

Z-Plasty for First Web Space Contracture: A Reconstructive Approach

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ABSTRACT

Introduction. Z-plasty is a local flap transposition technique widely used in plastic and reconstructive surgery for scar revision and contracture release. In the hand, contracture of the first web space can significantly compromise thumb abduction and opposition, as well as pinch and grip strength, thereby affecting overall limb function. Z-plasty and its various modifications allow for tissue lengthening, scar reorientation, and redistribution of tension forces, constituting a useful reconstructive alternative in selected cases.

Methods. A narrative literature review was conducted focusing on the principles, historical evolution, surgical anatomy, diagnosis, classification, and treatment of first web space contractures. Particular attention was given to the geometric foundations, indications, limitations, and surgical technique of Z-plasty, including its simple, multiple, four-flap, and five-flap variants. Conservative treatment modalities, objective methods for assessing thumb mobility, and reconstructive alternatives available for more complex contractures were also reviewed.

Conclusions. Z-plasty remains a versatile and effective technique for the management of mild to moderate first web space contractures, particularly when the restriction is predominantly cutaneous and adequate adjacent tissue is available. Reconstructive success depends on accurate assessment of the depth and extent of the contracture, appropriate flap design, complete release of the scar band, preservation of vascularity, and postoperative rehabilitation. Severe or deep contractures involving fascia, muscle, or joint capsule, or presenting extensive tissue deficits, may require skin grafts or coverage with local, regional, or free flaps. Outcomes should be assessed not only by the widening of the first web space but also by the recovery of thumb abduction, opposition, pinch, and grip. Comparative studies are needed to standardize indications and determine the optimal Z-plasty configuration for each contracture pattern.

KEYWORDS: Z-plasty; first web space; scar contracture; thumb opposition; hand reconstruction; local flaps; scar revision.

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INTRODUCTION

Z-plasty is one of the most representative and versatile local flap transposition techniques in plastic and reconstructive surgery. Its fundamental principle consists of rearranging tissue distribution by creating two adjacent triangular flaps that, when transposed, allow modification of scar direction, lengthening of a retracted cutaneous segment, and redistribution of tension forces. Owing to these characteristics, Z-plasty has become an essential tool for managing linear scars, contracted bands, post-traumatic or postsurgical contractures, and correcting scar deformities located in anatomical regions of high functional and aesthetic relevance. (1)

From a geometric standpoint, the technique is based on a central incision representing the axis of the contracture and two lateral limbs of equal length forming the letter "Z." The magnitude of lengthening obtained depends primarily on the angle formed by these lateral limbs. The classic 60° configuration is among the most widely used, as it offers an adequate balance between theoretical length gain, flap viability, and technical ease. (2) However, the clinical behavior of tissues does not exactly reproduce geometric models, owing to variables such as elasticity, fibrosis, skin thickness, vascularization, and the presence of previous scars. For this reason, planning a Z-plasty must consider both its mathematical principles and the biological and anatomical characteristics of the area to be reconstructed. (3)

In addition to providing lengthening, Z-plasty allows reorientation of a scar into a more favorable direction with respect to skin tension lines, natural creases, and aesthetic units. This property can improve not only function but also the appearance of visible or deforming scars. Its applications therefore extend to multiple regions, including the face, neck, extremities, axilla, commissures, joint surfaces, and interdigital spaces. In the hand specifically, correction of contractures by Z-plasty can have a significant functional impact by increasing mobility and reducing the mechanical restriction produced by a retracted scar. (4)

Over time, multiple modifications of the classic technique have been developed, including multiple Z-plasty, four-flap, and five-flap variants, each designed to address specific contracture patterns or achieve greater tissue redistribution. The choice of a given variant depends on factors such as scar length, direction of the contracture, availability of adjacent skin, depth of the lesion, and the patient's functional needs. Despite its apparent simplicity, the technique requires careful planning, since inadequate design can increase the risk of flap necrosis, secondary deformity, excessive tension, dehiscence, or recurrence of the contracture.

In this context, the study of Z-plasty is fundamental to understanding the principles of reconstructive surgery based on local flaps. Its correct application allows a restrictive scar to be transformed into a more favorable configuration, makes use of adjacent tissue with similar characteristics, and, in many cases, avoids more complex reconstructive procedures.

The objective of this review is to analyze the historical, geometric, and surgical foundations of Z-plasty, its main variants, indications, limitations, complications, and clinical applications, with particular emphasis on its importance for the functional and aesthetic restoration of regions affected by scar contractures. (5)

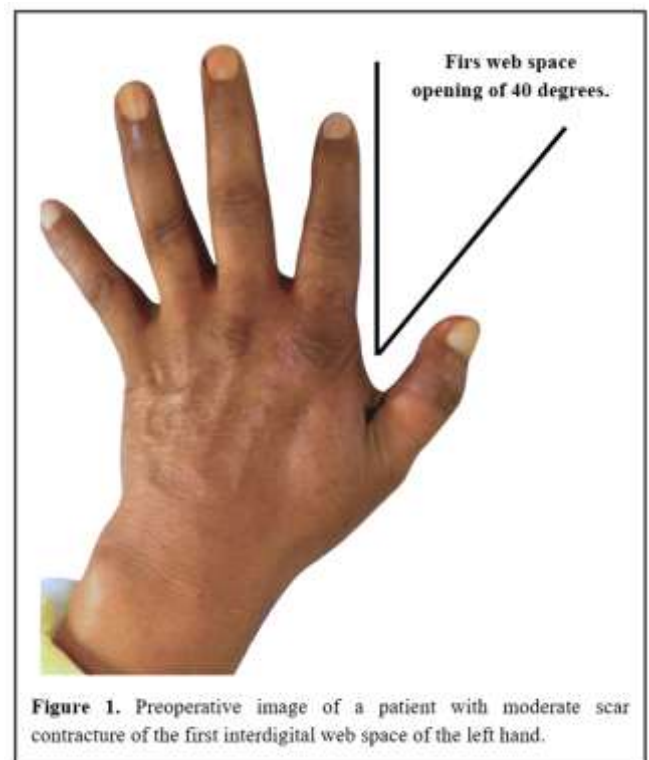
CASE PRESENTATION

A 52-year-old male patient presented with a history of a cutting injury to the left hand; the remainder of his history was reviewed and was unremarkable.

The current condition began approximately 5 months prior to evaluation, following a cutting injury to the left hand. During its course, the patient reported progressive narrowing of the first web space of the left hand, resulting in limited thumb abduction. He denied pain, paresthesia, or other associated symptoms.

He presented to the Plastic and Reconstructive Surgery Department for specialized evaluation of the described functional limitation and determination of therapeutic management.

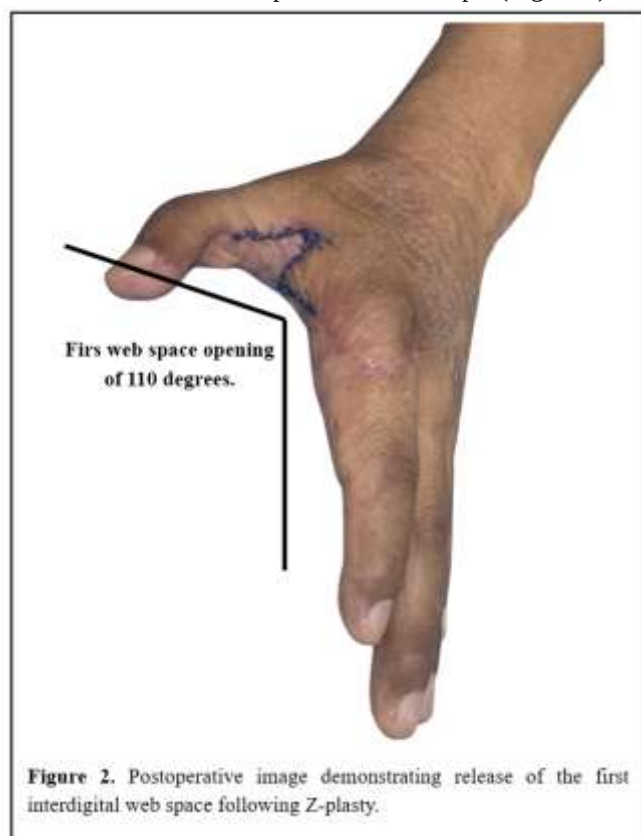
Examination of the left hand revealed a hypertrophic, retractile scar at the level of the first web space, resulting in decreased opening, with palmar abduction of 20° and radial abduction of 15°. Thumb opposition was limited but functional, Kapandji 7/10, with preserved metacarpophalangeal and interphalangeal flexion-extension and no pain on mobilization. Sensation in the median, ulnar, and radial territories was preserved, distal capillary refill was less than 2 seconds, and there was no evidence of neurovascular compromise. (Figure 1)



Following asepsis, antisepsis, and surgical marking of the left first web space, under local anesthesia with 5 cc of lidocaine

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with epinephrine, incisions were made for Z-plasty using a No. 15 scalpel. The triangular flaps were dissected and transposed, achieving release of the scar band and adequate opening of the first web space. Dermal closure was performed with 4-0 nylon simple sutures, confirming hemostasis and adequate flap viability; a sterile dressing was applied, and the procedure was concluded without immediate complications. In the **immediate postoperative period**, the patient showed satisfactory clinical progress, with a satisfactory increase in first web space opening, achieving radial and palmar thumb abduction of approximately 90°-110°, with no immediate evidence of vascular compromise of the flaps. (Figure 2)



DISCUSSION

First web space contracture constitutes a functionally relevant impairment because it limits the separation between the thumb and index finger, restricts thumb abduction and opposition, and reduces the capacity for pinch, cylindrical grip, and grasping of large-diameter objects. The first web space should not be regarded merely as a cutaneous fold; it is a three-dimensional unit located between the first and second metacarpals, composed of skin and subcutaneous tissue, fascia, the first dorsal interosseous muscle, and the adductor pollicis, and is closely related to, or traversed by, deep neurovascular structures. [1,2].

Z-plasty is a local transposition flap technique that uses two opposing triangular flaps to redistribute tissue, change the direction of a scar, and, fundamentally in the first web space, increase the length available along the axis of a contracture. In a classic Z-plasty with 60° angles, the theoretical geometric increase in length is approximately 75%; however,

the actual clinical gain depends on elasticity, fibrosis, scar depth, joint mobility, three-dimensional configuration of the space, and availability of adjacent healthy tissue. [3,4].

Z-plasty is particularly appropriate for mild to moderate linear cutaneous contractures with sufficient local skin. The four- and five-flap modifications increase the capacity for web space deepening. In experimental models, Fraulin and Thomson observed an elongation of approximately 133% for the 90° four-flap Z-plasty and 167% for the 120° variant, compared with 84% for the five-flap variant; however, the variant with the greatest gain was also more difficult to design and close. [5].

A 2024 clinical review confirmed that geometry must be adapted to the length of the band and the availability of skin: the four-flap Z-plasty provides substantial lengthening, whereas the five-flap variant allows treatment of relatively long central scars without requiring excessively long lateral limbs. [6].

A central problem in the literature is the absence of a universally accepted definition and measurement method for the first web space. A classic study of 195 healthy hands found a mean thumb-index angle of approximately 100°, whereas radial and palmar thumb abduction is usually expressed through different parameters, typically in the range of 60–70° depending on the measurement technique. Therefore, the soft-tissue web angle, the intermetacarpal angle, carpometacarpal abduction, and the Kapandji opposition score should not be confused with one another. [7,8].

Scoping reviews from 2025–2026 specifically highlight this heterogeneity and consider standardization of measurements and patient-reported outcomes a priority. [9,10]. For clinical research, it has been proposed to document, at minimum: thumb-index opening angle, palmar and radial abduction, intermetacarpal distance, Kapandji score, pinch strength, and a validated functional measure, in addition to standardized photographs. This strategy would allow more rigorous comparison of simple, four-flap, and five-flap Z-plasties, grafts, and local or regional flaps, a field currently dominated by small series, retrospective studies, and geometric models. [5,6,9,10].

I. Definition and Historical Evolution of Z-plasty

Z-plasty is a plastic surgery technique based on the design and transposition of adjacent triangular flaps. The central segment of the "Z" is ideally positioned along the axis of maximal retraction, with two lateral limbs designed in opposite directions. Transposition of the triangles achieves lengthening along one axis in exchange for redistributing tension and relatively shortening the perpendicular axis. In addition to releasing contractures, the technique allows scars to be reoriented and linear scars to be broken up. [3,4].

Historically, Borges and Gibson attributed to Horner, in 1837, one of the first interventions containing the geometric principle of Z-plasty; Denonvilliers reported a procedure for correcting cicatricial ectropion in 1854, Berger later

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described a true double transposition, and McCurdy introduced the term "Z-plasty" in 1913. [11]. This progressive development transformed a scar-correction maneuver into one of the basic principles of tissue redistribution in reconstructive surgery. In the classic 60° Z, an approximately 75% theoretical increase of the central axis is calculated. This figure is geometric and does not necessarily equate to functional in vivo gain; fibrosis, contracture depth, and the resistance of deep structures may reduce it. [3,5].

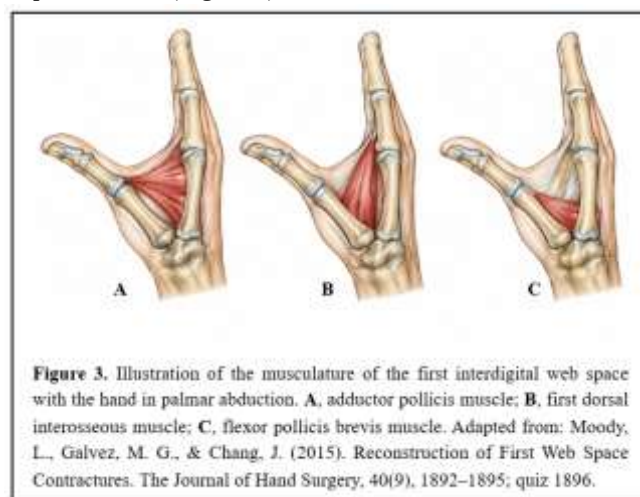
II. Epidemiology and Etiopathogenesis of Contractile Scars

There is no robust epidemiological figure specifically describing the incidence of acquired first web space contracture. This lack of data constitutes a relevant limitation of the literature. The best epidemiological data come from burn populations: a systematic review found scar contracture prevalences of 38–54% at discharge, decreasing over time, with a higher risk noted in more severe burns, flame burns, the pediatric population, and the upper extremity. [12]. The incidence of hypertrophic scarring after burns also shows enormous methodological variability, with published values ranging from 8% to 67%. [13]. These data should not be directly extrapolated to the first web space. From an etiological standpoint, contractures may occur after thermal or electrical burns, cutting wounds and lacerations, crush injuries, tissue loss, infections, prior surgery, or prolonged immobilization. Non-cicatricial or mixed deficiencies of the first web space also exist, associated with congenital anomalies, arthrogryposis, hypoplastic or palm-included thumb, Apert syndrome, and other congenital differences. Dupuytren's disease may produce a cord in the first web space, whereas denervation, spasticity, and retraction of the adductor pollicis may generate an adduction deformity that mimics or accompanies the cutaneous contracture. [14–16]. Contractile scarring results from a combination of extracellular matrix remodeling, myofibroblastic activity, and persistence of tensional forces; when a scar crosses a mobile region such as the first web space, contraction progressively reduces the cutaneous surplus required for abduction. If the process persists, the fascia, adductor pollicis, first dorsal interosseous muscle, and carpometacarpal capsule may become involved, and secondary skeletal deformity may even occur, such that an initially cutaneous injury can evolve into a complex three-dimensional contracture. [13,17].

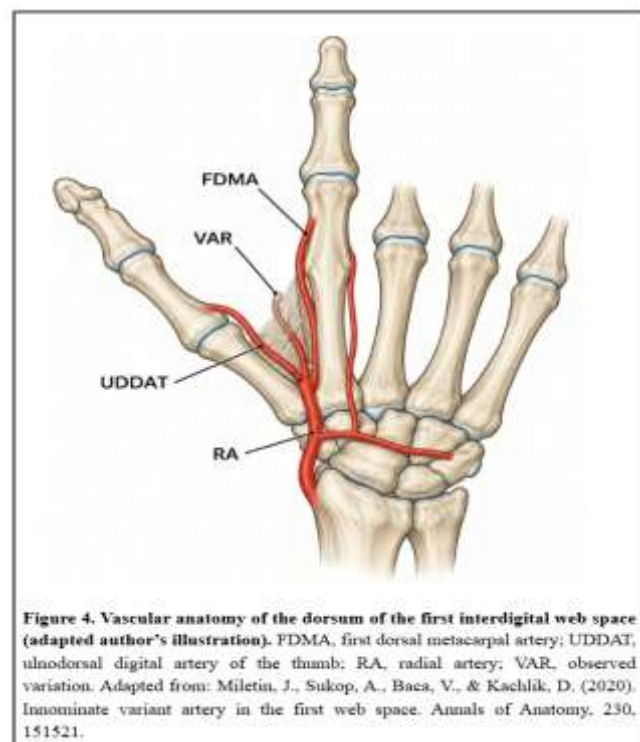
III. Surgical Anatomy of the First Web Space

The first web space corresponds to the triangular, or from a reconstructive perspective, approximately tetrahedral region located between the first and second rays. It is bounded osseously by the first and second metacarpals and is proximally related to the thumb carpometacarpal joint. This saddle-type joint provides the multiplanar mobility required for abduction, flexion-extension, and axial rotation associated with opposition. [1,14].

Superficially, there is relatively mobile dorsal and palmar skin, subcutaneous tissue, and fascia. In depth, the first dorsal interosseous muscle constitutes an important part of the dorsal plane, while the adductor pollicis forms an essential part of the palmar/deep plane. The regional surgical anatomy also includes the thenar eminence, the tendons of the abductor pollicis longus, abductor pollicis brevis, flexor pollicis longus, and thumb extensors, as well as the capsuloligamentous structures responsible for maintaining the relationship between the first metacarpal and the trapezium. [2]. (Figure 3)



The radial artery passes into the palm through the region of the first web space to contribute to the deep palmar arch and gives rise to branches relevant to the thumb and index finger; the region is also related to superficial sensory branches and to the deep branch of the ulnar nerve, which innervates the adductor pollicis and first dorsal interosseous muscle. (Figure 4) Deep dissection of a contracture must therefore avoid assuming that it involves a simple cutaneous plasty alone. [2].



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IV. Clinical Diagnosis and Differential Diagnoses

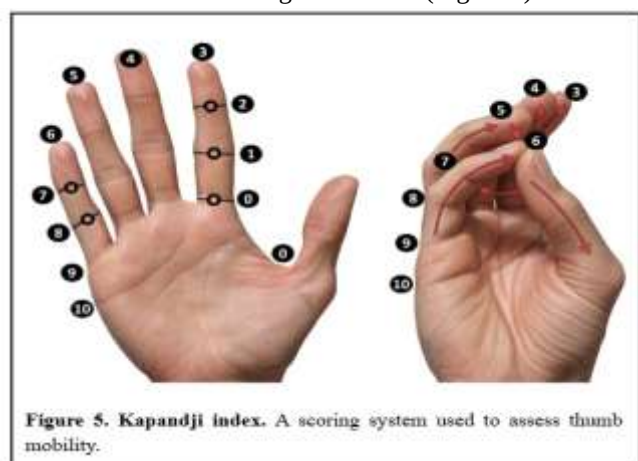
Diagnosis is essentially clinical. It should be determined whether the limitation arises from an isolated cutaneous band, a deep tissue contracture, or a combination of both. Inspection assesses the orientation, length, width, coloration, hypertrophy, and adherence of the scar; palpation during abduction helps identify the point of maximal tension. Systematic comparison with the contralateral hand is useful, as is differentiating active from passive mobility. A substantial difference between the two suggests a muscular, tendinous, or neurological component, whereas marked passive limitation points toward a fixed structural restriction. [9,14].

The main differential diagnoses include osteoarthritis or deformity of the carpometacarpal joint, capsular contracture, retraction or fibrosis of the adductor pollicis or first dorsal interosseous muscle, tendon injury or adhesion, Dupuytren's disease, median/ulnar/radial nerve palsy, spasticity with a palm-included thumb, and congenital anomalies of the first ray. Radiography or electrodiagnostic studies are not mandatory in a typical cutaneous scar but should be selected according to clinical suspicion. [9,14,16].

V. Measurement Methods and Diagnostic Support

A critical point is determining exactly which angle is being measured. Jensen et al. analyzed 195 hands and described a mean first web space angle of approximately 100°; this corresponds to the overall thumb-index angle in that study's methodology and should not be interpreted as 100° of carpometacarpal abduction. [7]. Anatomical texts describe approximately 60–70° of thumb separation in abduction, reflecting a different measurement construct. [2].

The Kapandji index assesses opposition using the hand itself as a reference, progressing from the side of the index finger to the fingertips and subsequently to the little finger's creases and the palm, with a maximum score of 10. It is simple and clinically useful but has a ceiling effect; kinematic studies show that scores above 6 do not necessarily represent proportional increases in true pronation/opposition of the first metacarpal. [18,19]. It should therefore not be used as the sole outcome variable after surgical release. (Figure 5)



Recent evidence favors recording several dimensions rather than a single figure. The review by Kim et al. found considerable heterogeneity in methods, positions, and cutoff points; intermetacarpal distance measured with calipers showed more favorable reproducibility than conventional goniometry in some studies, although a validated universal standard is still lacking. [9].

VI. Classification of First Web Space Opening

A clinically practical classification is that proposed by Coombs and Thomas, based on the thumb-index angle during maximal radial abduction with the metacarpophalangeal joints in a neutral position: [21].

Table 1. Classification of First Web Space Contracture According to Thumb–Index Angle and Estimated Skin Lengthening

Severity	Thumb–Index Angle	Approximate Skin Increase Required
Mild	60–90°	<50%
Moderate	40–60°	50–125%
Severe	<40°	>125%

This classification is useful for reconstructive planning but does not constitute an international standard and should not be extrapolated to angles obtained using a different technique. [10,21]. In the pediatric congenital setting, another classification based on the intermetacarpal angle has been used, with severe contracture $\leq 10^\circ$, moderate 10–20°, and mild 20–40°. [22]. This is a different radiographic/metacarpal metric and should not be mathematically combined with the Coombs classification. For publications on acquired Z-plasty in adults, it is more robust to report continuous pre- and postoperative values than to rely on a single category—for example, thumb-index angle, radial abduction, palmar abduction, IMD in millimeters, Kapandji score, and pinch strength.

VII. Conservative Treatment and Selection of Reconstruction

Treatment must be tailored to scar maturity, severity of functional loss, capacity for passive correction, and depth of the contracture. In recent or partially correctable scars, the initial strategy consists of hand therapy, active and passive exercises, scar mobilization, and first web space abduction orthoses. In burn patients, early rehabilitation, positioning, orthoses, and compression management form a central part of contracture prevention. [23].

Silicone sheets or gel and compression therapy play a role mainly in the hypertrophic component of the scar; intralesional corticosteroid infiltration and certain laser modalities may improve specific components of pathological

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scars but do not by themselves provide the additional tissue required by a fixed mechanical contracture of the first web space. A mature contracture that prevents passive abduction and limits relevant activities is, by practical definition, a reconstructive problem rather than purely a matter of scar maturation. [17,23].

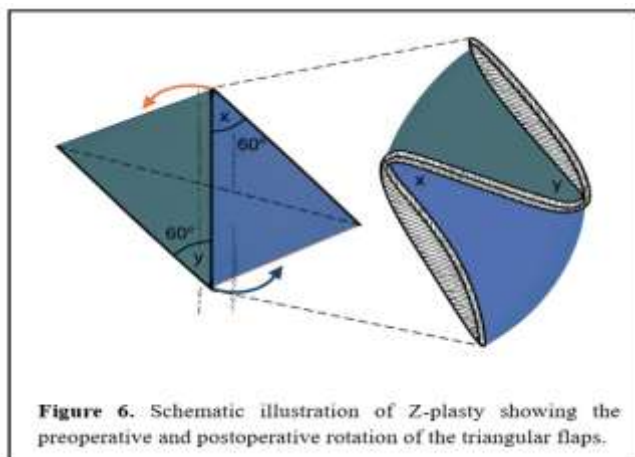
The surgical goal is not simply to "open" the commissure but to release all responsible levels and replace the tissue deficit with flexible, stable, and well-vascularized coverage. Options include Z-plasties, V-Y plasties, local transposition flaps, the Manta Ray flap, full-thickness skin grafts, dermal substitutes, dorsal metacarpal artery flaps, regional flaps such as the posterior interosseous or antebrachial flap, and free flaps for severe defects. [14,24].

Skin grafts are useful when insufficient adjacent skin is available, but they require a vascularized bed and carry a risk of secondary contraction. More generally—not specifically in the first web space—a multicenter randomized trial showed better outcomes for release of burn contractures with interposition perforator flaps than with full-thickness skin grafts, supporting the reconstructive principle of preferring vascularized tissue when anatomy and the defect permit. [25]

VIII. Z-Plasty of the First Web Space: Indications and Planning

The ideal indication for Z-plasty is a contracture with a predominantly cutaneous, relatively linear component, surrounded by viable skin with sufficient mobility to permit flap transposition. In severe contractures, circumferential burns, extensive cutaneous deficiency, exposure of tendon, bone, or joint, or deep muscular/capsular fibrosis, an isolated Z-plasty may be insufficient. [14,23].

Planning should be performed before infiltrating anesthetic, with the thumb gently brought to maximal possible opening to identify the axis of greatest tension. The length of the limbs, their angles, the vascularity of the flap tips, and the possibility of tension-free closure determine the viability of the design. In the classic Z, angles close to 60° are commonly used; smaller angles produce less lengthening and narrower flaps, whereas larger-angle designs increase theoretical gain but require greater mobility and may hinder closure. [3,5]. (Figure 6)



The percentages reported for the different Z-plasty variants should be interpreted with caution. In particular, the data from Fraulin and Thomson derive from geometric models and animal tissue, not from a randomized clinical trial in human hands. [5]. Furthermore, different authors label the angles of the variants according to different geometric conventions; it is therefore preferable to graphically depict the design used in a scientific article, in addition to naming it.

IX. Surgical Technique

Anesthesia may be local, regional, or general depending on the extent, patient age, associated procedures, and the anticipated depth of release. A localized cutaneous plasty in an adult can be performed under local anesthesia, whereas a deep or extensive reconstruction requires a different anesthetic approach. The critical point is not the type of anesthesia but ensuring atraumatic dissection, reliable hemostasis, and adequate assessment of flap perfusion.

Bhattacharya et al. emphasized that adequate release, coverage with local tissue, and maintenance of abduction through orthotic splinting constitute a single therapeutic package rather than independent stages. In their experience with post-burn contractures, a dynamic abduction splint was used for six weeks. [16].

Table 2. Essential Surgical Steps and Technical Considerations for First Web Space Contracture Release

Surgical Step	Essential Elements
Marking	Identify the axis of maximal contracture with the thumb in abduction. Draw the central limb over the band and plan limbs of appropriate length, typically symmetric in the classic Z. [3]
Preparation and anesthesia	Antisepsis, sterile field, and anesthesia appropriate to the extent and depth. Avoid distorting the markings before the design is finalized.
Incision	Incise according to the markings, respecting the base of each flap and avoiding excessively narrow tips.
Elevation	Elevate the flaps with sufficient thickness to preserve the subdermal plexus; avoid devascularization from excessive dissection.
Release	Release the scar band until correction is achieved; progressively explore the fascia, adductor, first interosseous muscle, or capsule only if limitation persists and the clinical picture warrants it. [14]

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Transposition	Exchange the position of the flaps without torsion or excessive tension; verify opening and perfusion before suturing.
Intraoperative measurement	Record the thumb–index angle and, if possible, radial/palmar abduction or intermetacarpal distance to objectively document the gain. [7,9]
Hemostasis and closure	Meticulous hemostasis; suture without strangulating the flap tips. Closure must maintain the correction without excessive tension.
Postoperative protection	Non-constrictive dressings and an orthosis maintaining first web space opening, followed by supervised rehabilitation. Duration is individualized according to stability, tissue characteristics, and technique. [16,23]

This period should not be assumed to be universal for all Z-plasties: rehabilitation depends on healing, flap size and vascularity, concomitant deep procedures, and recurrence risk.

Potential complications include ischemia or necrosis of the flap tips, hematoma, infection, dehiscence, hypertrophic scarring, sensory or vascular injury, insufficient release, secondary loss of opening, stiffness, and recurrence of the contracture. [3,14].

An excessively small design, underestimation of deep fibrosis, or insufficient rehabilitation can produce a satisfactory geometric gain during surgery but a poor long-term functional outcome.

X. Critical Discussion, Clinical Application, and Research Perspectives

The main strength of Z-plasty in the first web space is that it applies the principle of "like tissue for like tissue": it preserves local skin, maintains comparable sensibility and texture characteristics, avoids a distant donor site, and redistributes tension without necessarily requiring interposition of a graft. Nevertheless, precisely because it depends on the availability of adjacent tissue, its usefulness decreases as the severity and depth of the contracture increase. [14,24].

From a biomechanical perspective, the reconstructive goal should be expressed as the recovery of a three-dimensional functional volume, not merely as the elongation of a line. The first web space must allow the first metacarpal to separate from the second, move in the palmar plane, and undergo the axial rotation necessary for opposition. A Z-plasty may substantially increase cutaneous length and, despite this, fail to restore function if adductor retraction, carpometacarpal stiffness, or neuromuscular impairment persists. [14].

This explains why surgical outcome should not be evaluated solely by the final length of the scar.

The literature also compels reconsideration of the isolated use of the Kapandji score. A patient may achieve a Kapandji score of 8–10 through compensatory combinations of flexion and translation without fully normalizing abduction or pronation of the first metacarpal. [19].

Consequently, a publication on first web space opening should combine at least one angular, one linear, and one functional measure.

A minimum outcome set for future studies could include the following:

Preoperatively, in the immediate postoperative period, and at 3, 6, and 12 months of follow-up: thumb–index angle in a standardized position; radial and palmar abduction; intermetacarpal distance in millimeters; Kapandji score; lateral and tridigital pinch strength; a scar scale, when applicable; pain; complications; recurrence; and a patient-reported measure such as the QuickDASH or equivalent. Clinical photography should be obtained at a constant distance, position, and scale. This proposal derives from the methodological limitations identified in recent reviews and constitutes a recommendation for standardization, not an existing formal consensus. [9,10].

Intermetacarpal distance deserves particular attention as a potentially simple and reproducible variable. Thumb measurement studies have shown good interobserver reliability with calipers, whereas goniometry may have lower reproducibility, particularly for palmar abduction. [9,20].

For IMD to be comparable across individuals, adjustments for hand size, sex, age, and metacarpal length will need to be studied.

Regarding emerging technologies, three-dimensional photography, photogrammetry, inertial sensors, and kinematic analysis systems could better characterize the functional space than two-dimensional measurement. High-resolution ultrasound and elastography have potential for identifying scar depth and stiffness and distinguishing cutaneous contracture from deep fibrosis, although specific studies relating these parameters to the choice of a simple, four-/five-flap, or more complex flap are still lacking. Reviews published through 2026 continue to note the absence of a universal assessment tool or sufficiently validated cutoff values. [9,10].

Another priority is to compare the actual functional outcomes of Z-plasty variants. Fraulin's classic study established a solid geometric foundation, but its experimental component does not address whether an immediate 167% gain is maintained at one, five, or ten years, nor whether it translates into superior pinch or daily function. [5].

Rogers' 2024 series provides clinical information on the practical geometric advantages of four versus five flaps but likewise does not constitute a prospective comparative trial using standardized functional instruments. [6].

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For this reason, prospective multicenter studies stratifying patients by etiology—burn, cutting trauma, Dupuytren's disease, congenital—and by contracture depth, and comparing simple Z-plasty, four-flap, five-flap, alternative local flaps, and grafts using uniform functional criteria, would be particularly valuable. The specific incidence of first web space contracture following traumatic injuries and burns is also not adequately established; available epidemiological percentages correspond to burn contractures at various sites, not specifically to the first web space in isolation. [12,13].

In summary, Z-plasty remains a fundamental tool for mild to moderate, predominantly cutaneous contracture of the first web space. Its success depends less on reproducing a geometrically perfect "Z" than on correctly diagnosing the level of retraction, objectively quantifying the deficiency, selecting the variant that provides sufficient tissue, protecting deep neurovascular and muscular structures, and maintaining the gain through appropriate postoperative rehabilitation. In severe or three-dimensional contractures, the principle of "making a bigger Z" should be abandoned in favor of a reconstruction that imports sufficient vascularized tissue. [14,21,24].

XI. Limitations of Available Evidence

Interpretation of the literature presents four main limitations. First, studies employ different definitions of "opening": cutaneous angle, angle between rays, carpometacarpal angle, or linear distance. [9,10].

Second, numerous studies combine congenital, post-burn, and post-traumatic contractures, even though their mechanisms are not equivalent. Third, much of the data on Z-plasty elongation derives from theoretical geometry, experimental models, or small series. [5,6].

Finally, few long-term comparative studies focus specifically on the first web space; therefore, the choice between four and five flaps must still be based on anatomy, scar length, skin availability, and reconstructive experience rather than on definitive clinical evidence of functional superiority. [5,6,10].

CONCLUSIONS

Z-plasty constitutes one of the fundamental techniques within plastic and reconstructive surgery for the management of retractile scars and cutaneous contractures, particularly in anatomical regions where small modifications in length, orientation, and tension distribution can produce important functional changes. Its usefulness in the first web space of the hand clearly exemplifies this principle, since decreased opening between the thumb and index finger can significantly compromise opposition, pinch, grip, and, consequently, overall hand function. Its application should therefore be understood not merely as a scar-correction technique but as a reconstructive procedure aimed at restoring a functional unit. The rationale for Z-plasty is based on the transposition of two triangular flaps that allows the direction of a scar to be modified and lengthening to be obtained along the axis of the contracture. The classic 60° configuration theoretically offers

a length gain of approximately 75%; however, this increase corresponds to an ideal geometric model and does not necessarily represent the elongation achieved clinically. Factors such as fibrosis, skin elasticity, tissue thickness, contracture depth, and the presence of previous scars can considerably reduce the actual gain. Consequently, surgical planning should be based on individualized tissue assessment rather than solely on geometric calculations.

In first web space contracture, Z-plasty achieves its best results when the retraction is predominantly cutaneous, linear, or moderate, and sufficient healthy, mobile adjacent skin is available to permit flap transposition. The four- and five-flap variants can provide greater deepening or tissue redistribution in certain defects; however, no single configuration can be considered universally superior. The choice must be individualized according to scar orientation, magnitude of the deficit, tissue quality, and surgeon experience. Likewise, an apparently cutaneous contracture may be accompanied by fascial, muscular, capsular, or adductor pollicis retraction, so preoperative evaluation must precisely determine the depth of the restrictive component.

The main limitation of Z-plasty arises when the problem ceases to be exclusively a deficiency of cutaneous length. In the presence of deep fibrosis, extensive loss of coverage, exposure of vital structures, or severe contractures, simple local flap transposition may be insufficient. In these scenarios, more extensive release combined with skin grafts, local, regional, or even free flaps may be necessary. Inadequate selection of the procedure may favor recurrence of the contracture, flap necrosis, dehiscence, scarring abnormalities, or limited functional gain.

Finally, the success of a Z-plasty should not be determined exclusively by the lengthening achieved or by the change in the first web space angle. The true reconstructive outcome must be assessed through the recovery of thumb opposition, range of abduction, pinch and grip capacity, strength, mobility, and long-term maintenance of correction. Likewise, postoperative rehabilitation and scar management play an essential role in preserving the achieved outcome. In conclusion, Z-plasty remains a versatile, reproducible, and highly valuable technique within the reconstructive armamentarium; however, its effectiveness depends on adequate understanding of its geometric principles, anatomical and functional analysis of the contracture, and, above all, correct patient selection and choice of reconstructive variant. The ultimate goal should be not only to modify a scar but to stably restore the function, mobility, and tissue quality of the treated region.

AUTHOR CONTRIBUTIONS

Rodrigo García Zarco: conceptualization, project administration, supervision, writing – original draft, writing – review and editing. **Paul Alejandro Palacios Zaragoza:** formal analysis, resources, software, writing – review and editing. **Eduardo Balboa Hernández:** investigation,

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methodology, resources. **Kevin Adrian Tinajero Camacho:** investigation, methodology, resources. **Miriam Melina Vargas Mejía:** investigation, methodology, resources. **Marco Rafael de la Vega Ornelas:** investigation, methodology, resources. **Irad Antonio Zúñiga Salazar:** investigation, methodology, resources. **John Anthony García Hernández:** investigation, methodology, resources. **Ada Areli Cabrera Medina:** investigation, methodology, resources. **Ramiro Barajas Chávez:** investigation, methodology, resources. **Miriam Erendira Rodríguez Muñoz:** investigation, methodology, resources.

DECLARATION OF CONFLICT OF INTEREST

The author declares that he has no conflict of interest related to this article.

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CONSENT

The patient provided written informed consent for the publication of this case report and any related images.

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