>4</td>
<td>Male</td>
<td>Flame</td>
<td>24</td>
<td>Axilla</td>
</tr>
<tr>
<td>7</td>
<td>3.5</td>
<td>Male</td>
<td>Scald</td>
<td>36</td>
<td>Cubital fossa</td>
</tr>
<tr>
<td>8</td>
<td>35</td>
<td>Female</td>
<td>Scald</td>
<td>4</td>
<td>Cubital fossa</td>
</tr>
<tr>
<td>9</td>
<td>12</td>
<td>Male</td>
<td>Flame</td>
<td>100</td>
<td>Popliteal fossa</td>
</tr>
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<td>10</td>
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<td>Female</td>
<td>Scald</td>
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<td>Cubital fossa</td>
</tr>
<tr>
<td>11</td>
<td>8</td>
<td>Male</td>
<td>Flame</td>
<td>18</td>
<td>Axilla</td>
</tr>
<tr>
<td>12</td>
<td>6</td>
<td>Female</td>
<td>Flame</td>
<td>18</td>
<td>Axilla</td>
</tr>
<tr>
<td>13</td>
<td>4.5</td>
<td>Female</td>
<td>Scald</td>
<td>12</td>
<td>Cubital fossa</td>
</tr>
<tr>
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<td>Female</td>
<td>Scald</td>
<td>14</td>
<td>Perineum</td>
</tr>
<tr>
<td>15</td>
<td>7</td>
<td>Male</td>
<td>Flame</td>
<td>24</td>
<td>Axilla</td>
</tr>
<tr>
<td>16</td>
<td>5</td>
<td>Female</td>
<td>Flame</td>
<td>12</td>
<td>Axilla</td>
</tr>
</tbody>
</table>

*C.B. = contracture band

The square flap was then advanced across the contracture area and fitted into the defect without trimming any redundancy.

Thereafter, the adjoining triangular flaps were rotated and then positioned proximally and distally, one on each side of the square advancement flap.

The incision was then closed by first suturing the deep dermal layer, followed by skin stitches.

The joint was splinted postoperatively in a position that avoided any tension on closure.

Splint removal and mobilization was allowed only after the 14 days it took for the suture line to heal.

Results

All the square flaps were effective in lengthening the contracture band. The length of the contracture band that was released ranged from 2 to 6 cm.

The percentage gain in length provided with this technique ranged from 212 to 350%. The average percentage of length gain in all regions was 247%, and adequate contracture release was achieved in all cases postoperatively.

The immediate postoperative average percentage for length gain per each anatomic region was as follows: axilla (5) = 191%; cubital fossa (8) = 261%; flank (1) = 220%; perineum (1) = 233%; popliteal fossa (1) = 264%.

All the square flaps healed uneventfully. Complications such as infection, hematoma or skin necrosis were not observed. Only one case (6%) demonstrated limited epidermolysis on the flaps, which healed by secondary intention without any functional sequel (Table II).

All patients underwent physiotherapy, silicon gel sheeting and application of compression garments postoperatively. The follow-up interval was 6 months to 1.5 years, average 11 months.

Patients or their parents were satisfied with the results of the operations in terms of skin tightness and aesthetic result.
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Case presentations

Case 1 (Patient #11): an 8-year-old male presented 1.5 years after sustaining thermal burns, with contracture band over the anterior axillary fold of the right axilla measuring 4.3 cm and abduction restricted beyond 120°.

A square flap was advanced from the axillary fossa, and both triangular flaps transposed and rotated, one proximal and one distal to the square flap. Postoperative length gain of the contracture band was 10 cm. In addition, abduction of 180° was achieved and maintained at follow up 14 months later (Fig. 2).

Case 2 (Patient #7): a 3.5-year-old child presented 3 years after sustaining scald burns, with contracture band over the medial edge of the right cubital fossa measuring 3.2 cm and extension restricted beyond 150°.

A square flap was advanced from the cubital fossa, and both triangular flaps transposed and rotated, one proximal and one distal to the square flap. Postoperative length gain of the contracture band was 8 cm. Extension of 180° was achieved and maintained at follow up 8 months later (Fig. 3).

Discussion

Burn injury in low- and middle-income countries is a frequent source of trauma.5 When wound management is insufficient, deep burn usually causes massive fibrosis that affects the deep skin layer.

This fibrosis over the joint causes significant contracture, adversely influencing its function.6 Moreover, the different growth rate of the burn scar and its neighbouring normal skin, especially in children, plays a major role in contracture development.7 Once a contracture is entirely established, surgical intervention becomes inevitable to sustain function.

The square flap is a 3-flap plasty consisting of a square advancement flap combined with 2 triangular transposition flaps.

The original Limberg model design of the square flap contains a square and two triangular flaps, at an acute angle. This design was later modified in 1987 by Hyakusoku and Fumiiri, adjusting one of the triangular flaps to a right angle, which resulted in better lengthening compared to the previous design.4

Table II - Operative data and results

<table>
<thead>
<tr>
<th>Patient no.</th>
<th>Pre-operative length (cm)</th>
<th>Width of square flap (cm)</th>
<th>Post-operative length (cm)</th>
<th>Percentage of length gain (%)</th>
<th>Complications</th>
<th>Follow up (months)</th>
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<td>4</td>
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<td>9</td>
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<td>2</td>
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<td>14</td>
<td>3</td>
<td>3</td>
<td>7</td>
<td>233%</td>
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<tr>
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<tr>
<td>16</td>
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<td>4.5</td>
<td>10.5</td>
<td>233%</td>
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</table>
The square flap is a type of local flap that is appropriate for the surgical release of a single linear band contracture at various locations that have adjacent healthy tissue.

The square flap has been demonstrated to be suitable for type IIa and IIb axillary web scar contractures and type I cubital contracture release.\(^8,\!^9\)

In our study, we used the square flap technique to release linear contractures on various parts of the body. We performed surgical contracture release in the axillary web where the contracture band involved either the anterior or posterior axillary line in five cases, linear contracture bands at the lateral or medial edge of cubital contracture in eight cases, and contracture band over the perineum, popliteal fossa and flank in one case for each.

All the square flaps were successful in lengthening the contracture bands, and demonstrated a differing in-

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**Fig. 2** - A) Original contracture band over right axilla at anterior axillary line and square flap design. B) Flap transfer and immediate outcome results after surgery. C) Follow-up visit at 6 months. D) At the 14-month follow-up visit, showing that the result at long-term follow-up is maintained.
crease for each of the anatomic regions. The immediate increase by simple mathematical length ranges from 212 to 350%, with an average of 247%, which is maintained for an average one-year follow up.

Many local flap methods used to break down, release a linear scar contracture band and provide good lengthening potential for post burn linear contracture bands have been described previously in the literature. A single large Z-plasty delivers good lengthening but large flaps are susceptible to more transverse tension. Modifications such as multiple Z-plasty in series, four-flap, five-flap, and seven-flap Z-plasties provide suitable lengthening with lesser transverse tension.\textsuperscript{10}

In our clinical series we demonstrated, by simple mathematically calculated post-surgical length analyses, that the square flap technique lengthens the original scar band by 2.47-fold.

A more recent study by Huang and Ogawa stated that the square flap method was more efficient than the single, 4-flap, and 5-flap Z-plasty methods as it lengthens the original scar band by 2.825-fold, compared with the ≤2.239-fold lengthening ability of all types of Z-plasties (1.73%, 2.12% and 1.5% for single Z-plasty, 4-flap Z-plasty and 5-flap Z-plasty respectively).\textsuperscript{11}

Moreover, in 2008 Daya found that 7-flap plasty provided an average 105% immediate post-operative length gain.\textsuperscript{12}

Fig. 3 - A) Original contracture band over medial edge of cubital fossa with square flap design. B) Flap transfer and immediate outcome results after surgery. C) Follow-up visit at 8 months.
There are many advantages reported in the literature of using the square flap in contracture release. The square flap creates a larger flap area to interpose a normal texture skin flap between the scarred burn flaps for optimal length gain, further stretching potential and higher length-breadth ratio compared to other Z plasties. Also, the square flap method is associated with the lowest physiological tension, which means that the deformity and the dependence on the laxity of the adjacent skin are minimal.

The square flap is shown to be a simple technique and easy to replicate. It gives good lengthening and breaks the line of the contracture with the square advancement flap, which provides a suitably large, vascular and pliable soft tissue flap between burned scarred tissues. Moreover, it is associated with a good cosmetic outcome on long-term follow-up.

The limitation of this study is the small number of patients. More cases and an extended follow-up interval will be needed to affirm the reliability and efficacy of the square flap technique for the release of scar contracture in different anatomic regions.

**Conclusion**

The square flap technique appears to be a simple and easy technique. It provides good lengthening potential and effective release of the contracture band over various anatomic regions, with good cosmetic outcome and no recurrence on long-term follow-up.

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**BIBLIOGRAPHY**


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Conflict of interest. The author declares no conflict of interest.

Ethical approval. All procedures performed in this study were in accordance with ethical standards, following approval of the ethics committee of the Faculty of Medicine, South Valley University, Qena, Egypt, and with the 1964 Helsinki declaration and its later amendments.

Informed consent. Informed consent was obtained from all participants included in the study.