

Surgical Treatment of Cutaneous Tumors and Reconstruction of the Resulting Defects: The Contemporary Role of the Rhombic (Limberg) Flap

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ABSTRACT

Cutaneous tumors are the most frequent malignancies in fair-skinned populations, and the majority arise on the head and neck, where complete oncological excision must be reconciled with strict aesthetic and functional demands. This narrative review examines the contemporary treatment of skin tumors from both perspectives. The oncological section summarizes risk stratification, margin selection for basal cell carcinoma, cutaneous squamous cell carcinoma and melanoma, the role of micrographic and frozen-section margin control, and the principle that definitive flap reconstruction must never precede documented clearance. The reconstructive section analyses the rhombic (Limberg) transposition flap as the principal model of local reconstruction, covering terminology, historical development, the vascular anatomy of the dermal-subdermal plexus on which random-pattern flaps depend, the geometry of the classical 60/120-degree design, and the Dufourmentel, Webster, Quaba-Sommerlad, multiple-flap and hybrid modifications. Published clinical series are reviewed, together with complications, contraindications and non-surgical alternatives. Contemporary evidence, although limited to small retrospective series, consistently reports flap survival approaching 100%, same-day discharge under local anesthesia and high patient-reported satisfaction, particularly in elderly patients with favorable skin laxity. The rhombic flap remains a first-line option for small and medium-sized defects of the lateral midface and cheek, provided that the flap vector is selected according to the lines of maximum extensibility and that the technique is adapted to the defect rather than the defect to the technique

KEYWORDS: Skin cancer; basal cell carcinoma; squamous cell carcinoma; Limberg flap; rhombic flap; local flaps; facial reconstruction; surgical margins.

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I. INTRODUCTION

Cutaneous neoplasms represent the single largest group of malignancies treated by plastic surgeons and dermatologic surgeons worldwide. Keratinocyte carcinomas, historically grouped as non-melanoma skin cancer (NMSC), together with cutaneous melanoma, now constitute the most frequent malignant tumors in fair-skinned populations, and their incidence continues to rise in almost every registry that records them [1,2]. Because more than 80% of these lesions arise on chronically photo-exposed surfaces, and because the head and neck represent only 9% of the total body surface area while concentrating the majority of tumors, the surgeon is repeatedly confronted with the same clinical problem: how to achieve complete oncological clearance in an anatomically dense, functionally critical and aesthetically unforgiving region, and how to close the resulting defect in a single stage, with minimal morbidity, in a population that is frequently elderly and medically complex [3,4].

The therapeutic algorithm for cutaneous tumors has therefore two inseparable components. The first is oncological: establishing an accurate histological diagnosis, stratifying the lesion by risk, and selecting an excisional or non-excisional modality that offers the highest probability of cure. The second is reconstructive: restoring the cutaneous envelope with tissue of comparable thickness, color, texture and adnexal content, while respecting the boundaries of aesthetic subunits and the vectors of resting skin tension. These two components are sequential in execution but simultaneous in planning; a reconstruction conceived before margins are confirmed is a frequent source of oncological compromise, and an excision planned without regard to the reconstructive consequences is a frequent source of avoidable deformity [5,6].

Among the local options available for the second component, the rhombic transposition flap described by Alexander Alexandrovich Limberg occupies a singular position. Nearly a century after its conception, it remains one of the few reconstructive techniques that can be drawn at the bedside in less than a minute, executed under local anesthesia in twenty minutes, applied to almost any anatomical region, and taught reproducibly to trainees because its geometry is explicit rather than intuitive [7,8]. Its persistence in contemporary practice is not nostalgia: recent series continue to report flap survival rates approaching 100%, high patient-reported aesthetic satisfaction, and the possibility of treating nonagenarian or emaciated patients without general anesthesia [9,10].

The present narrative review has three objectives. First, to summarize the contemporary evidence governing the diagnosis and excisional treatment of cutaneous tumors, with emphasis on margin selection and margin control. Second, to analyze critically the anatomical, geometrical and physiological basis of local flap reconstruction, using the rhombic (Limberg) flap and its modifications as the principal

model. Third, to define, based on published clinical series and our reading of the literature, the situations in which this flap should be the first choice, the situations in which it should be modified, and the situations in which it should be abandoned in favor of an alternative.

II. EPIDEMIOLOGY

NMSC is by far the most frequent malignancy in white populations and constitutes more than one third of all cancers diagnosed in the United States. Estimates place the annual incidence above

one million cases, of which roughly 70% to 80% are basal cell carcinoma (BCC) and 20% to 30% are cutaneous squamous cell carcinoma (SCC); the combined incidence of

keratinocyte carcinoma is approximately eighteen to twenty times that of melanoma [1]. Because traditional cancer registries frequently exclude or under-record these tumors, all such figures should be regarded as conservative. Lifetime risk of developing BCC has been estimated at 28% to 33%, and of SCC at 7% to 11%, for individuals born in the mid-1990s [1].

The weight of ultraviolet radiation differs between the two histotypes. Intense, intermittent UV exposure during childhood and adolescence is causally linked to BCC, whereas cumulative chronic exposure over decades is the dominant driver of SCC; occupational UV exposure is now accepted as an independent risk factor, and in some jurisdictions NMSC in outdoor workers is formally recognized as an occupational disease [1]. Additional contributors include increased longevity, changes in clothing habits and outdoor activity, stratospheric ozone depletion, genetic predisposition and iatrogenic or disease-related immunosuppression. Cutaneous melanoma, although far less frequent, is the most rapidly increasing cancer in white populations, with annual increases of 3% to 7% and a doubling of incidence rates every ten to twenty years; mortality has nevertheless stabilized in North America, Australia and much of Europe, largely as a consequence of earlier detection and consequent reduction in tumor thickness at diagnosis [1].

The practical corollary for the reconstructive surgeon is demographic. NMSC generally occurs in individuals older than 50 years, and incidence rises steeply thereafter. The typical candidate for reconstruction after tumor excision is therefore an elderly patient, frequently with hypertension, diabetes mellitus, chronic obstructive pulmonary disease, peripheral vascular disease or anticoagulation, in whom general anesthesia carries measurable risk and in whom



Figure 1.- Type of skin cancer.

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prolonged or staged reconstruction is poorly tolerated [9,10]. Conversely, this same population usually offers the most favorable technical condition for local transposition flaps, namely abundant skin laxity. Advanced age, so often listed among the relative contraindications to elective surgery, is in this specific context a reconstructive advantage.

III. DIAGNOSTIC AND ONCOLOGICAL PRINCIPLES

A. Histological confirmation and risk stratification

Definitive reconstruction should never precede histological certainty. Incisional or punch biopsy is indicated whenever the clinical diagnosis is uncertain, when the differential includes melanoma, or when the extent of resection would be materially altered by the histological subtype. Dermoscopy has substantially improved preoperative discrimination but does not replace histopathology. Once the diagnosis is established, lesions are stratified into low-risk and high-risk categories based on anatomical site, diameter, histological subtype, degree of differentiation, perineural or lymphovascular invasion, primary versus recurrent status, previous irradiation of the field, and host immune status [11,12].

The so-called mask areas of the face, comprising the central face, eyelids, eyebrows, periorbital skin, nose, lips, chin, mandible, preauricular and postauricular skin, temple and ear, are designated high-risk irrespective of tumor diameter, as are genital, hand and foot lesions. This designation is not merely prognostic: it determines the method of margin control, and therefore the timing of reconstruction [11,13].

B. Margin selection in conventional excision

For low-risk primary BCC, a peripheral clinical margin of 4 mm with excision to the mid-subcutaneous fat achieves complete histological clearance in approximately 95% of cases [11]. For low-risk cutaneous SCC, margins of 4 mm to 6 mm are generally recommended, with wider margins for tumors exceeding 2 cm in diameter, poorly differentiated tumors, or lesions arising in high-risk locations [12]. For primary cutaneous melanoma, margins are dictated by Breslow thickness: 0.5 cm to 1.0 cm for melanoma in situ, 1 cm for tumors up to 1.0 mm, 1 cm to 2 cm for tumors of 1.01 mm to 2.0 mm, and 2 cm for tumors thicker than 2.0 mm [14].

Two caveats deserve emphasis. First, the completeness of excision is significantly operator-dependent: incomplete excision rates fall as surgical experience increases, an effect demonstrated even when nominally identical margins are used [15]. Second, subclinical extension is the rule rather than the exception in morphoeic, infiltrative, micronodular and recurrent BCC, and in poorly differentiated SCC; in these subtypes, fixed peripheral margins systematically underestimate the true tumor extent.

C. Margin control and the timing of reconstruction

Mohs micrographic surgery provides complete circumferential peripheral and deep margin assessment and is

the standard of care for high-risk tumors of the face, for recurrent lesions, and for aggressive histological subtypes; appropriate-use criteria have been formalized and are widely applied [13]. In a randomized trial with ten-year follow-up comparing Mohs surgery with conventional excision for facial BCC, recurrence rates were approximately 4% versus 12% for primary tumors and approximately 4% versus 14% for recurrent tumors, favoring micrographic control [16]. Where Mohs is unavailable, intraoperative frozen-section analysis of the specimen offers a practical alternative, and is the approach adopted in most of the published Limberg flap series, in which margins were confirmed before flap elevation [10].

The corollary is procedural: inadequate margin clearance is an absolute contraindication to immediate local flap reconstruction. A transposition flap redistributes tissue across the wound bed and displaces the original tumor bed, which compromises the anatomical mapping of any subsequent re-excision and may bury residual disease beneath healthy skin. When definitive margin status cannot be established intraoperatively, the wound should be temporized with a dressing, a synthetic dermal substitute or delayed primary closure, and reconstruction deferred until clearance is documented [5,7].

IV. PRINCIPLES OF RECONSTRUCTION AFTER TUMOUR EXCISION

A. The reconstructive decision

The classical reconstructive ladder progresses from secondary intention healing, through primary closure, skin grafting, local flaps, regional flaps and finally free tissue transfer. In cutaneous oncological surgery of the face, however, the ladder is applied less as a hierarchy than as a menu, and the elevator metaphor is more accurate: the surgeon selects the simplest technique that satisfies the aesthetic requirement, which is not always the lowest rung [6].

Primary closure remains the first option and should be pursued whenever it can be achieved without distortion of a free margin. Its limits are quickly reached on the convex prominences of the face, where wound closure tension is transmitted directly to the eyelid, ala or oral commissure, and where the resulting ectropion, alar retraction or commissural asymmetry is functionally and cosmetically unacceptable [17].



Figure 2.- RSTL lines in Limberg flap.

Full-thickness skin grafting is technically simple but carries the well-described penalties of color and texture mismatch, secondary contraction, a depressed contour over convex surfaces, and the need for a separate donor site; graft retraction may itself distort adjacent subunits [17,18]. Secondary intention healing retains a role for concave

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surfaces such as the medial canthus, alar crease and conchal bowl, but is unreliable elsewhere on the face.

Local flaps therefore occupy the therapeutic center of gravity for small and medium-sized facial defects. They transfer skin of nearly identical thickness, color, actinic history and adnexal density from the immediate vicinity of the defect, in accordance with the principle of replacing like with like, and they preserve sensation and vascularity because they are not dependent on take from a recipient bed [7,19].

B. Aesthetic subunits and tension lines

Two planning frameworks govern local flap design on the face. The first is the principle of aesthetic subunits: incisions and resulting scars should be placed, wherever possible, at the junction of subunits, and tissue should be recruited from within the same subunit as the defect so that thickness, pigmentation, sebaceous quality and hair-bearing characteristics are matched [10,20].

The second framework is mechanical. Relaxed skin tension lines (RSTL) describe the direction of minimal tension in skin at rest and are the lines along which incisions heal with the least tension and the most favorable scar. They are not identical to the classical Langer lines, which were derived from cadaveric puncture studies and diverge appreciably from RSTL in regions of complex movement such as the forehead, temple, lateral canthus and oral commissure; the persistent conflation of the two in the literature is a recognized source of clinical error [21,22]. RSTL are identified in vivo by gently pinching the skin perpendicular to the presumed line, which produces long, uniform, symmetrical furrows; oblique pinching produces an irregular S-shaped pattern. Lines of maximum extensibility (LME) lie at 90 degrees to the RSTL and indicate the direction in which skin stretches most readily [7,21].

The operative consequence is a simple rule that governs every rhombic flap: the flap is recruited along the LME, where tissue is most easily borrowed, and the donor defect is closed along the RSTL, where the resulting scar is least conspicuous. When these two axes are inverted, the flap becomes difficult to inset, the donor site closes under tension, and the scar widens.

V. THE RHOMBIC (LIMBERG) FLAP: TERMINOLOGY, HISTORY AND ANATOMY

A. Terminology

The literature refers interchangeably to the Limberg flap, the rhombic flap and the rhomboid flap, and the imprecision is worth resolving. In Euclidean plane geometry a rhombus is an equilateral parallelogram: four sides of equal length, no right angles, and equal opposite angles. A rhomboid, by contrast, is a parallelogram with oblique angles and unequal adjacent sides, in which only opposite sides are equal [23,24]. Since the classical Limberg design is constructed from a figure whose four sides are equal, the correct adjective is rhombic. Several authors have made this argument explicitly, and rhombic is

now accepted as the precise descriptor, although rhomboid remains the more commonly used term in indexed literature [23,24,25]. In this review the terms Limberg flap and rhombic flap are used synonymously for the classical 60/120-degree design, and rhomboid is reserved for designs, such as the Dufourmentel variant, in which the defect is genuinely not equilateral.

B. Historical development

Limberg, a maxillofacial surgeon working in Leningrad, devoted his career to the geometrical planning of local flaps and published on the subject from 1928, when he introduced the term opposite triangular flap. His 1946 monograph on the mathematical principles of local plastic procedures described the closure of rhombus-shaped defects, and this work reached the English-speaking world as a chapter in *Modern Trends in Plastic Surgery* edited by Gibson [8,26]. His 1963 treatise proposed a systematic approach to the coverage of larger defects using adjacent triangular flaps; the 1984 English translation rendered the original term as convergent triangular flap [7,27]. The intellectual contribution was not the transposition of skin, which long predated him, but the demonstration that transposition could be reduced to reproducible geometry and therefore taught.

C. Vascular and structural anatomy

The rhombic flap is a full-thickness, random-pattern transposition flap. It has no named axial vessel and depends for its perfusion on the interconnected dermal and subdermal plexuses, which lie between the reticular dermis and the hypodermis and are rich in arterial anastomoses [7,28]. Five vascular plexuses are described within the integument, namely the dermal and subdermal networks, which are frequently considered a single functional unit, together with the subcutaneous, prefascial and fascial networks; the collateral flow between them confers the vascular redundancy on which random-pattern flaps depend [29].



Figure 3.- Limberg flap design.

Three practical consequences follow. First, the flap must be raised with a cuff of subcutaneous fat sufficient to preserve the subdermal plexus within the pedicle; excessively thin elevation is a principal cause of distal necrosis [7]. Second, a length-

to-width ratio of 2:1 to 4:1 is generally safe in the head and neck, where perfusion is abundant, whereas a ratio approaching 1:1 should be considered in regions of marginal vascularity such as the distal lower limb [28,30]. Third, in large defects, where the flap exceeds classical dimensions, identification and preservation of a perforator at the base, if

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necessary, with hand-held Doppler, converts an unreliable random flap into a substantially more robust one [30].

The physiology of flap survival explains the characteristic early clinical course. Incision transects sympathetic fibers, releasing catecholamines and abolishing neurotransmitter reuptake, which produces local vasoconstriction; this limits intraoperative blood loss but also reduces critical perfusion at the distal flap. After one to two days, loss of sympathetic tone induces vasodilatation and perfusion improves, and neovascularization across the wound interface begins between the third and seventh postoperative days [29,31]. Distal congestion or duskiness observed on the first postoperative day therefore frequently resolves without intervention, and premature revision should be avoided.

VI. FLAP DESIGN AND OPERATIVE TECHNIQUE

A. The classical design

The design begins by converting the excisional defect into a rhombus with internal angles of 60 and 120 degrees. Two parallel lines are drawn along the axis of maximum extensibility, enclosing the lesion with adequate oncological margins, and two further lines are added medially and laterally to complete the figure; because the defect can be enclosed in either of two orientations, two candidate rhombi exist for any given lesion. The axis joining the 60-degree angles is termed the long axis, and the axis joining the 120-degree angles the short axis [7,32].

The flap itself is then constructed in two strokes. The first limb is drawn by extending the short axis beyond the rhombus by a distance equal to its own length. The second limb is drawn from the end of that extension, parallel to the nearest side of the rhombus, at an angle of 60 degrees and of the same length. All sides of the rhombus and of the flap are thereby equal. Four flaps can be constructed for any rhombus, one at each corner, but only two are usually feasible in clinical practice, and only one is normally optimal [7,32,33].

Selection between the candidate flaps is governed by three considerations in descending order of importance: the direction of the LME, which should coincide with the axis of the flap so that the donor defect closes along the RSTL; the proximity of free margins and critical landmarks, which must not be displaced; and the boundaries of aesthetic subunits, including differences in skin thickness, pigmentation and hair-bearing status between donor and recipient sites [7,20,32]. The final scar assumes the configuration of a zigzag or of a question mark, which is itself advantageous because a broken line is perceptually less conspicuous than a straight one of equal length.

B. Modifications

Four classical modifications and several contemporary variants address the principal limitations of the original design, and are summarized in Table I.

Dufourmentel, in 1962, widened the range of acceptable acute angles to between 60 and 90 degrees, thereby avoiding

the sacrifice of healthy tissue required to force an irregular defect into a strict 60-degree rhombus. The first incision bisects the angle formed between the extension of the short diagonal and the extension of an adjacent side of the defect; the second is drawn parallel to the long diagonal. The result is a broader pedicle, a greater arc of rotation, less mobilization of healthy tissue and easier donor site closure, at the cost of greater geometrical complexity [7,34,35].

Webster, in 1978, observed that reducing the apical angle of the flap facilitates closure of the secondary defect. He described a 30-degree flap combined with division of the 60-degree base angle of the defect by an M-plasty, producing two 30-degree angles. Donor site tension and the risk of standing cone formation are correspondingly reduced [36].

Quaba and Sommerlad, in 1987, addressed the frequent situation in which the defect is circular rather than rhombic. Rather than converting the circle into a rhombus, and thereby excising healthy tissue, they designed a smaller rhombic flap whose sides equal two thirds of the circle diameter, preserving the characteristic 60-degree tip angle [37].

Multiple-flap designs extend the technique to larger and more complex defects. Two, three and four rhombic flaps arranged around a single

defect have been described for extensive pilonidal disease, myelomeningocele closure and large truncal defects, at the cost of longer scars and a more demanding geometrical layout [38,39,40]. Tissue-sparing variants such as the Cassiopeia flap were developed to minimize loss of normal skin during removal of round tumors [41], and simplified Dufourmentel designs have been proposed to improve the naturalness of the final contour [42].

A recent contribution combines both classical designs in a single flap: an irregular,

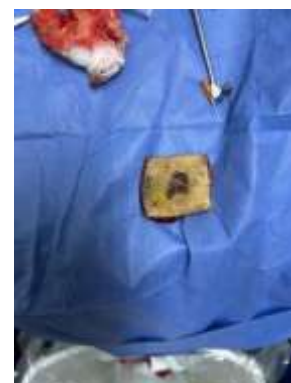


Figure 4.- Rhomboid dissection of basocellular carcinoma



Figure 5.- Rhomboid flap inset



Figure 6.- 2-month post-surgical image of Limberg flap.

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near-square rhomboid defect is accepted without additional excision, in the manner of Dufourmentel, but the flap is developed along the short diagonal, in the manner of Limberg, with a deliberately broadened pedicle and excision of a small Burow triangle to refine the contour. Applied to a zygomatic SCC in an 82-year-old patient, this hybrid achieved tension-free closure with preservation of surrounding tissue and no functional impairment [43]. Such patient-oriented hybridization, rather than doctrinaire adherence to a single geometry, reflects contemporary practice.

C. Operative sequence

Positioning and anesthesia. Most rhombic flaps of the face are performed under local infiltration anesthesia; general anesthesia or intravenous sedation is reserved for large defects, anxious patients or those with coexisting indications. Vasoconstrictor should not be injected in excess around the pedicle or beneath the flap, since flap perfusion may be compromised; infiltration five to ten minutes before incision improves haemostasis [31,44].

Excision and defect preparation. The lesion is excised with confirmed clear margins, and the excision is then extended to produce the planned rhombic configuration. Excess subcutaneous tissue at the base of the defect that would impede transposition is removed [9].

Flap elevation. The two limbs are incised, and the flap is raised in a uniform plane, with dissection carried beyond the base of the flap to prevent an elevated bump on transposition [8]. Careful dissection at constant depth limits bleeding, and bipolar diathermy is preferred; aggressive monopolar cautery damages the dermal and subdermal plexuses on which the flap depends [7,31].

Inset and closure. The flap is rotated into the defect and the tension assessed before any suture is placed. Closure begins at the donor site, where tension is greatest, particularly at the apex, and proceeds with transposition and stabilization of the flap. Deep dermal anchoring sutures offload tension from the superficial layers; interrupted or mattress sutures are used for the skin. Corners are handled with corner or half-buried horizontal mattress sutures, and forceps pressure on the flap tip is avoided [7,31].

Postoperative care. A light dressing, antibiotic ointment along the suture line and instruction to avoid tension on the reconstructed area constitute standard care. Sutures are removed at one to two weeks according to site. Same-day discharge is the norm and has been documented in every patient of the published facial series [9,10,30].

TABLE I. CLASSICAL AND CONTEMPORARY MODIFICATIONS OF THE RHOMBIC (LIMBERG) FLAP

Modification (year)	Design principle	Principal advantage
Limberg (1946)	Equilateral rhombus with 60 and 120 degree angles; short axis extended by its own length; second limb parallel to the adjacent side at 60 degrees	Reproducible geometry; four candidate flaps per defect; ideal tissue match
Dufourmentel (1962)	Acute angle of the defect between 60 and 90 degrees; first incision bisects the angle between the short diagonal and the adjacent side; second incision parallel to the long diagonal	Broader pedicle, greater arc of rotation, less healthy tissue sacrificed, easier donor closure
Webster (1978)	30 degree flap with M-plasty division of the 60 degree base angle into two 30 degree angles	Reduced donor site tension; lower risk of standing cone formation
Quaba and Sommerlad (1987)	Circular defect reconstructed with a rhombic flap whose sides equal two thirds of the circle diameter, 60 degree tip angle preserved	Avoids conversion of a circular defect into a rhombus; preserves normal skin
Multiple rhombic flaps	Two, three or four rhombic flaps arranged around a single large or complex defect	Extends the technique to defects beyond the size limit of a single flap
Hybrid Limberg-Dufourmentel (2026)	Irregular near-square defect accepted without additional excision; flap developed along the short diagonal with a widened pedicle and a small Burow triangle	Maximum tissue preservation with a patient-oriented, defect-adapted geometry

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TABLE II. REPRESENTATIVE PUBLISHED CLINICAL SERIES OF THE RHOMBIC (LIMBERG) FLAP IN CUTANEOUS TUMOR RECONSTRUCTION

Series	Population and defects	Reported outcomes
Kirazoglu et al. (2020)	13 patients, central midface; mean age 68 years (49-81); mean defect 7.76 cm ² (2.25-25 cm ²); 10 BCC, 1 SCC, 1 lentigo maligna, 1 melanoma	All under local anesthesia with same-day discharge; 100% flap survival; no hematoma, necrosis or recurrence; mean VAS satisfaction 9.38/10; mean follow-up 11.53 months
Gualtieri et al. (2025)	8 patients, lateral midface; age 66-92 years (mean 81); 6 SCC, 2 BCC; defects from 2.5 x 2.5 cm to 4 x 3 cm	78% under local anesthesia; no flap distress, necrosis, hematoma or infection; all patients free of disease at 6 months
Chasmar (2007)	Narrative review of 54 published reports across all body regions, including 9 on pilonidal sinus and 3 on hand surgery	Single or multiple rhombic flaps applied with high safety and good cosmesis; proposed as first choice for many full-thickness defects
Tchernev et al. (2026)	Single case, 82-year-old woman, 1.5 x 1.5 cm zygomatic SCC	Hybrid Limberg-Dufourmentel flap; tension-free closure; clear resection lines; no functional impairment

BCC: basal cell carcinoma; SCC: squamous cell carcinoma; VAS: visual analogue scale.

VII. CLINICAL EVIDENCE AND REGIONAL APPLICATIONS

A. The face and midface

Two contemporary series define current expectations for facial reconstruction. Kirazoglu and colleagues reported thirteen consecutive patients undergoing Limberg flap reconstruction of the central midface, with a mean age of 68 years, a mean defect area of 7.76 cm² and a range extending to 25 cm². All procedures were performed under local infiltration anesthesia with same-day discharge; every flap survived with uneventful healing, no hematoma, no partial or total necrosis and no recurrence over a mean follow-up of 11.53 months. Mean patient satisfaction on a visual analogue scale was 9.38 of 10 [10]. The authors argue, persuasively, that in the anterior nasolabial area and the nasal lateral wall the Limberg flap may be preferable to paramedian forehead or cheek rotation flaps for defects of this size, and that skin laxity, rather than chronological age, is the principal determinant of success.

Gualtieri and colleagues reported eight patients reconstructed for lateral midface defects after resection of cutaneous malignancy, with ages ranging from 66 to 92 years and a mean of 81. Six were squamous cell carcinomas and two basal cell carcinomas; 78% of operations were performed under local anesthesia. No flap distress, necrosis, hematoma or infection was recorded, and all patients were free of disease at six months [9]. The lateral midface, and specifically the zygomatic prominence and adjacent cheek, is repeatedly identified as the facial region in which this flap performs best, because donor laxity is generous and the resulting broken-line scar falls naturally within or parallel to the RSTL.

Specialized facial applications include the floor of the nose, the alar rim, the upper eyelid, the chin and the earlobe; each of these has been described in dedicated reports, and the flap retains particular value where the nasolabial flap is unsuitable [8,45]. Reported experience also supports its use in the medial canthal and infraorbital regions, provided that the vector of donor site closure is directed away from the lower eyelid to avoid ectropion.

B. Extrafacial applications

The versatility of the design outside the face is well documented. A literature review by Chasmar identified 54 published reports spanning virtually every body region and multiple surgical specialties, including nine dedicated to pilonidal sinus disease and three to hand surgery [8]. The trunk, shoulder, lumbosacral region, inguinoscrotal and perianal areas, breast and upper and lower limbs have all been reconstructed with single or multiple rhombic flaps [7,46,47]. Aetiologies extend well beyond neoplasia to include pilonidal sinus disease, hidradenitis suppurativa, pressure ulceration, burn contracture, myelomeningocele and lupus [7,8,38,39].

Two boundaries deserve mention. Large defects have traditionally been regarded as a contraindication, yet case reports have documented successful closure of extensive truncal defects with rhombic flaps, and the classical size limit should therefore be regarded as a strong relative rather than an absolute constraint [46,47]. Conversely, regions of poor surrounding laxity, including the scalp, forehead and glabella, the caudal third of the nose, the skin overlying extensor joints, the palm and the anterior lower leg, remain genuinely unfavorable, and attempting a rhombic flap in

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these areas commonly produces distortion, dehiscence or distal necrosis [48,49].

VIII. COMPLICATIONS AND THEIR PREVENTION

Complications after rhombic flap reconstruction may be grouped as general, vascular and aesthetic. General complications, comprising infection, hematoma, wound bleeding, pain and dehiscence, are reported at low frequency in the facial series and are managed conventionally [9,10].

Vascular complications are the most consequential. Partial or complete flap necrosis is uncommon in adequately selected patients but is concentrated in those with identifiable predisposing factors: active tobacco use, uncontrolled diabetes, peripheral vascular disease, previous irradiation of the field, immunosuppression and low body mass index with consequently limited skin availability [30,31]. Distal tip suffering, which is more frequent than frank necrosis, usually resolves within several days and should be managed expectantly. Prevention is technical rather than pharmacological: preservation of an adequate subcutaneous cuff, avoidance of a narrow pivot, restrained use of cautery, atraumatic handling of flap corners and tension-free inset [9,31].

Aesthetic complications comprise standing cone or dog-ear deformity, pin cushioning, trapdoor scarring and scar widening. Their pathogenesis lies in the distribution of tension vectors, impaired lymphatic drainage within the transposed segment, the transposition maneuver itself, and regional variables such as skin thickness and elasticity [7,50,51]. A systematic approach to dog-ear management has been described and reduces the need for revision [50]. Patient-reported outcome data specifically addressing rhombic flap scars indicate generally favorable long-term appearance, and adjunctive measures including intralesional agents, laser resurfacing and scar-modifying therapy are available when required [51,52]. It should be emphasized to patients preoperatively that a zigzag scar longer than the original defect is the expected result and not a complication.

Contraindications warrant explicit listing. Absolute contraindications comprise inadequate margin clearance, active infection of the operative field, and the absence of viable local tissue. Relative contraindications comprise uncontrolled diabetes, current tobacco use, significant peripheral vascular disease, therapeutic anticoagulation that cannot be adjusted, previous irradiation, immunosuppressive therapy, low body mass index and previously reconstructed donor territory [7,30,31]. Several of these are modifiable, and preoperative optimisation, particularly smoking cessation and glycaemic control, measurably reduces the complication rate.

IX. NON-SURGICAL AND ADJUVANT MODALITIES

Surgical excision remains the treatment of choice for most cutaneous tumors, but a review of skin tumor treatment

would be incomplete without acknowledging the alternatives that compete with or complement it. Topical imiquimod and 5-fluorouracil, photodynamic therapy, cryosurgery and electrodesiccation with curettage retain defined roles for superficial BCC and for actinic keratoses and in-situ SCC, particularly in patients unfit for surgery or with field cancerization; cure rates for these modalities are consistently inferior to those of excision for nodular or infiltrative tumors [11,12].

Definitive radiotherapy is an appropriate option for patients who decline surgery or for whom surgery would be excessively morbid, and adjuvant radiotherapy is indicated after excision of tumors with extensive perineural invasion or positive margins that cannot be re-excised. Hedgehog pathway inhibitors have transformed the management of locally advanced and metastatic BCC, and immune checkpoint inhibition has substantially altered outcomes in advanced cutaneous SCC and melanoma [11,12,14]. These agents may render an initially unresectable tumor amenable to excision, which places the reconstructive surgeon within a multidisciplinary pathway rather than at its end. Sentinel lymph node biopsy remains an integral component of staging in melanoma above defined thickness thresholds and should be performed before, not after, reconstruction that would disturb lymphatic drainage [14].

X. CRITICAL ANALYSIS AND FUTURE DIRECTIONS

The enduring value of the rhombic flap rests on four properties that are difficult to reproduce with any other single technique: a design that is explicit and therefore teachable, a random-pattern blood supply that requires no preoperative imaging, a single-stage execution compatible with local anesthesia, and donor tissue that is by definition an ideal match. Against these must be set three genuine limitations.

The first is geometric rigidity. The classical design requires conversion of the defect into an equilateral rhombus, and this conversion sacrifices healthy tissue that has no oncological reason to be removed. The Dufourmentel, Quaba-Sommerlad and hybrid modifications exist precisely to circumvent this, and the contemporary tendency to accept an irregular defect and adapt the flap to it, rather than the reverse, should be regarded as the current standard rather than as a deviation [35,37,43].

The second is scar length and orientation. The final scar is longer than that of a primary closure and includes limbs that necessarily cross tension lines at some point. Careful selection among the four candidate flaps mitigates but does not abolish this, and in regions where a linear scar can be hidden within a natural crease, primary closure or an advancement flap may be aesthetically superior.

The third is the quality of the evidence base. The published literature consists almost entirely of retrospective

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case series, expert descriptions and anatomical reviews. The two most recent facial series comprise thirteen and eight patients respectively [9,10]. No randomized comparison exists between the rhombic flap and its principal alternatives, namely the bilobed flap, the nasolabial transposition flap, the cheek rotation flap or full-thickness grafting, for equivalent facial defects. Reported complication rates approaching zero in series of this size should be interpreted with appropriate caution, since such series are underpowered to detect events with an incidence below approximately 10%.

Three lines of development are therefore worth pursuing. First, prospective multicenter registries with standardized patient-reported outcome measures, of the type piloted for rhombic flap scars [51], would allow meaningful comparison between reconstructive options. Second, digital planning tools, including template-based markers and augmented-reality overlays that project RSTL and candidate flap geometries onto the operative field, address the principal difficulty encountered by trainees, which is not execution but selection among the four candidate flaps. Third, the systematic incorporation of perforator identification by hand-held Doppler into the design of larger rhombic flaps may extend the safe size limit and further reduce distal necrosis [30].\

CONCLUSIONS

The treatment of cutaneous tumors is a two-stage discipline in which oncological adequacy is non-negotiable and reconstruction is the variable that determines the patient's experience of the outcome. Complete excision, guided by risk stratification and confirmed by micrographic or frozen-section control where indicated, must precede any definitive flap.

Within the reconstructive component, the rhombic flap of Limberg retains, after almost a century, a central position for small and medium-sized defects that cannot be closed primarily, particularly in the lateral midface, cheek and zygomatic region of elderly patients with favorable skin laxity. Its advantages are single-stage execution under local anesthesia, excellent color and texture match, minimal donor site morbidity, low complication rates in appropriately selected patients, and a geometry that can be taught reproducibly. Its limitations are the sacrifice of healthy tissue imposed by strict geometry, a scar that is longer and more broken than that of primary closure, and an evidence base composed almost exclusively of small retrospective series.

Contemporary practice should therefore favour a modified, patient-oriented application of the technique: accept the defect as it is where possible, widen the pedicle where perfusion is uncertain, select the flap vector by the lines of maximum extensibility rather than by habit, and abandon the flap without hesitation in regions of poor laxity

or in patients whose comorbidities predict flap failure. Applied within these limits, the rhombic flap remains one of the most reliable and reproducible instruments available for reconstruction after cutaneous tumor excision.

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