

Clinical outcomes of lateral digital flap–based local flap combinations in the reconstruction of post-burn metacarpophalangeal joint contractures

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Ethics Committee Approval

Written informed consent was obtained from all patients for surgical treatment and the use of clinical photographs. Ethical approval was obtained from the institutional Ethics Committee before study initiation.

All procedures in this study involving human participants were performed in accordance with the 1964 Helsinki Declaration and its later amendments.

Conflict of Interest

No conflict of interest was declared by the authors.

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Abstract

Background/Aim: Post-burn metacarpophalangeal (MCP) joint contractures may severely impair hand function due to scar formation involving the palmar surface and volar digital skin. This study aimed to evaluate the clinical and functional outcomes of local flap combinations based on the lateral digital flap for the reconstruction of post-burn MCP joint contractures.

Methods: This retrospective case series included nine male patients who underwent surgical treatment for post-burn MCP joint contractures between May 2010 and April 2011. A total of 48 local flaps were applied in various combinations according to contracture localization and defect characteristics. The lateral digital flap was used as the primary reconstructive method, rhomboid flaps were used for web space reconstruction, and five-flap Z-plasty was applied selectively for deformities involving the palmar surface and/or first web space. All flaps were designed before contracture release, and dissections were performed under tourniquet control with magnification. Clinical outcomes were assessed using postoperative extension deficit and follow-up duration (months).

Results: All patients had contractures at the MCP joint level, with concomitant web space involvement in some cases. Complete restoration of MCP joint extension was achieved in eight patients. One patient had a 10° extension deficit localized to the proximal interphalangeal joint rather than the MCP joint. Follow-up ranged from 1 to 10 months. No flap loss or major postoperative complications were observed during follow-up.

Conclusion: Local flap combinations based on the lateral digital flap constitute a biomechanically compatible, reliable, and functionally effective reconstructive option for post-burn MCP joint contractures in the early to mid-term period. In patients with multiple MCP joint contractures accompanied by web space deformities, combining the lateral digital flap with rhomboid flaps and/or five-flap Z-plasty allows comprehensive correction within a single surgical session.

Keywords: burn sequelae; MCP joint contracture; lateral digital flap; local flap reconstruction; Z-plasty

Introduction

Deep burns involving the hand may lead to long-term functional sequelae that extend well beyond superficial scar formation. Hand function depends on a precise balance between soft tissue elasticity, joint mobility, and coordinated tendon gliding. When the palmar surface and volar digital skin are affected by burn injury, post-burn scarring progressively alters this balance. The skin–subcutaneous tissue complex gradually loses pliability and behaves as a shortening sheath, forming contracture bands that cross joints and restrict motion. When such contractures involve the metacarpophalangeal (MCP) joint, the resulting loss of extension may severely compromise grasp, release, and fine motor coordination.

The pathophysiology of post-burn MCP joint contractures is multifactorial. In addition to skin involvement, deeper structures including the joint capsule, ligaments, tendon sheaths, and perivascular connective tissue may contribute to progressive shortening. As a result, superficial release alone is rarely sufficient to restore durable joint motion. Inadequate release or reconstruction with tissue that is poorly matched to joint biomechanics increases the likelihood of recurrence and functional limitation.

Successful post-burn reconstruction is governed by a fundamental principle: restoration of joint motion is meaningful only if the resurfacing tissue can tolerate and sustain that motion. A systematic review focusing on delayed burn reconstruction identified flap failure and contracture recurrence as major determinants of outcome, highlighting the importance of appropriate reconstructive technique selection [1]. In the hand, this selection is particularly critical. Excessive tissue bulk, even when vascular reliability is ensured, may impair fine motor function. Consequently, distant or free flaps—although effective for defect coverage—may not always be optimal for MCP joint reconstruction due to tissue mismatch.

Acellular dermal matrices have been introduced as alternative resurfacing options in burn reconstruction. While their role continues to evolve, their long-term behavior in regions exposed to constant motion and multidirectional tension, such as the MCP joint, remains controversial with respect to durability, cost, and availability [2]. In routine clinical practice, reconstructive decisions are often constrained by local tissue conditions rather than ideal theoretical options. Under these circumstances, local flaps provide a biologically sound and practical solution.

The surgical strategy adopted in this study is based on the premise that reconstruction with tissue similar in thickness, elasticity, and orientation to native skin may enhance functional recovery and reduce secondary contracture. This concept aligns with algorithmic approaches to post-burn contracture management, which emphasize contracture localization, severity, defect size, and tissue quality in surgical planning [3]. Lateral digital flaps have been described as a practical option for post-burn digital flexion contractures, supporting their use as a foundation for MCP-level reconstruction [4]. Accordingly, lateral digital flaps were used as the primary reconstructive option for MCP joint contractures, while rhomboid flaps and five-flap Z-plasty were incorporated to address associated web space and

palmar surface deformities. This local flap–based combination strategy allows comprehensive correction of complex deformities within a single operative session.

This study is based on clinical data collected between May 2010 and April 2011 and includes 48 local flap procedures performed in nine patients. The primary objective was to evaluate the functional outcomes of lateral digital flap–centered local flap combinations in the reconstruction of post-burn MCP joint contractures. Given its retrospective case series design, the study aimed to provide clinically relevant insights into surgical planning and outcomes rather than comparative statistical inference. Clear outcome reporting and transparent methodology were prioritized to support clinical interpretability.

Materials and methods

Study design and patient selection

This study was designed as a retrospective observational case series. Patients who underwent surgical treatment for post-burn metacarpophalangeal (MCP) joint contractures between May 2010 and April 2011 were evaluated. A total of nine patients were included, in whom 48 local flaps were applied in various combinations according to contracture localization and defect characteristics. All patients were male, with a median age of 20 years (range not available due to the retrospective data structure).

In most cases, the initial burn injury occurred during childhood, and reconstructive surgery was performed in early adulthood. Surgical intervention had been delayed primarily due to socioeconomic limitations. Delayed reconstruction is clinically relevant, as prolonged contracture maturation is associated with progressive shortening of not only the skin but also deeper structures such as the joint capsule and periarticular tissues [1].

This study was conducted in accordance with the principles of the Declaration of Helsinki and was reported in line with STROBE recommendations for observational studies.

Principles of surgical planning

Preoperative flap planning was performed before contracture release in all cases. Although the final defect configuration becomes fully apparent only after complete release of the contracture band, pre-release flap design provided a structured operative roadmap and facilitated reconstruction. This approach supported coverage with adjacent tissue of appropriate quality and enabled anticipation of tension vectors once joint motion was restored.

The primary reconstructive objective was to achieve coverage using local flaps whenever feasible. Local flaps offer several advantages in burn sequela surgery, including limited donor-site morbidity, feasibility under regional anesthesia, single-stage application, and a lower risk of secondary contracture compared with skin grafts. Moreover, excessive tissue bulk associated with distant or free flaps may negatively affect fine motor performance of the hand. Although thin perforator free flaps have been reported for selected extremity contractures, free flap reconstruction remains associated with increased operative complexity and resource utilization [5].

Applied flap techniques

Three local reconstructive techniques were utilized according to the anatomical distribution and severity of contractures. The lateral digital flap was used as the primary

reconstructive option for MCP-level digital contractures. Rhomboid flaps were employed for advancement and deepening of involved web spaces, and five-flap Z-plasty was applied selectively in cases involving the palmar surface and/or the first web space.

The rationale for flap selection was based on hand-specific reconstructive requirements. While free anterolateral thigh flaps have been reported for burn contracture reconstruction in various anatomical regions, including the axilla [6,7], the MCP region requires thin, pliable tissue capable of tolerating constant motion along dynamic tension lines. Large series evaluating long-term outcomes of contracture surgery emphasize that restoration of joint range of motion is the primary objective, while the optimal reconstructive technique depends on anatomical location and tissue requirements [8]. Accordingly, the lateral digital flap served as the cornerstone of reconstruction at the MCP level, complemented by rhomboid flaps and five-flap Z-plasty when additional tissue length or web space correction was required.

Anesthesia, dissection, and contracture release

All procedures were performed under tourniquet control with the aid of surgical magnification. Magnified dissection was used during lateral digital flap elevation to facilitate preservation of neurovascular structures. Complete release of contracture bands was performed as the initial step, and flap elevation was initiated only after full passive joint extension had been achieved. This sequence enabled accurate assessment of the post-release defect and minimized excessive tension on the reconstructive flaps.

Postoperative rehabilitation protocol

Postoperative rehabilitation was considered an integral component of treatment. All patients were managed with a daytime dynamic extension splint for the first two postoperative weeks. Formal physiotherapy was initiated at the end of the third postoperative week. This protocol was intended to preserve surgically achieved extension during the early phase of scar maturation and remodeling [9]. Joint range of motion was monitored clinically using goniometric assessment.

Outcome measures

Clinical outcomes were evaluated using postoperative extension deficit as the primary functional parameter and follow-up duration as a secondary descriptive variable. Extension deficit was recorded in degrees and documented in tabular form. Follow-up duration was recorded in months. No comparative statistical testing was performed due to the descriptive nature of the case series design. The functional relevance of burn-related contractures and their contribution to disability have been discussed in prior clinical literature [9].

Ethical considerations

Ethical approval was obtained from the institutional Ethics Committee. Written informed consent was obtained from all patients for both surgical treatment and publication of clinical photographs.

Results

Patient demographics and clinical background

The study cohort consisted of nine patients, all of whom were male. All burn injuries occurred during childhood, and reconstructive surgery was performed after a prolonged delay,

reflecting long-standing post-burn sequelae. The median age at the time of surgery was 20 years (Table 1).

Table 1. Demographic characteristics and burn history

Variable	Findings
Number of patients	9
Sex	Male (100%)
Age at surgery, years	20
Timing of burn injury	Childhood
Time to reconstruction	Delayed

Contracture localization

All patients presented with flexion contractures involving the metacarpophalangeal joints of the second to fifth digits. Additional involvement of the first and adjacent web spaces was observed in several patients, resulting in more complex deformities affecting overall hand span and grasp function (Table 2).

Table 2. Anatomical distribution of contractures

Localization	Number of cases
MCP joints (digits 2–5)	9
First web space	3
Second–fourth web spaces	4

Types and combinations of local flaps

The lateral digital flap was used as the primary reconstructive technique in all patients. In cases with associated web space contractures, rhomboid flaps were used to achieve adequate deepening. Five-flap Z-plasty was applied selectively in deformities involving the palmar surface and/or the first web space to provide additional skin length and redistribute tension. These flap combinations enabled simultaneous correction of multiple anatomical components of deformity within a single operative session (Table 3).

Table 3. Local flap types and indications

Flap type	Indication
Lateral digital flap	MCP-level digital contractures
Rhomboid flap	Web space contractures
Five-flap Z-plasty	Palmar surface and/or first web space

Surgical burden

The number of local flaps required per patient varied, reflecting heterogeneity in contracture severity and anatomical extent. Patients presenting with multiple MCP joint contractures and concomitant web space involvement generally required a greater number of flaps. The number of flaps ranged from 2 to 12, with a mean of 5.3 flaps per patient (Table 4).

Table 4. Number of flaps per patient

Parameter	Value
Minimum	2
Maximum	12
Mean	5.3

Functional outcomes

Postoperative extension deficit was used as the primary functional outcome parameter. Complete restoration of MCP joint extension was achieved in eight patients. One patient demonstrated a residual extension deficit of 10°, localized to the proximal interphalangeal joint rather than the MCP joint, indicating effective correction at the target MCP level (Table 5).

Table 5. Postoperative extension deficit

Extension deficit	Number of cases
0°	8
10° (PIP joint)	1

Follow-up and clinical course

Follow-up duration ranged from 1 to 10 months, representing early to mid-term outcomes. During this period, no flap loss, major wound complications, or clinically evident early recurrence of contracture were observed (Table 6).

Table 6. Follow-up duration

Follow-up period (months)	Number of cases
1-3	3
4-8	5
≥9	1

Correlation with clinical photographs

Representative clinical photographs corroborated the functional findings. Preoperative images demonstrated pronounced MCP joint flexion contractures, whereas postoperative images showed restoration of MCP extension and, when applicable, improved web space depth (Table 7).

Table 7. Correlation between figures and clinical findings

Figure	Clinical condition
Figures 1a-b	Isolated MCP contracture reconstructed with lateral digital flap
Figures 2a-b	Five-flap Z-plasty combined with lateral digital flap
Figures 3a-b	Lateral digital flap combined with rhomboid flap and five-flap Z-plasty

Figure 1a. Preoperative appearance of a flexion contracture involving the palmar region and the second to fifth metacarpophalangeal (MCP) joints following burn injury. Marked limitation of MCP joint extension is observed due to palmar scar tissue.



Figure 1b. Early postoperative appearance of the same patient following contracture release using a lateral digital flap. Restoration of MCP joint extension is evident, with preservation of palmar skin integrity achieved through local flap coverage.



Figure 2a. Preoperative appearance of a contracture involving the palmar region and the second to fifth MCP joints after burn injury. Preoperative markings demonstrate the planned five-flap Z-plasty and lateral digital flaps along the contracture line.



Figure 2b. Postoperative appearance of the same patient following contracture release using a combination of five-flap Z-plasty and lateral digital flap. Adequate MCP joint extension is achieved, with improved palmar skin elasticity and preservation of local tissue similarity.



Figure 3a. Preoperative appearance of a severe contracture involving the palmar region and the second to fifth MCP joints following burn injury. Extensive palmar scarring and significant limitation of MCP joint extension are evident.



Figure 3b. Postoperative appearance of the same patient after contracture release using a combination of lateral digital flap, rhomboid flap, and five-flap Z-plasty. Functional MCP joint extension has been restored, the web spaces have been deepened, and palmar skin continuity has been reconstructed using local flaps.



Discussion

Post-burn hand contractures represent a major challenge in reconstructive surgery because the deformity often evolves into a multilayered pathology rather than remaining a superficial skin problem. Prolonged scarring may affect not only the skin and subcutaneous tissue but also periarticular structures, compromising joint biomechanics and coordinated hand motion [9]. Scar contractures are common after burn injury, and their prevalence has been summarized in systematic reviews [10]. Contractures involving the metacarpophalangeal (MCP) joint are particularly detrimental, as this joint plays a pivotal role in grasp strength, fine motor coordination, and synchronized digital motion.

This case series suggests that local flap combinations centered on the lateral digital flap can provide reliable early- to mid-term functional outcomes in the reconstruction of post-burn MCP joint contractures. All patients underwent delayed reconstruction, with initial burn injuries sustained during childhood and corrective surgery performed years later. Delayed reconstruction has been associated with recurrence and technical complexity, likely reflecting progressive maturation of scar tissue and shortening of deeper structures [1,11]. Despite this unfavorable context, the absence of flap loss, major complications, or clinically evident early recurrence in this series supports the safety and reliability of the applied local flap strategy.

The preference for a local flap-based approach in this study reflects both biomechanical and functional considerations. Skin grafts, although technically straightforward, are associated with a risk of secondary contracture in joint reconstruction and limited durability in high-motion areas [11]. Free or distant flaps, while effective for defect coverage, may introduce excessive tissue bulk that interferes with fine hand function and tendon gliding [5-7,12]. In contrast, local flaps provide tissue with comparable thickness, elasticity, and orientation, supporting physiological gliding planes and multidirectional motion. The lateral digital flap is particularly suitable for MCP-level defects because it uses adjacent tissue, facilitates preservation of neurovascular bundles, and aligns favorably with the joint's motion vectors [4].

A further strength of the present approach is the deliberate use of flap combinations rather than reliance on a single reconstructive technique. Post-burn MCP joint contractures are frequently accompanied by web space deformities, particularly involving the first web space, which can limit grasp by reducing thumb-index span. In such cases, restoration of MCP extension alone may be insufficient for meaningful functional improvement. Algorithmic approaches to post-burn contracture surgery emphasize correction of all contributing components of deformity, including web space narrowing, to optimize functional outcomes [3].

Functional outcomes in this series were assessed using postoperative extension deficit, a pragmatic and clinically relevant parameter used in burn contracture evaluation [9]. Complete restoration of MCP joint extension was achieved in most patients, and the only residual deficit observed was localized to the proximal interphalangeal joint rather than the MCP joint itself, indicating effective correction at the targeted level.

Postoperative rehabilitation likely contributed to maintenance of surgical gains. Dynamic extension splinting followed by structured physiotherapy is widely regarded as essential during the scar maturation phase to preserve surgically achieved range of motion [9].

Limitations

Several limitations should be acknowledged. The retrospective case series design and small sample size limit generalizability and preclude statistical comparison. In addition, a standardized preoperative severity grading system was not available due to the retrospective data structure, limiting direct comparability with other series. Follow-up was limited to the early to mid-term period; late recurrence, which remains a concern in burn sequela surgery, could not be evaluated [1,11]. These

limitations are inherent to many case series and support the need for larger prospective studies with longer follow-up.

Conclusion

Local flap combinations centered on the lateral digital flap constitute a reliable, practical, and functionally effective reconstructive option for post-burn metacarpophalangeal joint contractures. Even in delayed reconstruction, satisfactory restoration of MCP joint extension can be achieved using appropriately selected local tissues. In patients with multiple MCP joint contractures accompanied by web space deformities, combining the lateral digital flap with rhomboid flaps and/or five-flap Z-plasty enables comprehensive correction within a single operative session. Postoperative rehabilitation, including dynamic extension splinting and timely physiotherapy, remains indispensable for maintaining surgically achieved gains. Further studies with larger cohorts and longer follow-up are required to better define long-term durability and recurrence patterns.

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