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# Experimental Rat Flap Models

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## Abstract

Experimental flap surgery aims to increase our understanding of flap physiology and to test new surgical techniques to increase flap viability. Many experimental flap models have been described with the advancement of flap surgery and research. Most commonly used experimental flaps used in rats, including dorsal skin, flank, epigastric, oblique groin, pectoral, latissimus dorsi, rectus abdominis and fibula flaps, will be described.

**Keywords:** experimental flaps, rat, flap physiology

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## 1. Introduction

Animal experiments performed on rats have played a crucial role in the development of flap surgery over the past years. There are many experimental rat flap surgery models. Main purposes of these models include understanding flap physiology, as a training tool for residents and to test new surgical techniques. The effect of pharmacological agents, delay procedures and different anastomosis techniques on flap survival can be studied on these models. The evaluation of the results of these experiments usually involves flap necrosis area calculation based on calibrated photographs, histological evaluation and angiographic imaging.

## 2. Skin flaps

### 2.1. Dorsal skin flap

This flap was described by McFarlane et al. [1] in 1965. This is one of the most commonly used flaps for random flap studies. This flap is raised based on a caudal pedicle from the

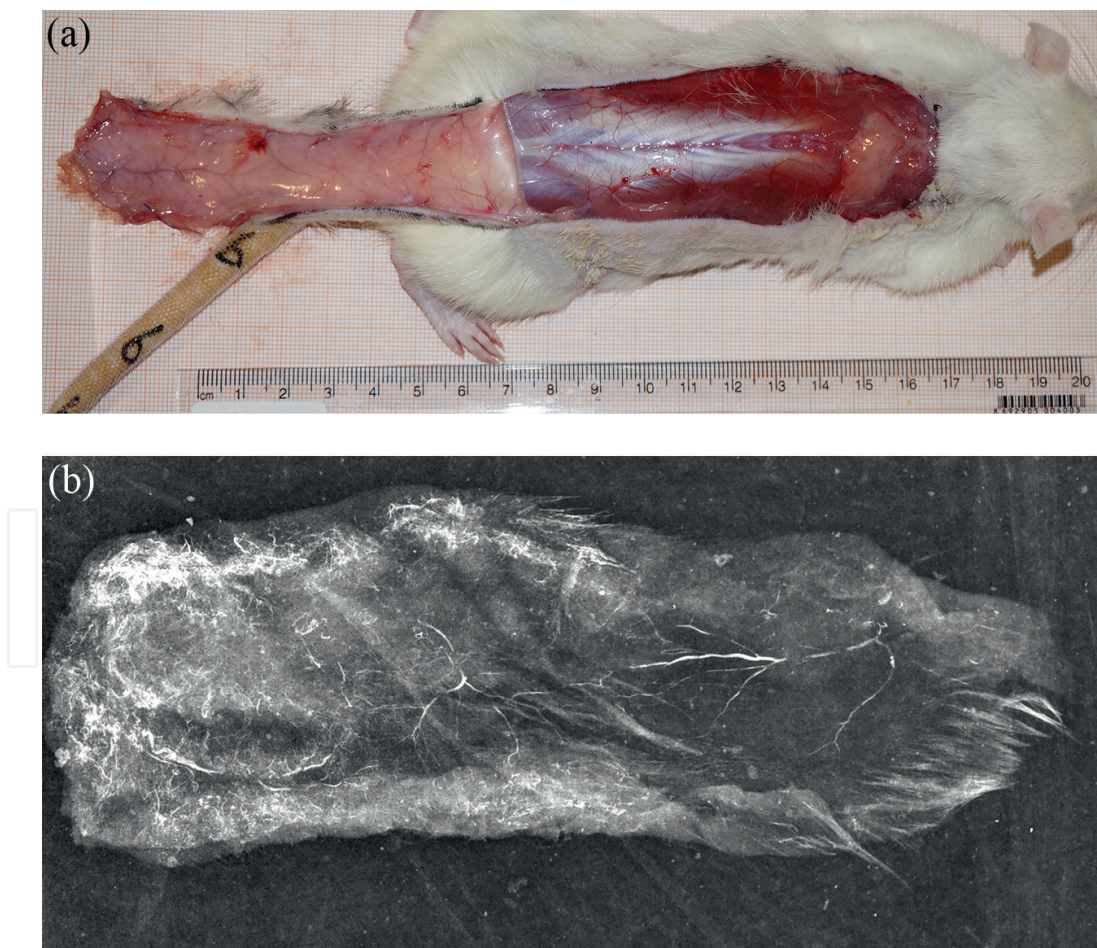
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dorsal rat skin. This flap was originally described as being 10×4 cm in dimension or as having a length-to-width ratio of 2,5/1. Later, this original description was modified to 9×3 and 10×3 dimensions, a modification that proved to demonstrate more consistent results [2]. Various flap viability ratios have been reported depending on dimension. The author believes that 9×3 cm flap provides the most consistent flap viability ratio (**Figure 1**).

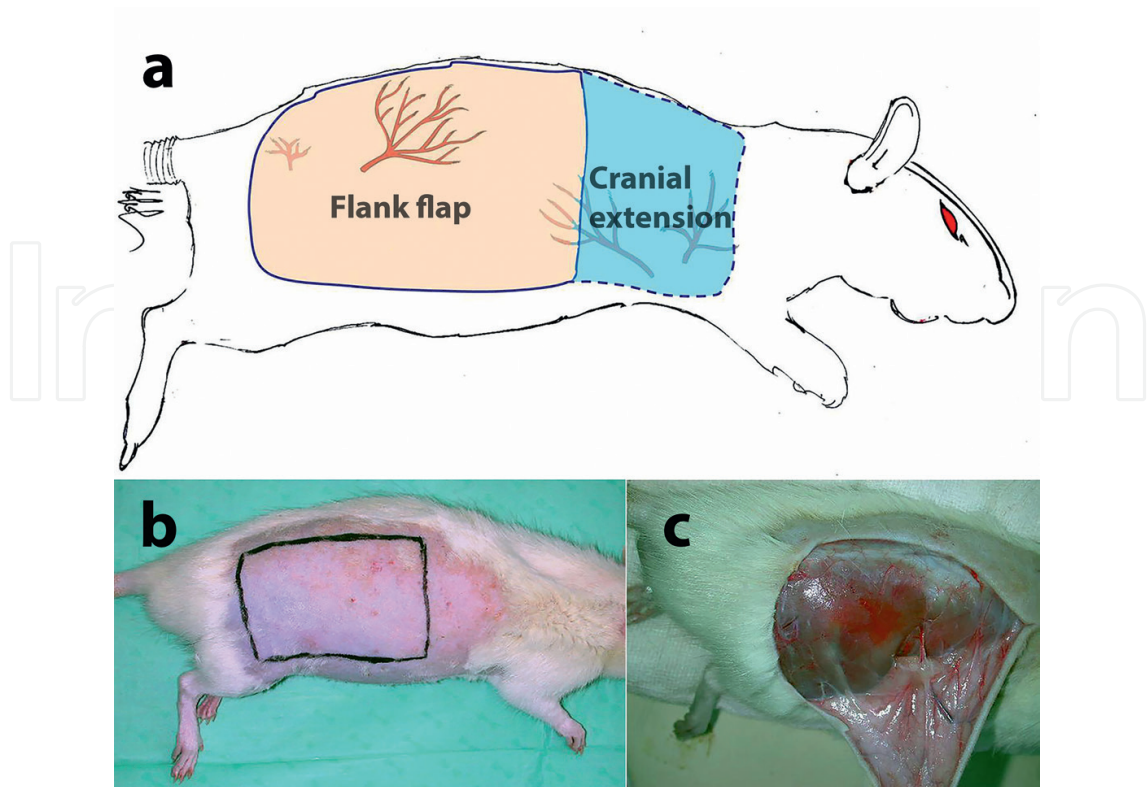
Templates are commonly used to mark flap dimension on the skin before the flap elevation. It is important to note that these templates might result in inaccuracies due to the curvature of animal's body.

## 2.2. Flank flap

Syed et al. [3] described this flap as the skin area supplied by the iliac branch of iliolumbar artery. Its borders were from the back of 12th rib to the proximal part of the tail medially and the axillary line laterally. It was suggested as a consistent model for experimental flap research (**Figure 2**).



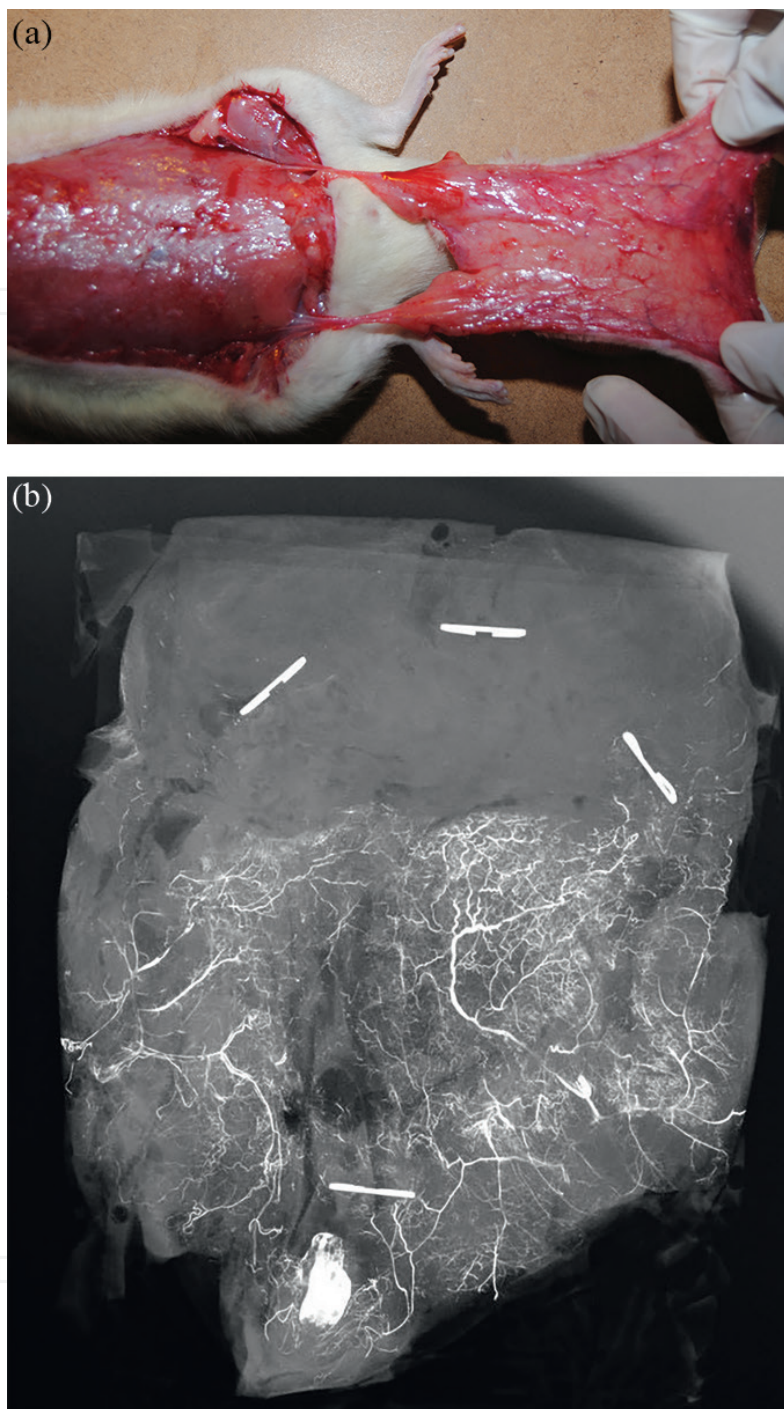
**Figure 1.** Dorsal skin flap. (A) Flap elevation and (B) angiographic image.



**Figure 2.** Flank flap. (a) Flank flap and its cranial extension; (b) skin marking and (c) flap elevation.



**Figure 3.** Oblique rat groin flap.



**Figure 4.** Epigastric flap. (A) Flap elevation and (B) angiographic image.

### 2.3. Epigastric flap

Finseth and Cutting [4] first described this flap back in 1978 as a neurovascular island flap. This flap is commonly used for axial flap studies and microvascular anastomosis studies. This flap is also commonly used in conjunction with angiographic studies. The flap is designed on superficial epigastric vessels which originate from the femoral artery. The superficial epigastric trunk divides into lateral and medial branches. The lateral branches have been reported to

be variable by some studies [5]. The median vessels collateralize with the branches of internal mammary vessels. The lateral branches collateralize with lateral thoracic artery (**Figure 3**).

#### 2.4. Oblique rat groin flap

Nishikawa et al. [6] described this flap in 1991. The purpose of this flap is to prevent flap neo-vascularization from its underlying bed, which could interfere with the results in certain type of studies. This flap is designed over adipose fat pads which act as a barrier for new vessel formation (**Figure 4**).

### 3. Muscle flaps

Various muscle flaps have been identified for research in rats. Other than those included in this section, adductor muscle flap [7], gracilis flap [8], gluteus maximus [9], gastrocnemius [10, 11], quadriceps femoris flap [12] and cremaster flaps have been described [13].

#### 3.1. Pectoral flap

This flap was first defined by Zhang et al. [14]. It consists of two parts, superficial and profundus. These parts are supplied by separate neural and vascular systems. The profundus



**Figure 5.** Pectoral flap.

part is in association with axillary vessels and is more commonly used for experimental studies (Figure 5).

### 3.2. Latissimus dorsi flap

Tilgner et al. [15] described the latissimus dorsi flap in rats. Rat latissimus dorsi muscle has a similar vascular anatomy when compared to humans. It is supplied by the thoracodorsal pedicle and five to six intercostal perforators. It is a suitable model for vascular delay studies and has been reported to have a consistent necrosis pattern [16] (Figure 6).

### 3.3. Rectus abdominis flap

This flap was described by Zhang et al. [17]. Myocutaneous flaps can be raised with this model. The skin island is designed over the anterior sheath of the rectus muscle. Inferior edge of the flap is planned 2.5 cm above the symphysis. The muscle is supplied by superior and inferior epigastric arteries and veins. Microvascular flap transplantation is possible with this model with average vessel diameter of 0.5 mm (Figure 7).

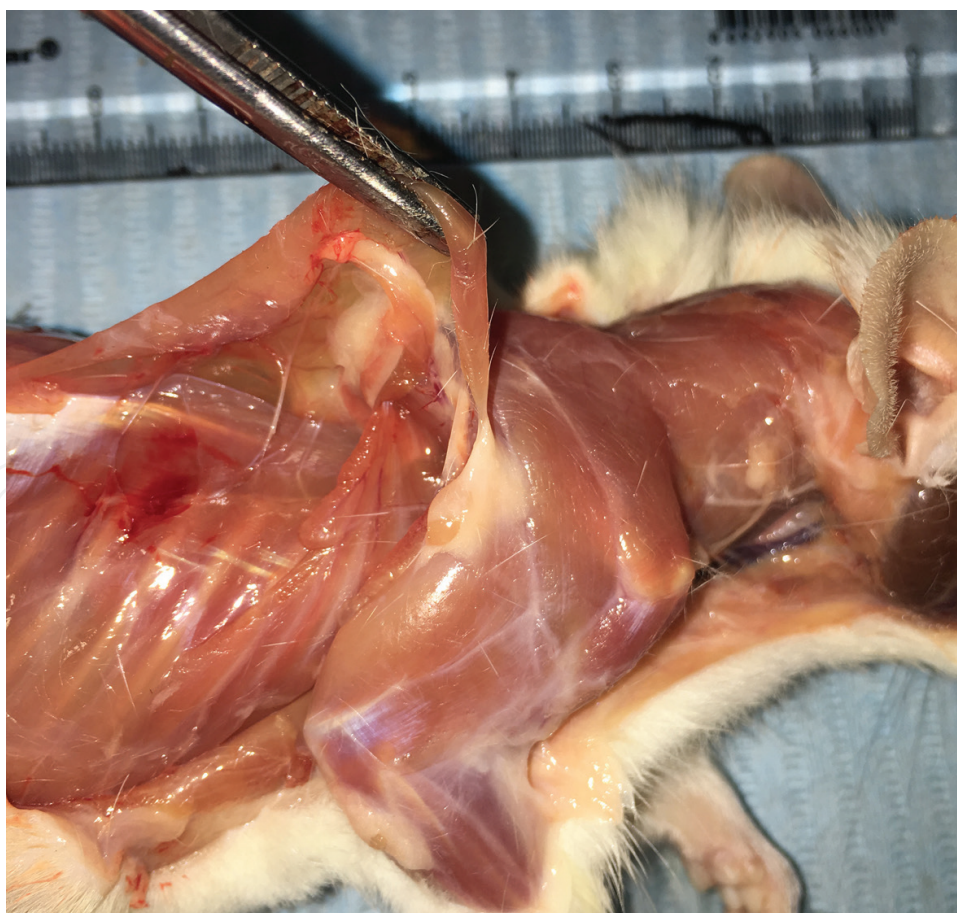
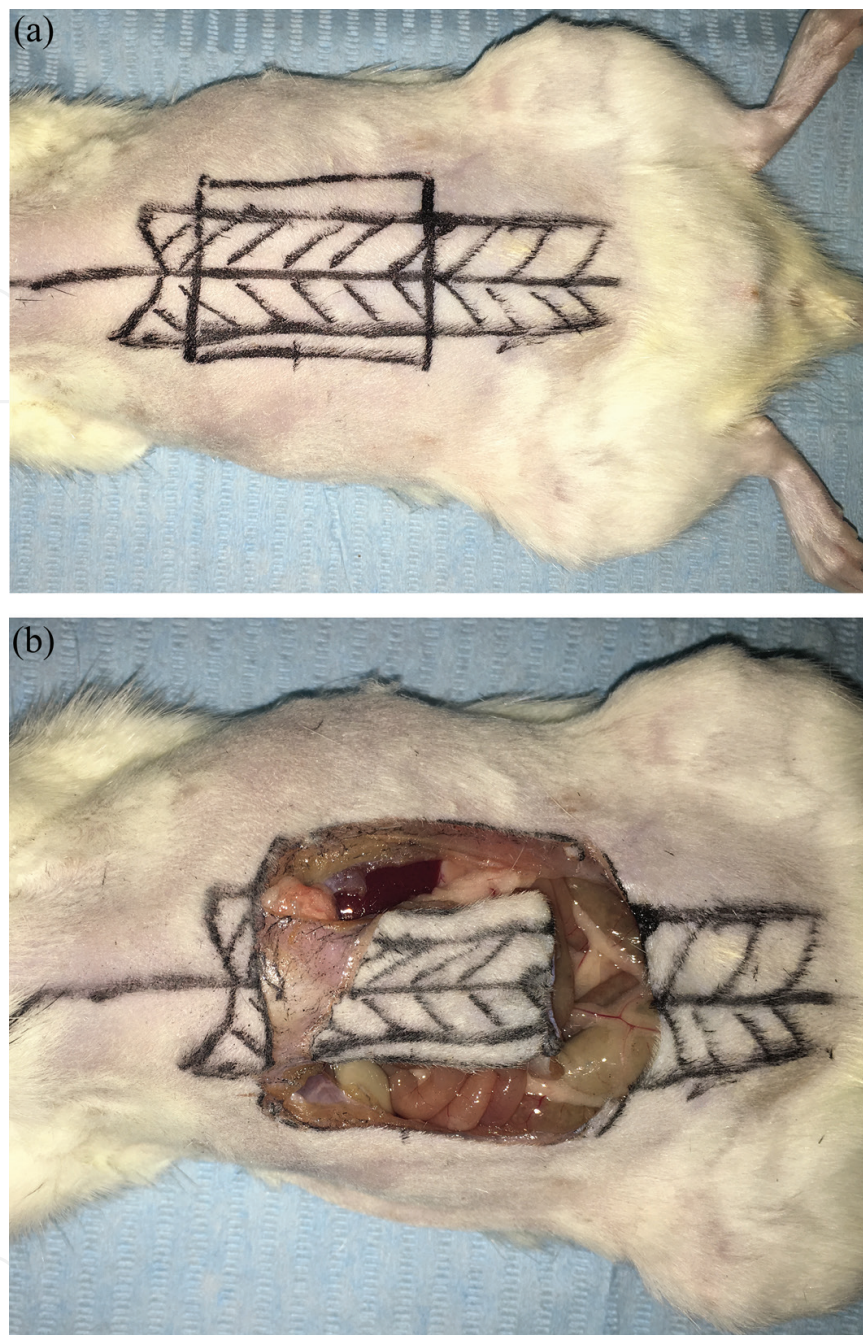


Figure 6. Latissimus dorsi muscle flap.



**Figure 7.** Rectus abdominis flap. (a) Flap design and (b) flap elevation.

#### **4. Fibula flap**

Fibula flap is one of the most common flaps used in mandibular reconstruction in clinical practice. Chen et al. [18] described the rat fibula bone flap as a free vascularized bone flap model. The flap is usually raised with a medial incision as opposed to humans in which a lateral approach is used. Flexor hallucis muscle is usually included in the flap. Peroneal vessels that supply the flap originate from the popliteal and anterior tibial artery vessels (**Figure 8**).





**Figure 8.** Fibula flap.

## 5. Conclusion

Rat models have been proven to be a very valuable tool for flap research. In spite of the developments in the field of cell cultures, *in vitro* studies are usually not as valuable as animal studies in this field. Although other animal models have been proposed, rats are by far the most commonly used species for these purposes. They are easier to maintain and more readily available. Although much more valuable than *in vitro* studies, rat experiments do also have their limitations. The application of the results of rat model experiments on human subjects may not always be possible. Differences in the life span and the wound healing processes between humans and rats should be considered.

## Author details

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