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ARTICLE

A banner flap with adjacent rotation flap for closure of circular skin defects: a schematic comparison with conventional rotation flap technique

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ABSTRACT

The local flap method is a minimally invasive, quick, and common technique of closing skin defects. Several methods using multiple local flaps are employed for the purpose of closing relatively large defects, and minimizing the resultant scar and deformity. We present a combined local flap method using a banner flap with an adjacent rotation flap (B-R flap) with the potential for closing circular defects. A retrospective analysis was performed in 15 patients treated with the B-R flap for circular skin defects over a 2-year period. The sizes of the flap and the healthy skin excision area were evaluated using image analysis software, and were compared to a model of a conventional rotation flap that would be necessary to close the same defect. All flaps were successfully engrafted. The B-R flap required a 39.1% smaller rotation flap and an 85.9% smaller area of healthy skin compared to the conventional rotation flap technique. There was one adverse event, partial epidermal necrosis that was conservatively treated and healed. The B-R flap is comparatively less invasive; it allows a smaller area of healthy skin to be excised. It can be a useful option for closing a circular defect.

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Local flap; fasciocutaneous flap; multiple flap reconstruction; scalp reconstruction

Introduction

The local flap method is a minimally invasive, quick, and easily available technique for closing circular defects in the skin. It has limitations related to size, mobility, and the donor site. Several procedures combining multiple local flaps are often used, which makes it possible to close a relatively large defect with minimal use of a donor site, disperse the tension, and obscure the scar [1–8]. This article describes a combined local flap method, a banner flap with an adjacent rotation flap (B-R flap) that was especially designed to close circular defects in regions under tension.

Materials and methods

Surgical technique

This procedure uses two flaps (Figure 1(A,B)). The first flap (F1) is a transposition flap mobilized to the primary defect. This flap is banner-shaped, with width 10–20% shorter and length 10–20% longer than the diameter of the defect. The dermal pedicle of this flap is minimally undermined in order to maintain the flap's blood supply. The base of the flap requires a width ≥40% of the flap length to avoid flap tip necrosis. The second flap (F2) is designed to cover the donor site of F1. Lines are drawn tangentially to the edge of F1 (L1, L2), and the intersection of these two lines is the rotation center of F2. The area enclosed by these lines and the edge of flap can be excised if it restricts flap mobility or makes a dog ear deformity. The arc length of F2 is determined according to the tension of the skin and can be extended if the flap's mobility is insufficient. F1 and F2 are usually elevated as random pattern cutaneous flaps; however, they can be elevated as fasciocutaneous flaps, or the operator can include skin perforators if there is concern about the blood supply, i.e. elevating the narrower-based F1 whose length–width ratio is <1:2.5, or when reconstructing a defect on a distal extremity. In order to maintain adequate blood flow, the directions of F1 and F2 are designed so as not to be distally based. For reconstructions in the extremities, flaps proximal to the defect are utilized, with their blood flow in the vertical direction to the long axis of the limb.

Ethics

This study was performed in a university hospital with institutional review board approval (No. 4228). Written informed consent was obtained from the patients for publication of this study and accompanying images.

Subjects

A retrospective analysis was performed in 15 patients treated with the B-R flap procedure for circular skin defects during a 2-year period (April 2017–March 2019).

Schematic analysis

The digital photo images of the defects and the flap design were obtained and analyzed by imaging software (ImageJ, National Institutes of Health, Bethesda). The length of L1 and L2 (l), the angle between L1 and L2 (i.e. rotation angle of F2) (α), the central angle of F2 (β), the required size of F2 (x) and the area of excised healthy skin (y) were measured. All the values were represented as the ratio to the radius of the primary defect (r), and expressed as the mean ± SD.

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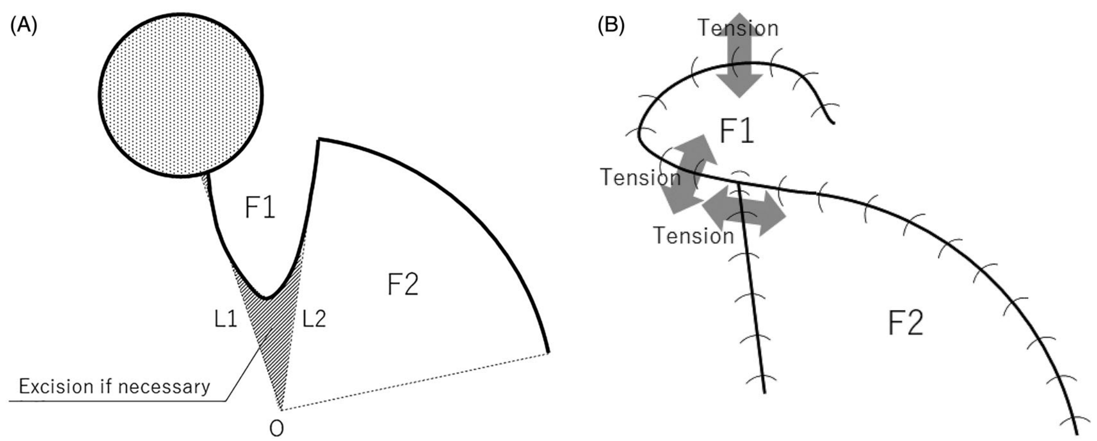

Figure 1. (A) The design of the B-R flap. The first flap (F1) is a transposition flap designed adjacent to the primary defect. This flap is banner-shaped, with its width 10–20% shorter and length 10–20% longer than the diameter of the defect. The dermal pedicle of this flap requires its width to be ≥40% of its length. Then second flap (F2) is designed to cover the donor site of F1. Lines tangential to the edge of F1 (L1, L2) are drawn, and the intersection of these two lines (O) is the rotation center of F2. The area enclosed by these lines and the edge of the flap can be excised if it disturbs the flap mobility or makes a dog ear deformity. (B) After the transposition and rotation of the flaps.

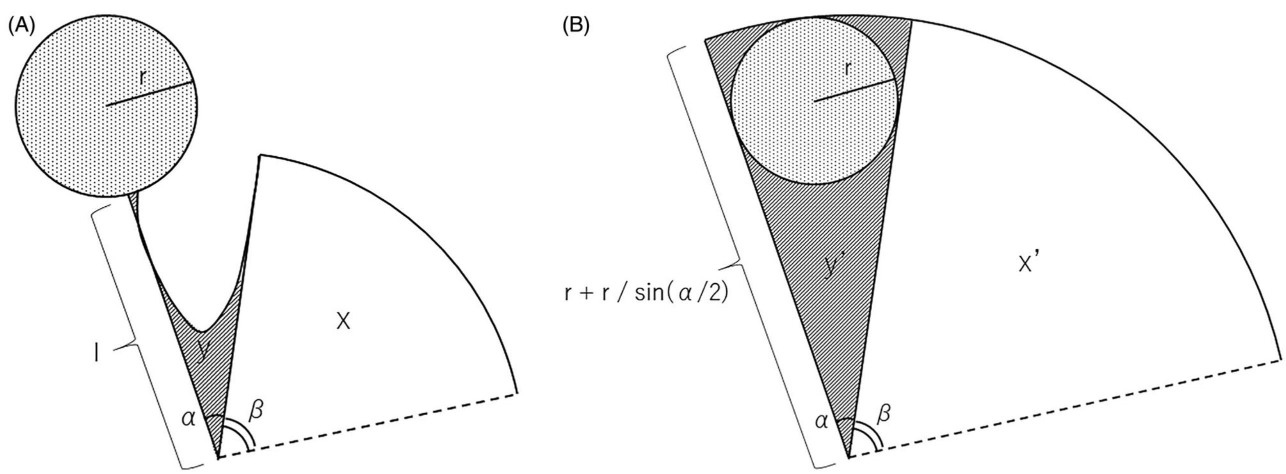

Figure 2. Comparison between the B-R flap and a conventional rotation flap using a schematic. (A) The B-R flap. F1: the first flap. F2: the second flap. L1 and L2: Lines tangential to the edge of F1 (length = l). The angle between L1 and L2 (i.e., rotation angle of F2) (α), the central angle of F2 (β), the required size of F2 (*x*) and the excision area of the healthy skin (*y*) are measured using imaging software. All the values are calculated using the radius of the primary defect (*r*) as the reference length. (B) The conventional rotation flap. The fan-shaped skin defect is made to circumscribe the original circular defect, with its central angle equal to the mean of the rotation angle of F2 (α). A rotation flap for covering the fan-shaped defect is designed with its central angle equal to F2 (β). The radius of this rotation flap is calculated to be $r + r/\sin(\alpha/2)$. The required size of the rotation flap (*x*′) and the excision area of healthy skin (*y*′) are then calculated.

For comparison, a schema of a conventional rotation flap was designed to make its size the smallest necessary to close the same defect: First, the fan-shaped skin defect was made to circumscribe the original circular defect, with its central angle equal to the mean of α. Second, a rotation flap for covering the fan-shaped defect was designed with its central angle equal to the mean of β. The radius of this rotation flap was calculated to be

$$r + r/\sin(\alpha/2) \quad (1)$$

The required size x' of the rotation flap and the area y' of excised healthy skin were calculated (Figure 2).

Results

The B-R flap was used for closure of circular defects resulting from tumor resection (11 cases), debridement of an intractable ulcer (3 cases), and harvesting a free flap (1 case). The size of the defects ranged from 20 × 19 mm to 85 × 70 mm. The required F1 flap size ranged from 22 × 18 mm to 95 × 58 mm, and the required F2 flap size from 35 × 22 mm to 108 × 100 mm. The length and width of F1 were 11 ± 6.8% longer than the long axis of the defect and 12 ± 5.7% shorter than the minor axis of the defect, respectively. F2 was always harvested as a random pattern flap. F1 was harvested as a random pattern flap in 10 cases, and was harvested including a skin perforator in 5 cases. All flaps were successfully engrafted, with one case suffering partial epidermal necrosis that was conservatively treated and healed (Table 1).

The measurement values of the design of the B-R flap were as follows: $l = 2.72 \pm 0.74$, $\alpha = 40.8 \pm 9.3°$, $\beta = 60.1 \pm 14.2°$, $x = 4.78 \pm 6.96$, and $y = 0.31 \pm 0.49$. The result of the calculation using the schema of the theoretical rotation flap were $x' = 7.85$ and $y' = 2.20$. The B-R flap required a 39.1% smaller rotation flap and preserved 85.9% of healthy skin excision area compared to the conventional rotation flap technique at a 6.7% adverse event rate.

Table 1. Patients and outcomes.

		Defect			First flap		Second flap		
No.	Age/sex	Area (mm)	Cause	Locality	Size (mm)	Vascularity	Size (mm)	Vascularity	Adverse event
1	46/M	72 × 57	Dermatitis	Scalp	80 × 50	Random pattern	90 × 85	Random pattern	None
2	73/M	22 × 21	Eccrine poroma	Lower leg	25 × 18	Random pattern	35 × 35	Random pattern	None
3	81/M	64 × 60	SCC	Scalp	70 × 50	Random pattern	88 × 85	Random pattern	None
4	46/F	77 × 67	Ulcer	Sacral region	80 × 60	Random pattern	92 × 74	Random pattern	None
5	84/M	36 × 36	SCC	Temporal region	44 × 32	Random pattern	62 × 45	Random pattern	None
6	90/F	26 × 25	SCC	Instep	32 × 20	Perforator	43 × 38	Random pattern	None
7	81/M	23 × 20	Ulcer	Thumb	26 × 18	Random pattern	34 × 28	Random pattern	None
8	90/M	40 × 28	Ulcer	Instep	42 × 22	Perforator	49 × 43	Random pattern	None
9	75/M	85 × 70	SCC	Lower leg	95 × 58	Perforator	108 × 100	Random pattern	Epidermal necrosis
10	87/M	40 × 38	SCC	Jaw	48 × 31	Random pattern	47 × 45	Random pattern	None
11	77/F	30 × 28	SCC	Lower leg	33 × 25	Perforator	45 × 30	Random pattern	None
12	80/M	20 × 19	BCC	Nasal ala	22 × 18	Random pattern	35 × 22	Random pattern	None
13	78/F	85 × 55	Flap harvest	Thigh	85 × 50	Random pattern	96 × 54	Random pattern	None
14	78/M	35 × 20	BCC	Upper eyelid	36 × 20	Random pattern	66 × 41	Random pattern	None
15	88/M	60 × 55	SCC	Precordium	66 × 50	Perforator	67 × 62	Random pattern	None

BCC: basal cell carcinoma; SCC: squamous cell carcinoma.

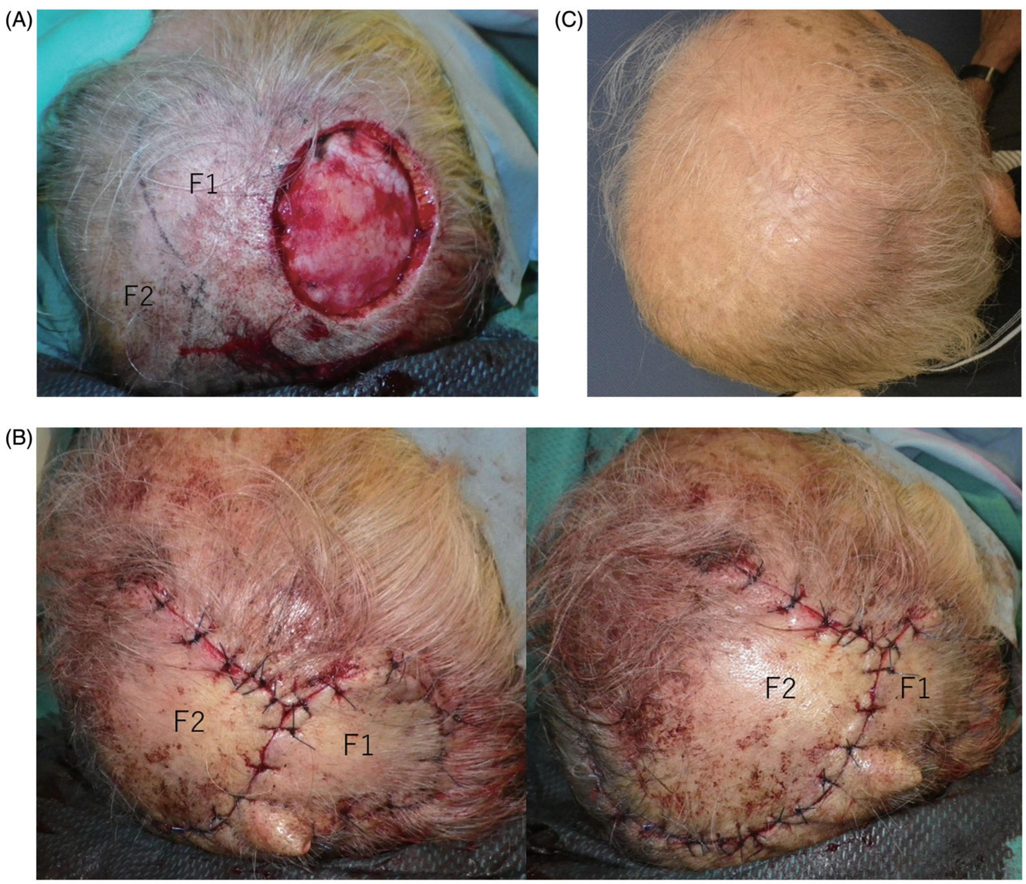

Figure 3. Case 1. (A) The defect after excision of a cutaneous carcinoma. A combination of a banner flap (F1) and a rotation flap (F2) (B-R flap) was designed to close the defect. (B) Defect closure by the flaps. (C) Six months after the surgery.

Cases

Case 1

An 81-year-old man presented with a squamous cell carcinoma located on the scalp. After the excision of the lesion, a 64 × 60 mm circular defect resulted. The B-R flap was performed to close the defect. The flaps successfully took without any complications (Figure 3).

Case 2

A 78-year-old man presented with a basal cell carcinoma located on the left upper eyelid. After the excision of the lesion, a 35 × 20 mm oval defect resulted. The B-R flap technique was used to close the defect. The flaps successfully took. At 18 months after surgery, the patient was satisfied with the invisible resultant scar, being free of contracture, and with minimal dog-ear deformity (Figure 4).

Case 3

A 90-year-old woman presented with a squamous cell carcinoma located on the instep of the left foot. A 26 × 25 mm circular defect resulted after excision. The B-R flap technique was used to close the defect. To maintain the blood flow, the flaps were

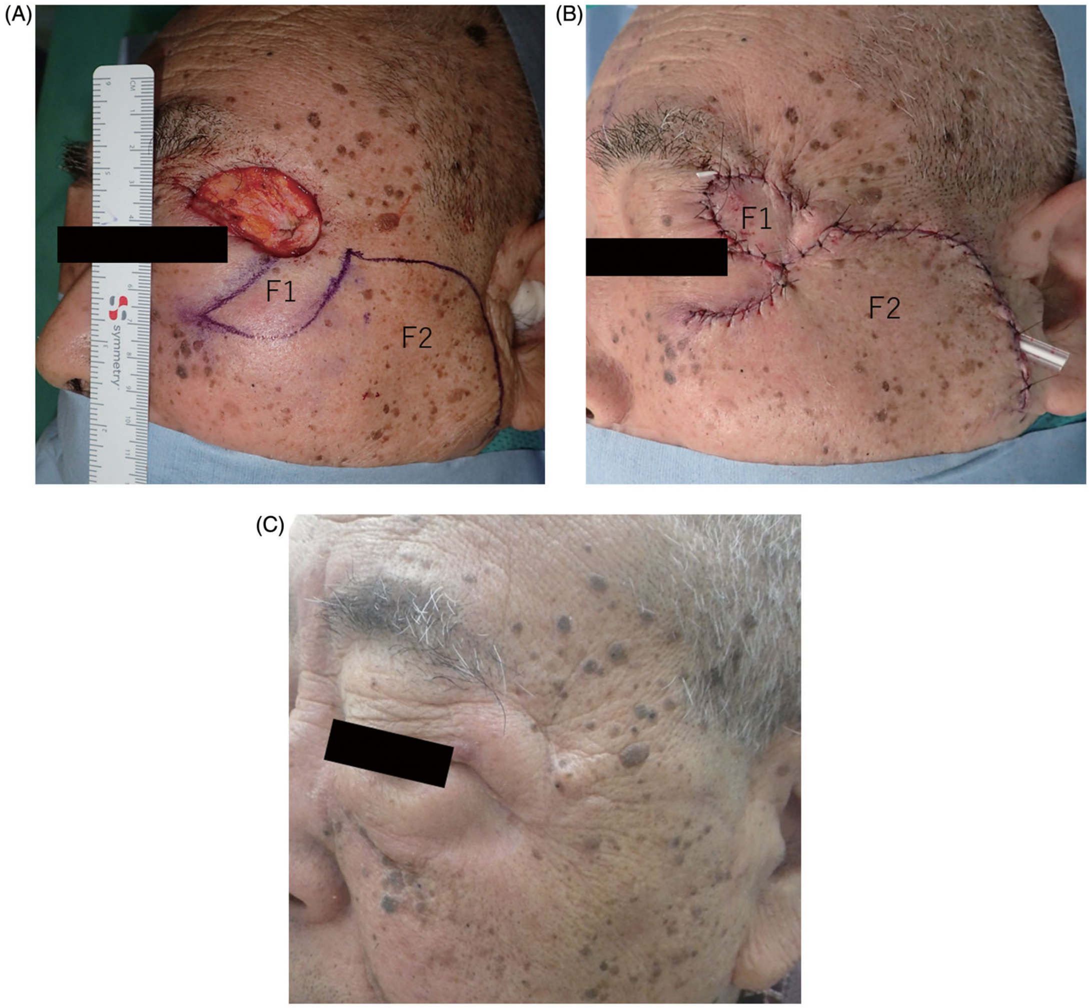

Figure 4. Case 2. (A) The defect after excision of a cutaneous carcinoma. Again, a combination of a banner flap (F1) and a rotation flap (F2) (B-R flap) was designed to close the defect. (B) Defect closure by the flaps. Suture lines were designed to be mostly along the borders of the aesthetic subunits. (C) Eighteen months after the surgery.

harvested proximal to the defect, with their blood flow in the vertical direction to the long axis of the leg. The flaps successfully took without any complications (Figure 5).

Discussion

Rotation flaps are commonly used to cover skin defects from tumor excision, trauma, and intractable ulcer. It is technically simple but sometimes requires an extremely large flap in order to close the defect and results in a large deformity. The main concept of the B-R flap is to convert a circular defect to a narrower wedge shape (the defect after the F1 transfer) with a minimal amount of healthy skin excision, in order to facilitate a rotation flap (F2) design smaller than the conventional rotation flap. In this study, a schematic analysis was made to compare the required flap size and the amount of healthy skin excision, on the assumption that flaps with the same central angle of rotation provide the same rotation angle. Evaluating the radius, rotation angle, and central angle of the rotation flap, F2 of the B-R flap was smaller than the conventional rotation flap and required less healthy skin excision.

When defects in the distal aspect of the extremities are reconstructed using a conventional rotation flap, it is often difficult to find sufficient area to yield a flap of adequate size. The conventional rotation flap also has many limitations when it is used on the head and the face because the donor site must be chosen to avoid the eye, the ear, the mouth, and the nose. We demonstrated that a small B-R flap allows for more flexibility in choice of donor site. The B-R flap is smaller compared to the conventional rotation flap and is more often easily employed in the aforementioned regions. The smaller surgical field provides a further benefit of potentially reducing the amount of local anesthetic, bleeding, and postoperative downtime.

Several methods using multiple flaps have been reported for closure of comparatively large defects with less tension, less sacrifice of healthy skin, and less resultant scar. One of the best methods meeting these requirements is the 'reading man procedure'. Mutaf et al. [9] described this method taking the concept of Z-plasty a step further by using two flaps. The reading man procedure is appreciated as aesthetically useful and is becoming an important option for facial reconstruction [10–13]. This method is applicable for other regions; however, it seems to be unsuitable for regions of less elastic skin such as scalp or planta pedis. Z-plasty extends the length of the resultant scar in one direction but also shortens the vertical direction. Therefore, the corners of the rectangular and triangular flaps are subject to strong tensional forces. Z-plasty requires that the mobility of the flaps be restricted in such regions. Flaps are contracted to the vertical direction of

Figure 5. Case 3. (A) The markings for the carcinoma excision and the B-R flap. (B) Defect closure by the flaps. (C) Twelve months after the surgery.

the Z-plasty because of the restricted mobility of the flaps. In contrast, the B-R flap is suitable for these regions because the tensional forces on F1 and F2 are considered to be at right angles to each other, and evenly distributed (Figure 1(B)). In addition, F2 relieves the tension at the base of F1, so as not to interfere with perfusion and healing.

This method is well-adapted for medium-to-large circular defects that are difficult to be simply closed or covered by a small local flap, as well as for regions where the neighboring skin is under too much tension to allow closure of the flap donor site, e.g. scalp, limb, or parasternal/paraspinal region. This method is not suitable for exposed regions because the pivot point of F1 is easily deformable into a dog ear, and because obscuring the long scar of F2 may present difficulties. When the B-R flap is used for exposed regions such as the face, the rotation angle of F1 should be $< 90^\circ$ in order to minimize the possibility of dog-ear deformity, and F2 should be designed with the resultant scar hidden in the borders of the aesthetic subunits, as shown in case 2.

Conclusion

A combined flap design using one banner flap and one rotation flap successfully covered circular skin defects. Compared to conventional rotation flaps, a smaller rotation flap is sufficient to cover the defect with excision of a smaller area of healthy skin. The B-R flap can be a useful option for reconstructive surgery in well-perfused areas.

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Disclosure statement

No potential conflict of interest was reported by the authors.

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