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Chimeric Anterolateral Thigh Perforator Flaps for Reconstruction of Wound Defects With Dead Space

A Retrospective Comparative Study

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Background: Reconstruction of wound defects with associated dead space requires adequate obliteration using well-vascularized tissue to reduce fluid accumulation and support infection control. Conventional musculocutaneous flaps are commonly used for this purpose, but may have limited flexibility in positioning the muscle component. This study evaluated the clinical utility of a chimeric pattern anterolateral thigh (ALT) flap with independently mobile skin and muscle components.

Patients and Methods: Between May 2016 and January 2024, 49 patients underwent reconstruction of wound defects with dead space using free or pedicled ALT flaps. Of these, 26 cases were reconstructed with the conventional musculocutaneous flap, employing the classic en bloc technique. The remaining 23 cases utilized a chimeric pattern perforator flap, consisting of separate skin and muscle components. The skin flap served to resurface the skin defect, while the independently mobile muscle flap was tailored to fill the dead space.

Results: Postoperative infection occurred in 3 of 26 patients in the conventional flap group and in none of the chimeric flap group, although the difference was not statistically significant. Both techniques achieved stable wound coverage. The chimeric flap allowed independent positioning of the muscle component according to the location and configuration of the dead space.

Conclusion: The chimeric pattern ALT flap offers greater technical flexibility by allowing independent positioning of the skin and muscle components. This technique may facilitate reconstruction of wound defects with eccentrically located or deep dead spaces. Despite the limitations of this study, these findings suggest a potential technical advantage rather than superiority over conventional musculocutaneous ALT flaps.

Key Words: wound defect, dead space, anterolateral thigh flap, chimeric flap

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The general method for reconstructing a wound defect involves resurfacing. However, when there is coexisting dead space, an additional approach is required beyond mere resurfacing. Dead space may develop after extensive debridement, including bone resection, or because of the 3-dimensional configuration of the wound.[1,2] Inadequately managed dead space can permit fluid accumulation and may contribute to persistent or recurrent infection, particularly in contaminated wounds.[3,4] Accordingly, successful reconstruction requires both durable surface coverage and appropriate management of the underlying cavity.

A skin flap is commonly used for resurfacing, whereas vascularized muscle can be used to fill a deep cavity and deliver well-perfused tissue to a compromised wound bed.[5,6] In cases where a wound defect coexists with dead space, both a skin flap and a muscle flap are necessary for successful reconstruction. Historically, the most popular and straightforward method for obtaining both flaps simultaneously has been the elevation of a conventional musculocutaneous flap, a technique widely used before the advent of the perforator flap concept.[7] However, because the muscle and skin components are spatially linked, the muscle component may be difficult to position when the dead space is deep, eccentric, or located at the periphery of the surface defect. A chimeric anterolateral thigh (ALT) flap allows the skin and muscle components to be harvested on separate branches of a common source vessel and positioned independently. The purpose of this study was to compare conventional musculocutaneous ALT flaps with chimeric ALT perforator flaps in the reconstruction of wound defects with associated dead space and to describe the technical flexibility of the chimeric design.

PATIENTS AND METHODS

This retrospective study was conducted in accordance with the World Medical Association Declaration of Helsinki and was approved by the Institutional Review Board of our hospital (2025-01-027-001). Between May 2016 and January 2024, 49

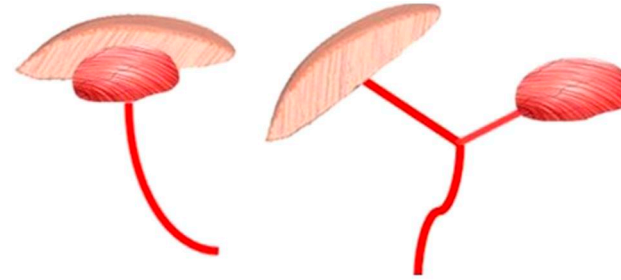


FIGURE 1. Schematic image of flaps. Conventional musculocutaneous ALT flap, designed as an en bloc pattern of a skin flap, a muscle flap and a main pedicle vessel (left). Chimeric pattern ALT perforator flap, designed as 2 flaps linking with each branch vessel to the main pedicle vessel (right).

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TABLE 1. Patient Demographics of Group 1 (Conventional Musculocutaneous ALT Flap)

	Sex/Age (y)	Diagnosis	Size of Defect (cm^2)	Size of Dead Space (cm^3)	Flap	Complication
1	M/61	DM foot, Lt.	6×5	2×2×1	Free ALT	None
2	M/56	DM foot, Lt.	10×8	5×4×2	Free ALT	None
3	F/45	DM foot, Rt.	12×7	4×3×2	Free ALT	None
4	M/47	DM foot, Lt.	13×5	4×3×1	Free ALT	None
5	F/75	DM foot, Rt.	18×9	4×4×1	Free ALT	None
6	F/70	Foreign body, lower leg, Rt.	26×8	8×3×2	Free ALT	None
7	M/60	Pressure sore, trochanteric region, Rt.	13×13	9×5×3	Pedicled ALT	None
8	M/51	DM foot, Rt.	6×6	2×1×1	Free ALT	None
9	M/60	DM foot, Lt.	6×5	3×2×1	Free ALT	None
10	F/52	Skin and soft tissue defect, scalp	8×5	2×3×1	Free ALT	None
11	M/23	Necrotizing fasciitis, forearm, Lt.	12×8	8×5×3	Free ALT	None
12	M/48	Pressure sore, trochanteric region, Lt.	12×7	8×5×3	Pedicled ALT	None
13	F/64	DM foot, Rt.	15×7	3×2×1	Free ALT	Infection
14	F/76	DM foot, Rt.	10×5	8×3×2	Free ALT	Infection
15	M/37	DM foot, Lt.	23×7	4×3×3	Free ALT	None
16	M/63	DM foot, Rt.	3 x 3	1×1×1	Free ALT	None
17	M/76	DM foot, Rt.	7×4	7×4×2	Free ALT	None
18	M/59	DM foot, Lt.	12×8	6×3×1	Free ALT	Infection
19	F/71	Crushing injury, forearm, Rt.	17×14	8×4×2	Free ALT	None
20	F/75	Skin and soft tissue defect, scalp	20×8	8×4×1	Free ALT	None
21	F/66	DM foot, Rt.	12×7	8×5×2	Free ALT	None
22	M/52	DM foot, Rt.	8×7	7×6×1	Free ALT	None
23	M/56	DM foot, Lt.	11×8	6×5×1	Free ALT	None
24	M/43	Skin and soft tissue defect, ankle, Lt.	7×7	2×2×1	Free ALT	None
25	F/57	DM foot, Rt.	3×3	1×1×1	Free ALT	None
26	M/72	Pressure sore, trochanteric region, Rt.	16×14	8×6×3	Pedicled ALT	None

wound defects with associated dead space were reconstructed using free or pedicled ALT flaps. Twenty-six defects were reconstructed using conventional musculocutaneous ALT flaps (group 1), and 23 were reconstructed using chimeric ALT perforator flaps (group 2).

Flap selection was not randomized. The operating surgeon selected the flap design according to the 3-dimensional wound configuration, the location and depth of the dead space relative to the surface defect, and intraoperative judgment regarding the ability of the muscle component to reach and fill the cavity. This nonrandom selection process created a potential risk of selection bias.

The conventional musculocutaneous ALT flap was designed as an en bloc unit consisting of a skin paddle, a segment of vastus lateralis muscle, and the main vascular pedicle (Fig. 1). The muscle component was located beneath the skin paddle and remained connected to it around the perforator and source vessel. Because the muscle and skin components were harvested together, extensive intramuscular perforator dissection was generally unnecessary.

TABLE 2. Patient Demographics of Group 2 (Chimeric Pattern ALT Perforator Flap)

	Sex/Age (y)	Diagnosis	Size of Defect (cm^2)	Size of Dead Space (cm^3)	Flap	Complication
1	M/58	DM foot, Rt.	13×8	4×4×1	Free ALT	None
2	M/73	DM foot, Lt.	12×7	4×3×1	Free ALT	None
3	F/49	DM foot, Rt.	10×10	6×4×1	Free ALT	None
4	M/58	Fournier's gangrene, penoscrotum	14×13	4×4×2	Pedicled ALT	None
5	M/86	DM foot, Lt.	11×10	4×3×1	Free ALT	None
6	M/62	DM foot, Lt.	8×7	4×3×1	Free ALT	None
7	M/61	Fournier's gangrene, penoscrotum	15×10	5×5×2	Pedicled ALT	None
8	M/70	Crushing injury, ankle, Lt.	20×10	6×4×1	Free ALT	None
9	M/77	DM foot, Rt.	6×5	3×2×1	Free ALT	None
10	M/53	DM foot, Lt.	7×6	4×4×2	Free ALT	None
11	M/48	Skin and soft tissue defect, lower leg, Lt.	23×10	6×5×2	Free ALT	None
12	M/79	DM foot, Lt.	7×6	2×2×1	Free ALT	None
13	M/58	Crushing injury, ankle, Rt.	18×10	6×5×2	Free ALT	None
14	F/69	DM foot, Rt.	10×7	3×3×1	Free ALT	None
15	M/52	DM foot, Rt.	7×7	4×4×2	Free ALT	None
16	F/46	DM foot, Rt.	8×5	2×2×2	Free ALT	None
17	M/48	DM foot, Rt.	5×3	2×1×1	Free ALT	None
18	F/43	DM foot, Rt.	8×4	3×2×1	Free ALT	None
19	M/60	DM foot, Lt.	7×6	5×3×2	Free ALT	None
20	M/35	Skin and soft tissue defect, ankle, Rt.	18×8	8×6×2	Free ALT	None
21	M/51	DM foot, Rt.	12×6	7×3×2	Free ALT	None
22	M/45	Osteomyelitis, ankle, Rt.	20×8	6×6×2	Free ALT	None
23	M/60	DM foot, Lt.	8×4	1×1×1	Free ALT	None

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TABLE 3. Comparison Between 2 Groups

Variable	Group 1 (Conventional Musculocutaneous ALT Flap)	Group 2 (Chimeric Pattern ALT Perforator Flap)	*P*
Sample size (number)	26	23	
Sex (number)			
Male	16	19	
Female	10	4	
Age (y)	58.27 ± 12.84*	58.30 ± 12.45*	0.992†
Diagnosis (number)			
DM foot	17	16	
Others	9	7	
Size of defect (cm^2)	93.88 ± 65.02*	94.17 ± 62.18*	0.988†
Size of dead space (cm^3)	42.12 ± 42.93*	27.91 ± 24.67*	0.166†
Complication (number)	3	0	0.096†

*Mean ± SD.
†*t* Test.

The chimeric ALT perforator flap consisted of a fasciocutaneous skin paddle and a separate segment of vastus lateralis muscle, each supplied by an independent branch of the descending branch of the lateral circumflex femoral artery (Fig. 1). A cutaneous perforator was identified using a hand-held Doppler, and the skin paddle was designed with the perforator in a central position. After elevation of the fasciocutaneous component and proximal dissection of the descending branch, the pedicle was further dissected distally to identify a separate branch supplying the muscle component. A segment of the vastus lateralis muscle was then harvested while preserving its vascular connection. During the inset, the skin paddle was used for resurfacing, and the independently mobile muscle component was positioned within the dead space.

Medical records were reviewed for demographic characteristics, wound etiology and location, defect size, estimated dead-space volume, flap type, and postoperative complications. All patients were followed for at least 1 year. Flap loss was defined as partial or total necrosis requiring operative treatment. For this retrospective analysis, uncontrolled infection was defined as persistent or recurrent clinical evidence of infection, including prolonged wound discharge from the



FIGURE 2. Diabetic foot ulcer presenting with a large defect with dead space on the forefoot. (A) A defect after radical debridement. (B) A conventional musculoskeletal ALT flap. (C) Appropriate defect resurfacing with inadequate dead space obliteration. (D) Complete healing after additional toe amputation and wound revision.

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FIGURE 3. A diabetic foot ulcer presenting with a large defect with dead space between the plantar skin and metatarsal bone. (A) A defect after complete debridement. (B) A free ALT perforator flap with a chimeric pattern. (C) Flap inset with a muscle flap occupying the deep dead space (yellow arrow: skin flap, blue arrow: muscle flap). (D) Complete healing without complications.

reconstructed cavity, that required an additional operative procedure such as debridement, wound revision, or amputation. Minor wound problems managed without operative intervention were recorded separately when documented. No standardized patient-reported or radiologic outcome measure was used.

Statistical analysis was performed using IBM SPSS Statistics version 20.0 (IBM Corp., Armonk, NY). Between-group comparisons were considered statistically significant at a 2-sided P value of 0.05 or less. Because of the small cohort and low number of complication events, the analysis was considered exploratory, and the absence of statistical significance was not interpreted as evidence of equivalence between the 2 flap designs (Tables 1 and 2).

RESULTS

The study included 49 patients (35 men and 14 women) with a mean age of 58.29 years (range, 23 to 86 y). The mean surface defect area was 94.02 cm^2 (range, 9 to 238 cm^2), and the mean

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FIGURE 4. Fournier's gangrene presents with a large defect with triangular dead space between the 2 testes. (A) Scrotal defect after complete debridement. (B) A pedicled ALT perforator flap with a chimeric pattern. (C) Flap inset with a muscle flap occupying the triangular dead space (yellow arrow: skin flap, blue arrow: muscle flap). (D) Complete healing without complications.

estimated dead-space volume was 35.45 cm^3 (range, 1 to 144 cm^3). Group 1 included 26 conventional musculocutaneous ALT flaps (23 free and 3 pedicled flaps), whereas group 2 included 23 chimeric ALT perforator flaps (21 free and 2 pedicled flaps). No statistically significant between-group differences were identified in patient age, surface defect area, or estimated dead-space volume (Table 3).

All flaps survived. Three patients in group 1 developed uncontrolled infection requiring an additional operative procedure, whereas no such events were observed in group 2. The between-group difference in complication rate did not reach statistical significance ($P = 0.096$). The 3 events in group 1 were associated with persistent infection and prolonged discharge from the reconstructed cavity rather than primary circulatory failure of the flap. These findings represent an observed trend and should not be interpreted as proof that the chimeric design reduces infection or is superior to the conventional musculocutaneous design.

Case 1

A 76-year-old woman presented with a severely infected right diabetic foot ulcer complicated by osteomyelitis (Fig. 2). After radical debridement, the surface defect measured 10×5 cm, and an 8×3×2-cm cavity remained around the first metatarsophalangeal joint. Reconstruction was performed using a conventional musculocutaneous free ALT flap. Although the flap remained viable, persistent infection and prolonged discharge developed during the early postoperative period. The wound ultimately healed after additional

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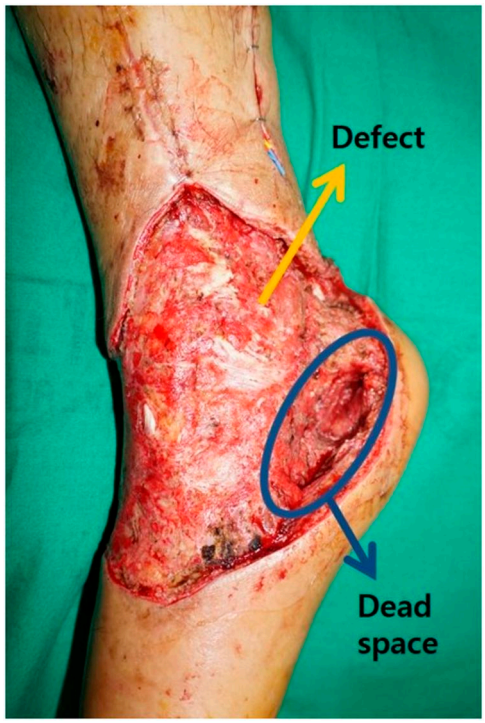


FIGURE 5. Wound defect with dead space after radical debridement. An extensive defect with a combined deep dead space on the periphery.

first-toe amputation and wound revision. The adverse outcome was likely multifactorial; inadequate source control, osteomyelitis, diabetes, and wound severity may all have contributed, and the event cannot be attributed to flap design alone.

Case 2

A 53-year-old man presented with a severely infected diabetic foot ulcer on the lateral aspect of the left foot (Fig. 3). Radical debridement, including fifth-toe amputation, resulted in a 7×6-cm surface defect and a 4×4×2-cm deep, narrow, peripheral cavity between the plantar skin and the phalanx. A chimeric free ALT perforator flap was used. The skin paddle covered the surface defect, and the independently mobile muscle component was positioned within the cavity. The wound healed without recurrent clinical infection during follow-up.

Case 3

A 61-year-old man presented with Fournier gangrene involving the penoscrotal region (Fig. 4). Radical debridement resulted in a 15×10-cm surface defect involving the scrotum and part of the penile skin, together with a 5×5×2-cm triangular cavity between the testes at the periphery of the defect. Reconstruction was performed using a pedicled chimeric ALT perforator flap. The skin paddle covered the surface defect, and the muscle component was positioned within the triangular cavity. The wound healed without recurrent clinical infection during follow-up.

DISCUSSION

Reconstruction of a wound defect with associated dead space requires management of both the surface and the underlying 3-

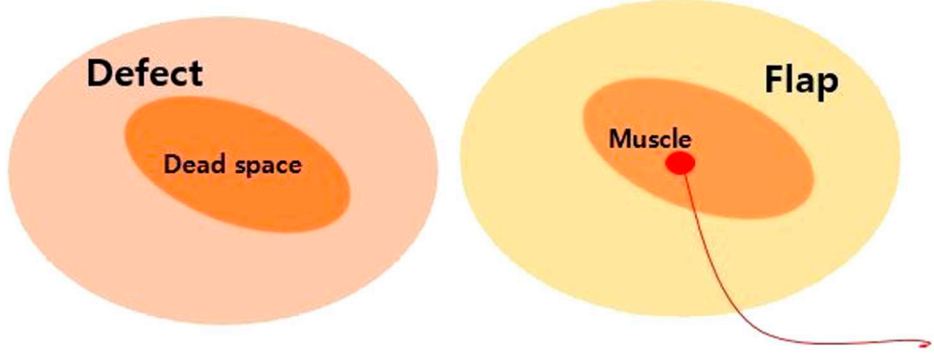


FIGURE 6. Dead space in the center of the defect and a conventional musculoskeletal flap. Suitable situation for coverage.

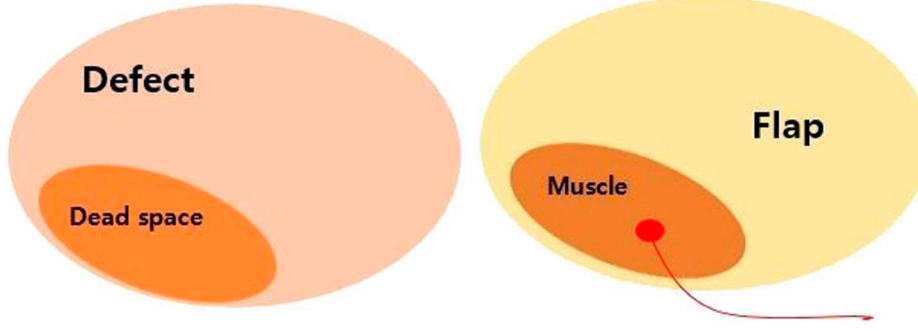


FIGURE 7. Dead space on the periphery of the defect and conventional musculoskeletal flap. An unsuitable situation as a peripheral perforator can make a skin flap dangerous.

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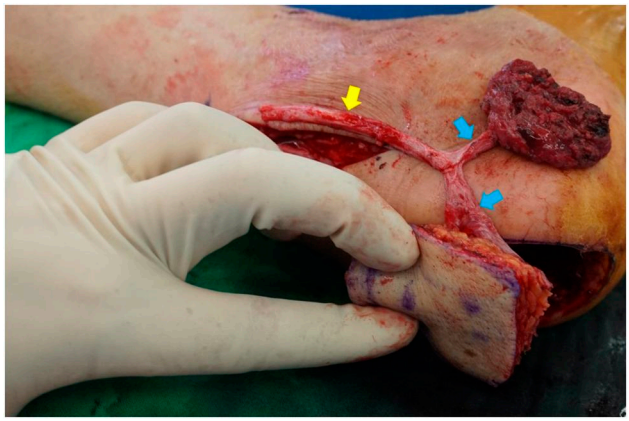


FIGURE 8. Chimeric pattern perforator flap. Each component is linked to one main pedicle through branch vessels (yellow arrow: main pedicle, blue arrow: branch vessel).

dimensional cavity.[8–10] Irregular cavities may remain after debridement because tissue removal follows the distribution of necrosis, infection, exposed bone, or hardware rather than a uniform geometric plane (Fig. 5). Dead space should not be regarded as a direct etiologic cause of infection. Rather, an unfilled cavity can permit fluid or hematoma accumulation and may create conditions that favor persistent bacterial contamination. Importation of well-vascularized tissue can improve local perfusion, support host immune responses, and facilitate delivery of systemic antibiotics to a compromised wound bed.[11]

Several techniques can be used to manage dead space. A partially deepithelialized local or free flap can provide soft-tissue bulk and may be useful for selected cavities.[12,13] Folding or contouring deepithelialized tissue is an established reconstructive maneuver and should not, by itself, be considered a cause of vascular compromise. The suitability of this approach depends instead on flap geometry, available tissue volume, pedicle orientation, and the dimensions and location of the cavity. Vascularized muscle is another option, particularly for contaminated or irregular wounds, because it is pliable and can be shaped to fill a cavity.[14]

A conventional musculocutaneous flap provides skin and muscle as a single unit.[15] It is technically straightforward and may be particularly suitable when the muscle component naturally aligns with a centrally located cavity (Fig. 6). Its principal limitation in this context is geometric rather than biologic: the spatial relationship between the skin paddle and muscle component is relatively fixed. The muscle can be tailored to some extent, but positioning may be less convenient when the cavity is eccentric, peripheral, or oriented differently from the surface defect (Fig. 7).

In a chimeric ALT flap, the skin and muscle components are supplied by separate branches of a common source vessel.[16–18] This configuration permits independent positioning and orientation of the components (Fig. 8). The skin perforator can remain centrally located within the skin paddle while the muscle component is directed toward a peripheral or vertically oriented cavity (Fig. 9). The principal contribution of the chimeric design in this series is therefore not the introduction of ALT flaps or muscle-containing flaps, both of which are well established, but the practical use of separate perforator-based components to address discordant surface and cavity geometry.

The chimeric design requires identification and dissection of the vascular branches supplying each component and may therefore be technically more demanding than an en bloc musculocutaneous flap.[19–21] In the present series, all flaps survived, and uncontrolled infection requiring reoperation occurred in 3 patients in the conventional group and in none of the patients in the chimeric group. However, the difference was not statistically significant. In addition, the chimeric flaps may have been selected for wounds with different cavity geometry or less extensive contamination, and underlying patient and wound factors were not sufficiently balanced or controlled to isolate the effect of flap design. Consequently, the findings support technical feasibility and a possible clinical advantage, but they do not establish superiority or a causal reduction in infection.

This study has several limitations. First, its retrospective, single-center design and nonrandomized patient selection may have introduced selection bias. Second, the relatively small sample size and low event rate limited the statistical power to detect differences in complications. Third, potential confounding factors affecting infection risk were not uniformly available for adjusted analysis. Finally, postoperative MRI or other objective imaging was not routinely performed; therefore, long-term muscle viability, volume retention, and atrophy could not be objectively evaluated.

Future prospective studies should use predefined selection criteria, standardized definitions of infection and source control, detailed adjustment for patient and wound risk factors, and objective imaging to evaluate postoperative muscle perfusion and volume retention. Larger multicenter cohorts will be required to determine whether the technical flexibility of the chimeric design translates into a lower complication rate.

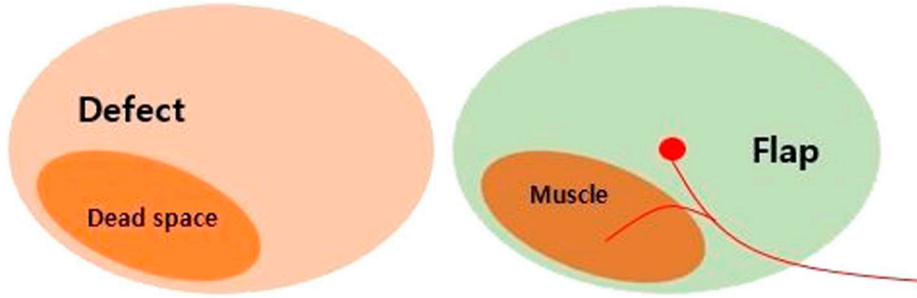


FIGURE 9. Dead space on the periphery of the defect and chimeric pattern perforator flap. A suitable situation is for an independently mobile muscle component to be positioned within a peripheral dead space while maintaining a skin perforator in an appropriate location.

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CONCLUSION

Chimeric ALT perforator flaps permit independent positioning of the skin and muscle components and may be useful when a wound defect is accompanied by a deep, eccentric, or peripheral cavity. In this retrospective series, all flaps survived, and fewer uncontrolled infections were observed in the chimeric group; however, the difference was not statistically significant, and the study was susceptible to selection bias and inadequate statistical power. The findings support the chimeric ALT flap as a technically versatile reconstructive option rather than establishing its superiority over conventional musculocutaneous ALT flaps.

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