Experimental Fascial Flap Model in the Dog: Free Flap of the Dorsal Thoracic Fascia

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ABSTRACT

For years, various types of fascial flaps have been used in clinical practice; however, there are many unanswered questions regarding their basic physiology, anatomy and histopathologic changes occurring after transfer. Simple and reliable flap models are needed to investigate these questions, but very few of these flap models have been described in experimental animals to date. The purpose of this study was to describe a new reliable fascial flap model in the dog—the dorsal thoracic fascia flap. This fascia is defined as the anatomic layer that contains the blood supply to the scapular and parascapular fasciocutaneous flaps.

Fourteen adult dogs were used in this experiment. The vascular anatomy of the dorsal thoracic fascia was studied by anatomic dissection and microangiography. Anatomic dissection revealed that the main axial vessel supplying the dorsal thoracic fascia was the superficial branch of the thoracodorsal vessel. Based on the vascular pedicle, fascia flaps generally measuring 15x24 cm were created. At gross observation, all of these large flaps based solely on the vascular pedicle were observed to be well-perfused. Microangiographic examination revealed the intense vascularity of the superficial branches of the thoracodorsal vessels in the whole area of all flaps. It was concluded that this is a simple and reliable fascial flap model which can be prepared as a free or pedicled flap. It has a consistent, long vascular pedicle with large-vessel diameters supporting a large fascial flap.

KEYWORDS: Fascial flap, canine model

In the last decade, several fascia flaps have been described and used to repair contour irregularities located in the face, and defects located in the oral cavity and extremity. In 1980, Smith described the free temporoparietal fascia flap.¹ In 1986, Wintch and Helaly described a new donor site for a free fascia flap—the serratus anterior fascia flap.³ In 1987, Kim et al. performed an anatomic study defining the dorsal thoracic fascia as a finite “anatomic layer” that contains the blood supply to the scapular and parascapular fasciocutaneous flaps, and may be transferred without the overlying skin of the back.³ Since then, the clinical application of free fascia flaps has yielded good results and high success rates. However reliable fascial flap models are needed to investigate questions related to their basic physiology, hemodynamics and viability. The histopathologic fate of the fascia in different regions of the body after transfer as free flap still remains unclear. Similarly, the vascular anatomy of fascial flaps is still incompletely described, and experimental models for further research are inadequate.

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The large anatomic boundaries, the consistent vascular anatomy, and the thin, durable quality of the tissue make the dorsal thoracic fascia flap an excellent choice for the reconstruction of extremity and oral mucosa defects. In the reported experiment, the dorsal thoracic fascia based on a vascular pedicle was demonstrated in the dog model; this is considered as a useful, reliable, large-sized flap which has not been previously used in an experimental animal.

This contribution to a better understanding of the basic features of fascial flaps in animal models was thought to provide potential benefits in clinical applications.

MATERIALS AND METHODS
Small animals as experimental models are inexpensive, easy to maintain, and have a long history in the development of new flap models. However, we preferred the dog as an animal model, rather than small animals, as this study was to provide a basis for further free or pedicled fascial flap studies, such as oral cavity reconstruction, which would be very demanding in smaller animals. Additionally, the very thin nature of the fascia would make these studies in small animals difficult.

A total of 14 adult dogs (8 to 16 months of age) were used in this experiment. All of the animals were subjected to the same surgical procedure. Institutional guidelines regarding animal experimentation were followed. The dogs were housed in an air-conditioned animal facility with 12-hr light-dark cycles and free access to food and water. Two pilot studies were performed prior to beginning the study, to perfect operative techniques and plan.

Twelve adult dogs (18 to 25 kg) were used for dissecting the dorsal thoracic fascia. General anesthesia of the adult dogs was achieved with intramuscular 2 percent xylazine (10 kg/100 kg) and ketamine injection (20 mg/kg), and oral entubation was carried out. Supplemental doses of ketamine were given as necessary. As a prophylactic antibiotic, cephalosporin was injected at a dose of 500 mg intramuscularly just before surgery and 3 days postoperatively. The operative areas were shaved and prepared with povidone-iodine solution. A 24-gauge cannula was introduced into one of the extremity veins. Normal saline was given through this catheter at a rate of 25 ml/hr. The experiment was divided into two parts, as anatomic dissection-flap preparation and microangiographic assessment of the flap.

Anatomy and Flap Dissection

Twelve adult dogs underwent dissections to determine the anatomy of the dorsal thoracic fascia and of the superficial branch of the thoracodorsal arterial pedicle, and their relationships to the adjacent muscles and overlying skin. A standardized inverted-J incision (13 to 27 cm) was created on the dorsal thoracic wall (Fig. 1). Through this incision, skin flaps were elevated, and the dorsal thoracic fascia with the adipose tissue lying superficial to this layer were exposed (Fig. 2). As the superficial branches of the thoracodorsal vessels were detected to lie within the fascia (the dorsal thoracic fascia) of the back during the pilot studies, no inadvertent injury to the blood supply of the flap during this portion of the procedure was expected. In human studies, no attempt was recommended to thin the fatty layer of the flap during harvest, as the exact requirements of the recipient site are best adjusted after flap transfer and revascularization. In the dog model, the thickness of the tissues between the subcutaneous tissue and the dorsal thoracic fascia is from 3 mm to 7 mm. Because of this wide variability in the thickness of the fatty layer between the fascia and subcutaneous tissue, flaps of variable thickness can be obtained.

The facial flap was designed as an ellipse measuring approximately 15 × 24 cm (min: 12 × 19 cm; max: 18 × 30 cm), bounded laterally by the posterior axillary line, superiorly by the scapular spine, inferiorly as low as the caudal costal border, medially by the spinous pro-
cesses, and mainly overlaying the latissimus dorsi and serratus ventralis muscles (Fig. 3). The margins of the fascia were marked, and flap elevation was planned from the medial border, the paraspinous region, toward the lateral border where the superficial branches of the thoracodorsal vessels enter into the fascia of the back and lie within this layer. As the flap was dissected, multiple perforators from these superficial branches were seen to supply the supraspinatus, infraspinatus, and other minor muscles of the region. These perforators were cauterized and divided. The superficial branches of the thoracodorsal vessels were then easily identified within the axillary space, and more proximal dissection toward the subscapular artery and vein was accomplished by ligating the main thoracodorsal artery supplying the latissimus dorsi muscle. During the surgical procedure, the pedicle length and the diameters of the flap vessels were measured in all animals.

Before vascular pedicle division, perfusion at the very distal areas of the flap was assessed by gross observation of bleeding. The total time for harvesting the flap was approximately 1 hour.

Following division of the vascular pedicle, flaps were taken and microangiographic assessment was performed, to evaluate the vascularity of the superficial branches of the thoracodorsal vessels. The skin incision was closed primarily with interrupted 2-0 nylon suture. There were no surgical complications. No functional disability was observed in the forelimb motions of the animals. All animals survived.

Microangiographic Assessment of Vascularity Angiography of the flap was performed immediately using a 30 percent solution of finely divided barium sulphate (Micropaque). The subscapular artery was cannulated with a 24-gauge vascular catheter, and secured with 6-0 silk. At first, the whole vascular network of the flap was washed out with an injection of normal saline solution. Using a 50-cc syringe and applying steady manual pressure, radiopaque solution was injected through the artery. From the subscapular vein, the venous outflow of barium sulphate was observed. This usually required about 100 ml of radiopaque solution per flap. All flaps were then radiographed with a soft x-ray machine from a distance of 32 cm, and at a setting of 24 kV and 10 mA, using microvision-C mammography film.

RESULTS

Although it is possible that dogs may exhibit some differences in anatomic organization from humans, the vascularity and anatomy of the dorsal thoracic fascia in the dog were found to be consistent with the results of human studies. Only Scarpa’s fascia, which lies superficial to the dorsal thoracic fascia in humans, was observed as rather rudimentary and poorly-defined in the dog. Additionally, at the definition of vessels, a difference was detected: the circumflex scapular vessels in humans are named as superficial branches of the thoracodorsal vessels in the nomenclature of the dog anatomy.

When the dissection was performed, the vascular pedicle—superficial branches of the thoracodorsal vessels—from the fascia to the origin of the main trunk of the thoracodorsal vessels was measured at approximately 8 cm (min: 6 cm, max: 11 cm) in length (Fig. 4). However, additional length may be obtained by ligating the main thoracodorsal artery and dissecting the pedicle proximally to include the subscapular vessels. The length becomes approximately 10 cm (min: 8 cm, max: 13 cm) when the thoracodorsal artery is ligated and dissection of the pedicle proceeded proximally to include the subscapular vessels. Vessel diameters average 1.0 to 1.3 mm for the superficial branch of the thoracodorsal artery and 1.6 to 2.2 mm for the superficial branch of the thoracodorsal vein. The diameter of the subscapular artery and vein was 1.2 to 1.5 mm and 2.4 to 2.7 mm, respec-
The superficial branch of the thoracodorsal vessel system was found to be within the dorsal thoracic fascia in all of the animals. Before vascular pedicle division, perfusion at the very distal areas of the flap was assessed by gross observation of bleeding, and all areas were observed as well-perfused in all flaps (Fig. 5). A dense vascular network was also noted with the aid of transillumination (Fig. 6).

After vascular pedicle division (Fig. 7), microangiographic examination revealed the intense vascularity of the superficial branches of the thoracodorsal vessels in all areas of all flaps (Fig. 8). The pattern of vascularity was intense and similar in all examples.

**DISCUSSION**

Free fascia tissue transfer has become an important adjunct in the closure of complex wounds that are best suited for thin flap coverage, such as the dorsal and palmar surfaces of the hand, the forearm, the dorsal and palmar surfaces of the foot, as well as the ankle and pretibial regions of the leg. The thin and pliable nature of fascial flaps provides gliding surfaces for the tendons, and also provides the variability required to correct subtle contour deformities around the eye, nose, upper lip, and chin, such as are seen in patients with hemifacial atrophy.

Increasingly, bare fascial flaps are used to line mucosal defects, since these flaps mucosalize quickly with minimal contraction, and skin is not a perfect substitute for the mucosa. The free temporoparietal fascia flap, radial forearm fascia flap, serratus anterior fascia flap, and lateral arm fascia flap are all well-described and commonly used flaps, but all have some limitations. The dorsal thoracic fascia should be added to the list of fascia flap donor sites, since it has a long pedicle length, a large size, and a low donor-site morbidity.

To evaluate fascial flaps thoroughly, a description of the dorsal thoracic fascia in the dog appeared as useful. The large size of the vascular pedicle in the dog model allows for the free transport of the flap much more easily than that of small-sized animal models in which fine dissection and handling of the tissues becomes demanding and the risk of failure higher. In our canine model, the fate of large-sized fascial flaps can be investigated.
when they are transferred as free flaps to different regions. Since these flaps are thought to provide gliding surfaces for tendons, the long-term results of the flaps can be evaluated. A study could be designed to compare the results of fascial and muscle flaps in reconstruction of extremity defects. The feasibility of using fascial flaps to reconstruct the oral cavity and to line mucosal defects as a mucosa substitute may also be investigated.7,11

In dogs, cervical wounds resulting from other animals’ bites are common, and can result in exposure of vital organs such as the esophagus, trachea, and vessels. Because of their long vascular pedicles, pedicled flaps of the dorsal thoracic fascia can be useful for the reconstruction of cervical, thoracic, and forelimb defects in dogs.

The dorsal thoracic fascia is defined as the anatomic layer that contains the blood supply to scapular and parascapular fasciocutaneous flaps. In the present study, it was shown that this layer contains a profuse network of vessels permitting large-sized flap preparation. The plane of dissection for the fascial flaps was not a “natural surgical plane.” The operating surgeon will transect numerous small vessels coursing from the dorsal fascia to the subdermal plexus during flap elevation. Therefore, the incidence of hematoma formation at the donor site and interference with graft adherence to the flap surface have been reported as rather common complications.6 In our animal model, fine dissection and intense hemostasis were thought to have prevented hematoma formation.

In our opinion, one of the most important issues in the usage of fascial flaps is that fascia is generally found as a sheet of fibrous tissue, such as lies deep to skin or forms investment for muscles and various other organs of the body, and its absence does not give rise to a functional disability. Fascia is not a major functional unit in the body, unlike muscle, bone, vessel, or tendon. It is apparent that the dorsal thoracic fascia flap has very minimal donor-site morbidity, consisting of only a vertical scar in a relatively hidden area. Additionally, clinical cases have demonstrated the potential of the dorsal thoracic fascia to serve as a free flap, to expand the dimensions of the latissimus dorsi myocutaneous flap, and to maximize the dimensions of the scapular/parascapular flap.5

Finally, the dorsal thoracic fascia free flap more precisely defined in a dog model can be investigated in detail, and thereby could be used more reliably in the clinical practice of reconstructive surgery.

REFERENCES

Köpeklerde Deneysel Flep Modeli: Dorsal Torasik Fasya’nın Serbest Flepleri

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Yıllardır bir çok tipte fasyal flepler klinik pratikte uygulanmaktadır; bununla birlikte, transfer sonrasında oluşan temel fizyolojik, anatomik ve histopatolojik değişiklikler hususunda bir çok cevaplamanmış soru bulunmaktadır. Bu sorunun araştırılabilmesi için basit ve güvenilir flep modellerine gereksinim duyulmaktadır ancak günümüzde, deney hayvanlarında bu flep modellerinin çok azi tanımlanabilmiştir. Bu çalışmanın amacı köpeklerde yeni ve güvenilir flep modeli tanımlamaktır (dorsal torasik fasyal flep). Bu fasya, skapular ve paraskapular fasyokutanöz fleplerle kan desteği sağlayan anatomik tabaka olarak tanımlanabilir.