Simplified Nomenclature for Compound Flaps

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Learning Objectives: After studying this article, the participant should be able to: 1. Understand the attributes and unique niche for compound flaps. 2. Assimilate a proposed simplified schema for classifying types of compound flaps based on their inherent vascular supply. 3. Appreciate how minor technical modifications in general do not necessarily create new categories of flaps.

The unique niche for compound flaps is their potential role for the repair of massive defects that demands the simultaneous restoration of multiple, missing tissue types. These complex flaps can be sorted into two major classes, and their subtypes on the basis of their means of vascularization are described. (1) Solitary vascularization, the composite flap: “multiple tissue components with a single vascular supply and dependent parts.” (2) Combined flaps: (a) Siamese flaps: “multiple flap territories, dependent due to some common physical junction, yet each retaining their independent vascular supply”; (b) conjoint flaps: “multiple independent flaps, each with an independent vascular supply, but linked by a common indigenous source vessel”; and (c) sequential flaps: “multiple independent flaps, each with an independent vascular supply, and artificially linked by a microanastomosis.” Many technical modifications that have improved or will improve the reliability of these flaps should not be confused as distinct flap types, but rather acknowledged as variations that can be more conveniently classified for the purposes of improved communication and research by using this basic schema as a guideline. (Plast. Reconstr. Surg. 105: 1465, 2000.)

If a vascularized tissue transfer is essential, a basic principle to minimize the overall morbidity should be the selection of one flap only to achieve this goal, whenever possible, that violates no more than a single, well-defined anatomic vascular territory. Yet more extensive defects for which there has been a loss of many and disparate components understandably deserve replacement in kind and may represent an exception to this rule. Instead, as a corollary to this guideline, the latter situation could best be rectified with a compound flap, where the requisite major structures are somehow linked together to simultaneously and more efficiently accomplish the objective without resorting to the use of many unrelated flaps from multiple donor sites.

Many forms of compound flaps have been described sporadically over the years. This has caused some confusion, because typically each modification of just how various vascular territories may be united often is given a different name. Also, as Core has admonished, in many instances these have been merely minor variations in surgical techniques only, yet the essential source of tissue vascularization has been unaltered. Just as Mathes and Nahai conceived a simplified schema for muscle flaps and Cormack and Lamberty for fascia flaps (primarily based on an understanding of the pertinent flap anatomy and nuances of vascular supply), that revolutionized the safe, reliable, and expeditious harvest of their basic flap types, a similar and straightforward classification of compound flaps would also be valuable. This system would not only enhance worldwide communication in describing similar ideas but, as Koshima stressed in his rebuttal to Core, would further advance the development of a more reliable role of these complex flaps in microsurgery and possibly their use as local flaps, if simple enough to be applicable.
BASIC SUBTYPES OF COMPOUND FLAPS

A compound flap by definition somehow incorporates many diverse tissue components into an interrelated unit. Such flaps can be partitioned into two major subdivisions that differ according to their primary method of vascularization (Fig. 1). Adapting the terms of Belousov et al.,1 within either subdivision there can be individual flaps (“monoflaps”) or multiple related flaps (“polyflaps”). These polyflaps are distinguished by a unique vascular pedicle that can be indigenous or manipulated surgically to conjugate these flaps in advantageous combinations.

Solitary Vascularization

Composite flaps. Conceptually, the simplest form of compound flap is the composite flap that en bloc contains multiple tissue components.7 This flap has a known solitary source of vascular supply intertwined within all parts that are thus dependent on each other if flap viability is to be maintained.2,8 The ubiquitous musculocutaneous or fasciocutaneous flaps would be commonly used examples, because these consist primarily of muscle or fascia, respectively, but also of a skin and subcutaneous tissue paddle that depends on muscle or fascial perforators for sustenance. In a sense then, all flaps are composite flaps because all are composed of a discrete microvasculature, connective tissues, intrinsic nerves, fat, etc., in addition to their basic defining parts, but this semantic technicality is intentionally overlooked in this proposed schema. Composite flaps are usually monoflaps, but can sometimes at their periphery be partially divided along major branches of the source vessel into multiple portions that allow greater freedom in insetting.9

Combinations of Vascularization

All other compound flaps have multiple sources of vascularization and would be categorized as combined flaps. There are three major subtypes of combined flaps that technically differ with regard to their various combinations of vascularization, yet all are similar in that each anatomic flap territory that is part of that combination retains an independent blood supply.

Siamese flaps. Harii first introduced the concept of combined flaps when he described a “combined myocutaneous flap and microvascular free flap” in which the skin territories of the latissimus dorsi muscle and groin flap remained connected essentially to form a bipedicled flap based on the thoracodorsal and superficial circumflex iliac vessels respectively.10 Either pedicle could be divided to increase the arc of rotation of the combination in a caudal or cephalad direction, but an auxiliary form of revascularization by means of microanastomoses was required for that territory no longer nourished as a local pedicled flap. Although a single flap, Belousov et al. called these large flaps, not inappropriately, “megaflaps.”7 Because typically these flaps are combinations of at least two anatomically distinct territories, each retaining their independent vascular supply but joined by means of some common physical boundary, the term Siamese flap is an appropriate descriptive appellation.7,8 Shibata et al. further advanced this concept by using a distally based combined posterior interosseous (dorsal forearm) and lateral arm flap to provide thin coverage of hand defects, which proved that at least a venous anastomosis can sometimes be avoided because the dorsal forearm veins proved sufficient to drain the entire flap.11

Conjoint flaps. Conceived originally as a combination of local flaps from the same angiosome, the conjoint flap has probably been the most frequently reported combined flap.12–15 These flaps have sometimes been called chimeric2,8 or polyflaps,1 and consist of multiple otherwise independent flaps each with an independent vascular supply from a major branch that are conjoined by means of a larger common source vessel.1,2 Multiple and varied tissue components can simultaneously be selected from a single donor site. Because these combinations ultimately have only a single source vessel, the
microsurgical transfer of these multiple flaps can require only a single recipient site. The subscapular system epitomizes this genre, by which fascia (e.g., scapula, parascapular), muscle (e.g., serratus anterior, latissimus dorsi), and osseous (e.g., rib, scapula) flaps, using the thoracodorsal or circumflex scapular branches, can allow more than five dozen known flap permutations that permit near total freedom in the independent insetting of each part. Other important, unique conjoint flap donor sites that can maintain the patient in a supine position include the anterior thigh using the lateral circumflex femoral axis (e.g., anterolateral and anteromedial fasciocutaneous, rectus femoris, and tensor fasciae latae muscles), and the foot for which nail beds, joints, small bone, and toe combinations may be based on the dorsalis pedis vessels and their important branches.

**Sequential flaps.** This most complex form of combined flaps always requires a microanastomosis. Multiple, otherwise independent flaps, each with an independent vascular supply, when joined to one another by this microanastomosis are sequentially linked together much as links on a chain. Thus, sequential flaps have also been termed “chain-link” flaps or sometimes “bridge” flaps, because usually a vascular “flow-through” exists across one flap to which the pedicle of the second is joined. Therefore, the first flap serves as a bridge or conduit for blood flow to cross from the recipient pedicle to reach a more peripheral attached or “piggybacked” flap. Because each flap in turn serves as the recipient site for the next, only one non-flap recipient site again is needed, which can be important when sparse. This can be useful, as we have proven, for a second free flap to salvage partial failure of the first (fortuitously a “flow-through” flap) without violating the initial precarious microanastomosis.

**TECHNICAL VARIATIONS**

Many distinct but minor modifications of these basic forms of compound flaps exist, and surely others even now are in developmental stages. As Core has pointed out, these primarily are only technical alterations of our proposed basic subtypes that when given a separate name have served only to cause obfuscation. Koshima’s “mosaic” flap is a good case in point to prove this ongoing dilemma. To understand even his nomenclature, the also confusing concepts of turbocharging and supercharging have to be better defined. Unfortunately, these terms have also been used interchangeably, sometimes within the same report and often to suggest that these technical maneuvers resulted in new flap types.

Semple has compared supercharging and turbocharging maneuvers to automotive terms. If an external power source is used to boost an engine’s performance, this is supercharging, e.g., when an unrelated distant vascular source is anastomosed to a flap to augment circulation (Fig. 2). The superior unipedicled TRAM flap salvaged by a trunk or upper extremity vessel anastomosis to the contralateral deep or superficial epigastric vessels would be the classic example. Some could argue that this flap would then be a combined unilateral myocutaneous TRAM flap joined in its middle to a contralateral microvascular free skin flap, reminiscent of Harii’s description of what now would be a form of a Siamese flap. Turbocharging, on the other hand, uses the engine’s own exhaust for additional power. Therefore, if the terminus or a branch of the major pedicle to a flap were joined to another minor pedicle, flow (the exhaust) to the flap (the engine) could be siphoned away to augment an undersupplied portion (Fig. 2). Semple directly connected the ipsilateral and contralateral deep inferior epigastric vessels of a TRAM flap, after first ensuring adequate retrograde pressures, to improve transmidline blood flow of a superior unipedicled flap, i.e., he turbocharged the flap. This TRAM flap variation could also be considered
a Siamese flap, because the contralateral deep inferior epigastric source vessel to what would be considered the random territory of the ipsilateral vessel was revascularized by the turbocharging maneuver.

Core et al. turbocharged the notoriously unreliable distal skin portion of a gracilis musculocutaneous flap, connecting the perforator to the medial thigh flap by means of a vein graft to a branch of the dominant medial circumflex femoral pedicle. A graft was required because these vessels were not contiguous. Koshima et al. connected the major pedicles of two adjacent thigh flaps directly to each other to augment flow, avoiding this need for a vein graft, and called the resultant variation a mosaic flap (Fig. 2). Again, in both cases an argument could be made that these really were Siamese flaps that had been turbocharged, and each differed only by a slight technical variation that provided the requisite vascularization. For that matter, Koshima pointed out that, if enough recipient vessels had existed, he would not use the mosaic flap principle (i.e., turbocharge), but would perform additional recipient vessel anastomoses to more safely supercharge any flap, as was done by Harri et al. in their original description of what we now unequivocally call Siamese flaps.

To further muddle the issue, permutations within and between combined flaps have also been described. The single flaps chosen to form a combined flap can be composed of the same or different tissue types (e.g., latissimus dorsi and serratus anterior conjoint muscle flap, anterolateral and medial thigh Siamese fascia flap), or of a series of multiple composite flaps. Some or all of these combined flaps can remain as local pedicled flaps or be used as free flaps. Sequential flaps as a group are different, because they always are fabricated by the surgeon. Koshima et al. have suggested that conjoint flaps also can be fabricated by joining various single flaps by means of a microanastomosis to large branches or the terminus of a major source vessel (Fig. 3). In reality, these then become a form of conjoint sequential flap and really no longer can be purely classified as conjoint flaps. Another example of the potential confusion and ambiguity still possible is the case of a caudal-pedicled local latissimus dorsi-groin flap used to cover a large thoracoabdominal defect where the thoracodorsal pedicle was revascularized by means of a flow-through radial forearm free flap, which would then make this a sequential Siamese flap by this simplified classification schema.

**DISCUSSION**

The obvious advantage of compound flaps as a group is their ability to provide simultaneously multiple types of tissue building blocks of sufficient size to correct any volume deficit, restore the underlying framework, and allow immediate coverage (Table 1). Shape and contour can be independently customized and inset with impunity, especially with the conjoint and sequential type combined flaps. Ideally, all the necessary components can be obtained from a single donor site that is then closed primarily. If multiple, otherwise independent free flaps arise from a single major source vessel, as in conjoint and sequential combined flaps, then only a single recipient site may be necessary, which often otherwise can be a significant limiting factor.
toration of multiple, unrelated functions by a combined dynamic muscle transfer represents one of many unique possibilities.\textsuperscript{16} Another frequent advantage of combined flaps is including a second small independent flap as part of a conjoint free flap to specifically protect or relieve tension at a tenuous recipient site.\textsuperscript{16}

Nevertheless, basic principles should not be shunned, and most demands for vascularized tissue can be satisfied without resorting to any compound flap.\textsuperscript{1} In our own experience with 783 flaps over the past two decades, only 5 percent of all flaps (approximately 14 percent of 251 free flaps) were better managed with a combined flap, and that most often by using permutations from the familiar subscapular system.\textsuperscript{16} Their limited role is directly related to disadvantages distinct for each subtype. Composite flaps can be bulky, and individual parts cannot be independently inset, which can be cumbersome. Siamese flaps require a convenient recipient vessel at the end of the flap’s reach, which may not be logistically available to provide the mandatory auxiliary revascularization. An infrequent but not uncommon problem with conjoint flaps is anomalies of pedicles to individual flaps that could then require the inconvenience of additional microanastomoses or even abandonment of the planned transfer.\textsuperscript{16,18,34} Monitoring can also be problematic, because one flap of a combination can be totally viable even as another withers undetected. Distal flap loss has been reported only in sequential flaps, presumably because of an increased thrombogenicity caused by the more proximal anastomotic sites.\textsuperscript{22} Compound flaps, just by their innate complexity, will have unique complications that must be anticipated and overcome, and as a group must always be chosen prudently and when appropriate.

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\textbf{REFERENCES}


Self-Assessment Examination follows on page 1471.
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1. WHICH OF THE FOLLOWING STATEMENTS CONCERNING COMPOUND FLAPS IS TRUE?
A. Each tissue component has an independent source of vascularization.
B. They are limited in choice to a select few donor sites.
C. They can be “monoflaps” or “polyflaps.”
D. They are only suitable for microsurgical tissue transfers.
E. They are best suited for metachronous restoration of different structures in complex defects.

2. CREATION OF WHICH OF THE FOLLOWING COMPOUND FLAP SUBTYPES ALWAYS REQUIRES MICROSURGERY:
A. Siamese flap
B. Conjoint flap
C. Composite flap
D. Sequential flap

3. WHICH OF THE FOLLOWING STATEMENTS CONCERNING THE MULTIPLE FLAP TERRITORIES OF COMBINED FLAPS IS TRUE?
A. They usually are dependent on a common vascular supply.
B. They can sometimes be harvested from the same angiosome.
C. They normally have a common physical boundary.
D. Each must incorporate identical tissue components.
E. They are related by a vascular “flow-through.”

4. WHICH OF THE FOLLOWING STATEMENTS CONCERNING CONJOINT FLAPS VASCULARIZED BY MEANS OF THE SUBSCAPULAR AXIS IS TRUE?
A. They can be independently based on the thoracodorsal and circumflex scapular branches.
B. They comprise only muscle or fascia flaps.
C. They require multiple recipient-site microanastomoses.
D. There are a dozen possible combinations.

5. KOSHIMA’S “MOSAIC” FLAP USING THE COMPOUND FLAP CLASSIFICATION SCHEMA SUGGESTED IN THE ARTICLE MOST CLOSELY RESEMBLES WHICH OF THE FOLLOWING?
A. A “supercharged” flap.
B. A “turbocharged” flap.
C. A “chain-circle” flap.
D. A Siamese flap.
E. A chimeric flap.

6. WHICH OF THE FOLLOWING IS A DISTINCT DISADVANTAGE OF COMPOUND FLAPS?
A. Composite flaps tend to be bulky.
B. Siamese flaps have unlimited reach.
C. Conjoint flaps are not affected by anatomic anomalies.
D. Sequential flaps must be bridged by a “flow-through.”

7. THE ADVANTAGES OF COMPOUND FLAPS INCLUDE THE FOLLOWING, EXCEPT:
A. They can correct any volume deficit.
B. They simultaneously provide framework and coverage.
C. They provide customization according to the shape and contour of the defect.
D. They often violate but a single donor site.
E. They allow independent insetting of components.
8. MONITORING OF COMBINED FLAPS CAN BE PROBLEMATIC BECAUSE OF WHICH OF THE FOLLOWING:
A. Increased thrombogenicity can lead to flap failure.
B. Survival of the most distal combined flap ensures success.
C. All independent components require identical vigilance.
D. Microsurgery has inherent limitations and known risks.

To complete the examination for CME credit, turn to page 1589 for instructions and the response form.