

*Review*

## A New Classification of Free Combined or Connected Tissue Transfers: Introduction to the Concept of Bridge, Siamese, Chimeric, Mosaic, and Chain-Circle Flaps

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Recently, combined tissues or flaps have been used for the repair of extensively massive or wide defects resulting from radical wide resection. To further advance the development of combined tissue transfers, they should be reclassified. Based on our cases with free tissue transfers, we have created a new classification of combined flaps composed of "bridge", "chimeric", "siamese", "mosaic", and "chain-circle" flaps. The bridge flap is fabricated out together of separate flaps with short vascular pedicles. These form a compound flap supplied with a solitary vascular source. The chimeric flap is compounded from multiple different flaps but consists of only a single different tissue form. Each of the flaps is usually supplied by different branches from the same source vessel. It differs from the bridge flap in that the pedicle of each flap or tissue has some length for its movement for transfer. The siamese connected flap has 2 adjacent flaps that are simultaneously elevated, and a disparate vascular pedicle for each flap must be reestablished. This connected flap has double isolated pedicles. The mosaic connected flap consists of 2 adjacent flaps that are simultaneously elevated, and the pedicle of the distal flap is anastomosed to the pedicle branch of the proximal flap in the "bridge" fashion. The vascular pedicle of the proximal flap is anastomosed to a single vascular source. The chain-circle flap has 2 or more flaps like the bridge and chimeric flaps, and the distal end of the vascular source is anastomosed to the branch of the recipient vessel. Based on results with our patients, the lateral circumflex femoral system seems to be the most suitable candidate for the axial pedicle of these combined flaps, because the system has several branches of large and small caliber, and several tissue components, such as the vascularized ilium, rectus femoris muscle, gracilis muscle, lateral femoral cutaneous nerve, and fascia lata, are located nearby.

**Key words:** microsurgery, free tissue transfer, combined flaps, chimeric flap, siamese flap, mosaic flap, chain-circle flap

A free combined tissue for transfer consists of 2 or more compound or composite flaps made up of 2 or more tissue components with 1 or more vascular

pedicles, or combined (connected) flap, which consists of 2 or more flaps with 1 or more vascular pedicles. Recently, these combined tissues and/or flaps have been used for the repair of extensively massive or wide defects resulting from radical wide resection of advanced or recurrent carcinomas and extensively wide defects in the extremities with single or double recipient vessels.

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Various free combined tissue transfers and combined (or connected) flaps that have been reported should be classified to further advance the development of free tissue transfer.

Although Hallock [1] classified combined such combined flaps as "chimeric", "siamese", and "bridge" flaps as composite, based on our 58 cases with free combined tissue transfers, some cases cannot be adapted to his classification. Therefore, in this paper, we introduce a new classification and its applications.

### New Classification of Free Combined or Connected Flaps (Fig. 1)

#### 1. Bridge flaps

The "bridge" flap is fabricated out of separate flaps with short vascular pedicles to form a compound flap supplied with a solitary vascular source. A microanastomosis is usually required to create vascular flow-through with linkage.

Flaps which have been described before which can be classified as bridge flaps are 2 radial forearm flaps combined to reconstruct an entire esophagus [3], a combined radial forearm-vascularized iliac bone graft [4], radial forearm-scapular osteocutaneous flaps [5] for the reconstruction of defects of the oral floor and mandible, and the combined transplantation of bilateral vascularized fibulas, the distal ends of the peroneal vessels of which were used for vascular combination by a cross-bridge vascular anastomosis [6]. Also classifiable as bridge flaps are bilateral latissimus dorsi musculocutaneous flaps for extensively large defects of the lower leg [6], a latissimus dorsi musculocutaneous flap and the vascularized fibula for osteocutaneous defects of the lower leg [6], scapular and wrap-around flaps for radial ray deficits [6], a latissimus dorsi musculocutaneous flap and a wrap-around flap for forearm scar contracture involving a thumb deficit [6], a latissimus dorsi musculocutaneous flap and the second and third toes for forearm scar contracture and finger deficits [6], and the second toe and second and third toes for deficits of 4 fingers [6].

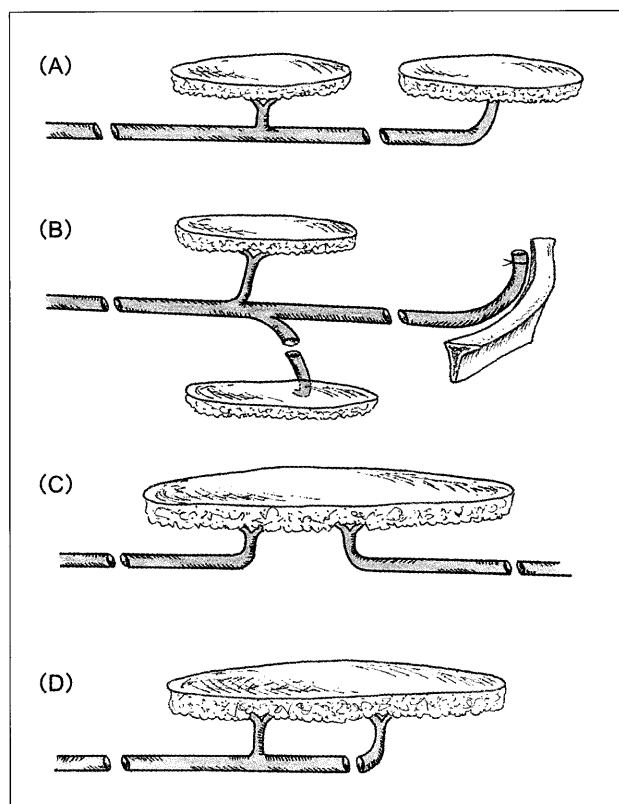
Based on results with our patients, besides these radial and subscapular systems, the lateral circumflex femoral system is also suitable for the creation of more complicated bridge flaps, because the descending branch of this system is very long (over 10 cm) and the flaps can be obtained from the same donor area; *i.e.*, anterolateral-anteromedial thigh flaps *etc.*

The main advantage of bridge flaps is that a consider-

able amount of free tissue can be transferred with a single vascular source. However, the pedicle vessel of each component is so short that the movement of the components is limited, and the components are fabricated together from different donor sites.

#### 2. Chimeric flaps

The "chimeric" flap is compounded from multiple different flaps, but consists of only a single different tissue form. Each of the flaps is usually supplied by



**Fig. 1** Classification of free combined or connected tissue (flap) transfers. **A**, the bridge combined flap is fabricated out of separate flaps with short vascular pedicles to form a new (compound) flap. A microvascular anastomosis is required to create vascular flow-through with linkage. **B**, the chimeric combined flap is compounded from multiple different flaps (tissues). Each of the flaps is supplied by a long pedicle anastomosed to the branch of axial source vessel. **C**, the siamese connected flap usually has 2 adjacent flaps that are simultaneously elevated, and a disparate vascular pedicle for each flap is anastomosed to double vascular sources. **D**, the mosaic connected flap consists of 2 adjacent flaps that are simultaneously elevated, and the pedicle of the distal flap is anastomosed to the pedicle vessel branch of the proximal flap.

different branches from the same source vessel. It differs from the bridge flap in that the pedicle of each flap or tissue has some length for its movement for transfer.

The chimeric flap was introduced to overcome the above disadvantages of bridge flap. The original chimeric flap by Hallock [1] is a combination of the rectus femoris muscle and an overlying anterolateral thigh flap, which is supplied by different branches from the same source vessel, the descending branch of the lateral circumflex femoral vessel. Extending this principle more widely, we have defined the chimeric flap as one which has 2 or more flaps with a single vascular source, with each flap having its own long vascular pedicle [7]. Some authors have already been described free chimeric flaps, such as the latissimus dorsi-serratus anterior muscles [8], and the scapular-parascapular flaps [9] and the scapular-scapula-parascapular flaps [10], which are simultaneously joined by the subscapular vessels but are independently mobile on the thoracodorsal and circumflex scapular branches, respectively. As a future application, a chimeric flow-through flap, which would include an anterolateral thigh flap-latissimus dorsi musculocutaneous flap, would also be suitable for the repair of extremities with extensively wide defects and only one major vessel. Chimeric flaps can overcome the disadvantages of bridge flaps, because 2 or more parts are anatomically combined with a single vascular source, and the individual combined tissues can be freely moved with a relatively long vascular pedicle.

### 3. Siamese connected flaps

The "siamese" connected flap, the concept of which was first reported by Cormack and Lamberty [2], has 2 adjacent flaps that are simultaneously elevated, and a disparate vascular pedicle for each flap must be reestablished. This connected flap does not have a single vascular source, but rather double isolated pedicles.

The combined latissimus dorsi-groin island and microvascular free flap, in which the superficial circumflex iliac vessels are anastomosed to the recipient vessels [11], is an example of this flap. Other possible Siamese flaps are the connected latissimus dorsi musculocutaneous flap-rectus abdominis musculocutaneous flap [12], the deltopectoral flap-deltoid flap [13], "supercharge" flap, which includes the rectus abdominis musculocutaneous flap-superficial inferior epigastric flap (or groin flap) [14, 15], bilateral rectus abdominis musculocutaneous flap [16], "turbo" gracilis myocutaneous flap [17], tensor fasciae latae musculocutaneous flap-sartorius mus-

culocutaneous flap [18], megaflaps [19], and the anterolateral thigh flap-vascularized ilium [20]. A possible future application, using the lateral circumflex femoral system, could be the use of three of four Siamese connected flaps, *i.e.*, saphenous-antrolateral thigh-groin-latissimus dorsi musculocutaneous flaps. However, such a flap necessitate multiple recipient vessels.

The main advantages of siamese flaps are an adequate blood supply via double vascular pedicles, and free extension of the flap size. The disadvantage of this type of combined flap is the need of 2 or more recipient vessels to anastomose the pedicle vessels.

### 4. Mosaic connected flap

The "mosaic" connected flap consists of 2 adjacent flaps that are simultaneously elevated, and the pedicle of the distal flap is anastomosed to the pedicle branch of the proximal flap in the "bridge" fashion. The vascular pedicle of the proximal flap is anastomosed to a single vascular source.

To overcome the above disadvantage of siamese flaps, we introduced mosaic connected flaps [21]. Based on results with our patients, a combined anteromedial thigh-groin flap with over 40 cm in length can be survived with a single recipient vessel. The advantages of mosaic flaps are that extremely long and large flaps can be vascularized with only one vascular source, and the flap can be easily elevated in one donor site. However, the indications are limited to cases in which the distal pedicles of the flap can reach the branch of the proximal axial pedicle vessel (This implies cases requiring folding of the flap at the middle portion of the long connected flap).

### 5. Chain-circle flap

The "chain-circle" flap, has 2 or more flaps like the bridge and chimeric flaps. The distal end of the vascular source is anastomosed to the branch of the recipient vessel (or anastomosed in end-to-side fashion). The term "chain-circle flaps" was created by us [7, 22]. The main advantage of this flap is that postoperative safe blood circulation is assured via the circle pathway of the linked pedicle vessels.

Finally, as the axial pedicle of these combined flaps, the lateral circumflex femoral system seems to be most suitable, because the system has several branches of large and small calibers, and several tissue components, such as the vascularized ilium, rectus femoris muscle, gracilis

muscle, lateral femoral cutaneous nerve, and fascia lata, are located nearby [7, 21, 23].

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