Review of Rhomboid Flaps and Their Modern Modifications

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Abstract

Background: First proposed by Alexander Limberg in 1945, the rhomboid flap has been modified to accommodate a variety of different surgical settings. Rhomboid flaps have proven to be integral in a variety of sub-specialties. Objective: The aim of this review is to examine the rhomboid flaps of Limberg, Dufourmentel, Webster, and Quaba and report the appropriate surgical context and advantages of each flap type. Methods & Materials: A literature search was performed of PUBMED, SCOPUS, and MEDLINE for articles assessing the proper surgical context and subsequent outcomes of the Limberg, Dufourmentel, Webster, and Quaba/Sommerlad flaps. Results: The use of rhomboid flaps proves optimal for closure of large defects because of the reduced risk of distal-end necrosis. Conclusion: This review details a thorough examination of modification of rhomboid flaps and their effectiveness as an alternative to primary closure.

Introduction

Following the formation of a surgical defect, a closure type is chosen to suit the surrounding tissue characteristics and defect size. While primary closure is often the first choice, simple suturing may not be sufficient to appropriately close the defect. Size is the most common deterrent from primary closure, where the long or short axes of the defect are either too long or too wide, respectively.1,2 Rhomboid flaps maintain continuity of texture, color, and vascularity with the surrounding tissue, eliciting the most successful aesthetic outcome.3 Rhomboid flaps are most commonly used for tumor resection in head and neck surgeries but are widely applicable in fields such as general and plastic surgery, ophthalmology, and otolaryngology.1,3

In 1946, Alexander Limberg first designed a surgical protocol for transposition of a rhomboid flap 120° onto a proximal skin defect.4 This was innovative and successful due to the retention of local vascularity via the pedicle.5 Claude Dufourmentel later modified this in 1966, using a reduced angle size to ±60° to limit the amount of disruption of healthy tissue during closure while increasing pedicle width.6,7 This closure is compared to that created by primary closure.6

The original Limberg flap was further modified by Richard Webster in 1960 to include a 30° transposition flap with an M-plasty closure.1,5 The addition of the M-plasty allowed for a better distribution of tension, reducing the strain on the distal tip of the flap. In 1987, Awf Quaba designed a modified rhomboid flap to address closing a circular defect with minimal healthy skin loss. While all four flaps are widely useful, it is imperative to not distort the anatomy or maintain skin laxity.3 Limberg, Dufourmentel, Webster, and Quaba flaps are types of transposition flaps that are generally smaller in size than both the advancement and rotational flaps.7,8

The varieties of rhomboid flaps provide superior results when compared to skin grafts of similar size and location because the sub-papillary and sub-dermal vascular plexuses are maintained through the flap’s pedicle, which is absent in skin grafts.4,7 The enhanced vascularization established through the pedicle lends the rhomboid methods to successful treatment in post-burn defect treatment.5 Even when adequate blood supply is maintained, the surgeon must be cautious of the tension on the distal end of the flap in order to reduce the likelihood of necrosis.3 It is important to note that the maintenance of perfusion pressure is the critical aspect to flap success, as compared to the width-to-length ratio of the pedicle as traditionally thought.10 Vascular testing methods, such as dermal bleeding pricks and reperfusion time testing, are performed prior to closure to ensure adequate perfusion.11

Discussion

Limberg Flap

The simplicity and efficacy of the Limberg flap makes it versatile, allowing for adequate cosmesis with few complications. The excision is made up of two equilateral triangles with 60° and 120° angles, respectively. The flap is then created by extending a line of equal length from either of the 120° angles. At the end of this extended line, a second line is created at an angle of 60° (Figure 1a). It is important to ensure this line is parallel to the side of the rhomboid defect.5,12 The flap is then transposed and ready for closure (Figure 1b). The placement of the Limberg flap greatly influences its survival and aesthetic appearance (Figure 1c). The flap should be positioned in the direction of minimal tension and maximum extensibility. The flexibility of the skin in the area to be excised can be inspected by pinching the skin with the forefinger and thumb.13 Placement
of the flap becomes more challenging on the face, where anatomical features may create boundaries. The incisions should not be placed on relaxed skin tension lines; instead, incisions should be made parallel to the relaxed skin tension lines. Placement of incisions parallel to the relaxed skin tension lines allows the resulting scar to fall within the creases of the skin. A reduction in tension on the flap decreases the likelihood of necrosis of the donor tissue. The parallelogram-shaped defects are ideal for the use of a Limberg flap.

Limberg flaps have been used in a variety of areas of the body. Particularly, this flap has been practical for defects on the face, neck, and back. However, the usefulness of the Limberg flap makes it easy to employ and modify for defects in other parts of the body, such as the oral mucosa, the floor and ala of the nose, and the lips.

Dufourmentel Flap
The design of a Dufourmentel flap allows for closure of rhomboid defects of differing angles, such as acute angle closure, when compared to closure with a Limberg flap. The angles of the rhomboid do not need to equal 60° as in the Limberg flap. Upon bisection of the parallelogram, a plumb line is placed at 90°. A second line is created parallel to one of the sides of the defect. The angle that is created from the two extended lines is bisected with a line that is the same length as a side of the rhomboid. The bisected line creates a smaller tip angle of the flap. From the end of the bisected line, another line is created that is parallel to the longitudinal axis of the parallelogram (Figure 2a). This parallel line must still be equal in length to the side of the rhomboid. The design of the Dufourmentel flap allows two flaps to be created from each of the four angles of a square defect. In the case of an asymmetrical rhomboid, four flaps can be created from a rhomboid defect (Figures 2b-c).

The ideal scenario for the use of a Dufourmentel flap is with an acute angle defect of greater than 60°. Other factors besides defect angle should be considered in the application of the Dufourmentel flap over other methods. The presence of laxity of the tissue favors the use of a Dufourmentel flap over the simpler Limberg flap. A Dufourmentel flap does not require as great of a transposition movement of the flap covering the primary defect as the Limberg method. If a defect is less than 60° and cannot be closed via primary closure, the defect angle is enlarged and a Limberg flap is employed.

Further alterations to the Dufourmentel flap were applied to address certain limitations of this type of transposition flap. One modification, a “diamond flap,” is used to decrease the amount of healthy tissue excised from a Dufourmentel flap. The diamond flap modified one of the acute corners of the rhomboid excision following initial completion of the Dufourmentel flap design. One of the acute corners is transformed into a circular shape. In order for the flap to close the new circular shape, an arc of the same dimension is created on the part of skin that is transposed.

Advantages of Limberg and Dufourmentel Flaps
Considering the tension of the skin, primary closure can cause an increase in desiccation and infection in defects. A similar trend was observed comparing secondary-intention healing and the use of the Limberg flap. Secondary intention requires greater care and increases the risk of infection of the open wound compared to the closed sutures of a Limberg flap. In areas of the body where skin may not have great laxity, secondary-intention closure may be preferred over a rhomboid flap such as the Limberg method.

The Dufourmentel flap is advantageous with smaller defects because of the narrow flap. Application of the Dufourmentel flap has shown satisfactory cosmetic results with a decrease in flap rotation, compared to the Limberg flap, and adequate survival from vascularity from subdermal plexus.

Rhomboi Flaps for Pilonidal Sinus Surgery
The Limberg flap has shown to be one of the quickest and least complicated treatments for wound healing in pilonidal sinus surgery. Through placement of the most inferior angle of the rhomboid slightly lateral to midline, the recurrence and maceration of the defect was decreased. A slight disadvantage of this modification to the Limberg flap is the excess healthy tissue that is lost. A study conducted by Kaya proposed a modification to the Limberg flap that included a complete lateralization of the rhomboid from the intergluteal cleft.

The Dufourmentel flap is also used for the treatment of pilonidal sinus disease. Yildar et al. applied a modified Dufourmentel flap for wider defects of pilonidal sinus disease. This modification involved using an S-type oblique excision along with a modified Dufourmentel flap that placed the excision lateral to the midline of the intergluteal sulcus. A modified, asymmetrical Dufourmentel flap can be used to treat pilonidal sinus disease with low rates of necrosis and complications.

A literature review of pilonidal sinus surgery found the use of the Limberg flap to be the quickest and least complicated treatment for wound healing. Pilonidal surgical procedures that healed with tension-free primary closure had greater disadvantages than wounds that healed using the Limberg flap.

Webster Flap
The Webster flap was developed in 1960 as a further adaptation of the original Limberg flap, which involves transposing the lateral buttock skin to close the defect. This technique allows for a more natural closure of the defect, with a decrease in recurrence rates compared to other methods.
utilizing a 30° angle of rotation and an M-plasty closure at the base of the defect (Figure 3, p. 17).9

The original protocol describes the procedure of removing triangular-shaped areas of both skin and subcutaneous tissues along the nasolabial folds, allowing for medial movement of the cheek tissues.38 Webster flaps have commonly been used on the lower lip following carcinoma removal where the defect size is greater than 80% of the total area.39 This technique prevents microstomia and poor aesthetic outcomes, as well as maintaining good oral competence and sensation.10 Webster flaps retain good sensation and muscle tone of the upper lip, with special attention to retention of facial grooves and blood supply.9

With the reduction of the flap’s angle of rotation from 60° to 30°, there is less disruption and removal of healthy tissue when compared to the aforementioned flaps. Additionally, the utilization of the M-plasty closure allows for a more uniform distribution of tension across the flap. This reduction in tension promotes better revascularization to the most distal ends of the flap, ensuring a more rapid healing time with less chance of distal-flap necrosis.

There have been several modifications of the Webster flap technique described in the literature, all of which utilize the reduced angle of rotation for more favorable surgical outcomes. One such modification is the combination of the Webster and Johanson techniques for closure of defects greater than 80% with a staircase scar. The Johanson technique was originally designed as a staircase suture for a defect no larger than two thirds of the total area with improved scarring aesthetic when compared to the linear suture of Webster.10 As with rhomboid flaps, the step technique described by Johanson is of clinical importance due to maintenance of tissue texture between the donor and lesion sites, retention of intact muscle fibers and innervation, and better aesthetic outcomes along the lateral lower lip.40 The proposed modification allows for the combination of closure of a larger defect (Webster) with the more aesthetically pleasing staircase sutures (Johanson).

In 2011, Minagawa et al. further modified the Webster flap, altering the flap formation itself, including the formation of the flap on the contralateral side of the defect versus bilaterally in concert with a nasolabial flap.41 The combination of closure via the modified Webster method and nasolabial flap ensured optimal aesthetic outcome of the lower lip with good donor site matching in color and texture. The unaffected oral commissure remained untouched, and the formation of horizontal suturing between the mouth and nasolabial groove was avoided.38

**Quaba/Sommerlad Flap**

The Quaba/Sommerlad flap was first described in 1987 as a rhomboid-flap modification for closure of circular defects (Figure 4a).42 Because circular defects are the most common types encountered in facial surgeries, their closure is of great clinical significance.43 This flap uses the basis of the Limberg flap with two key modifications: (1) no need to create a rhomboidal defect, and (2) a flap smaller than the defect size.42 The predominate advantage to this is a reduced sacrifice of healthy donor tissue. In the case of Quaba/Sommerlad, a diagonal is extended to be two-thirds the size of the defect (Figure 4b).39 Although most simple to achieve, the Quaba/Sommerlad flap taken from shortest diagonal does not always achieve the most aesthetically pleasing outcome.39 In contrast to the other rhomboid flap designs, the Quaba/Sommerlad flap is raised less than the size of the defect and donor tissue is allowed to contribute to the wound closer. Key stitch locations are integral to adequately distribute the tension to ensure good vascularization to the distal aspects of the flap.39

The Quaba/Sommerlad method has been especially helpful in the closure of hand defects where the cutaneous branch of the dorsal metacarpal artery serves as the perforator artery supplying blood to the flap from the pedicle.41 In hand surgery, in order to increase flap vascularity, Bailey et al. prosed a modification that starts the perforator artery at the junction of the dorsal metacarpal artery and the dorsal communicating branch of the common digital artery.37 This increases the ability to cover the dorsal aspect of the finger past the proximal interphalangeal joint. The increased blood flow makes this technique especially helpful when treating defects on burned or grafted areas.37

**Advantages of the Quaba/Sommerlad Flap**

There are numerous advantages to the Quaba/Sommerlad flap, the most obvious being the decrease in excision of healthy donor tissue when raising the flap.39 In addition, this protocol permits more variability of the donor site, allowing for better concealment of scarring.39

**Ablation and Rhomboid Flaps**

Rhomboid flaps are commonly used for closure of defects following skin-cancer excision. One study by Murillo et al. examined the use of skin-cancer ablation in conjunction with flap transposition for complete resection of the malignancy while maintaining optimal aesthetic outcomes.44 Due to the variety of skin thicknesses and compositions throughout the head and neck region, this study mapped the anatomical areas and based closure protocols on where the cancer was located. For instance, a rhomboid flap was utilized in the medial aspects of the cheek because of the ease of transposition of the attached skin.44 Closure of these defects produced great aesthetic outcomes.

**Conclusion**

The extensive application and versatility of rhomboid flaps contributes to their success and popularity among physicians. Several different types of and modifications to flaps better tailor this small surgical procedure for certain defects. The Limberg flap was the initial flap used for rhomboid defects, with effective healing and acceptable cosmetic appearance. The simple design of a Limberg flap gave rise to more advanced and complex flaps such as the Dufourmentel, Webster, and Quaba flap. Rhomboid flaps have shown great effectiveness over alternative methods of healing such as primary closure.5,46 Such advantages propel their use and are a common reason why these flaps are one of the first techniques used by surgeons. While certain closure techniques are invasive and involved, rhomboid flaps are associated with a good prognosis and rapid healing time.47 Continued modifications and advances in dermatologic surgery will further improve the outcomes of rhomboid flaps.
References


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