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Original Article

돼지 동물모델에서 얕은 혹은 깊은근막층으로 일으킨 피판의 안정성

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Safety of Elevation from Superficial Fascial Plane versus Traditional Deep Fascial Plane for Flap Elevation in a Porcine Model

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Purpose: In a random fasciocutaneous flap, deep fascia was thought to play an essential role. However, studies have reported that the superficial fascial plane could be elevated safely in fasciocutaneous flaps. We studied a porcine model to evaluate whether a random fasciocutaneous flap could be elevated by the superficial fascial plane in a hemodynamically safe manner.

Methods: A total of sixteen 3×9 cm proximal-based dorsal flank fasciocutaneous flaps were elevated by different planes: above the superficial fascial plane, below the superficial fascial plane and below the deep fascial plane. Distal flap necrosis and microangiography of each flap and histologic examination were evaluated.

Results: Distal flap necrosis was not significantly different among the various elevated planes. Microangiography showed that the suprafascial plexus of the superficial fascia was the most frequent dominant blood supply in a random fasciocutaneous flap. Biopsy also showed that the dominant vessels were located in the suprafascial layer of the superficial fascia.

Conclusion: The suprafascial plexus of the superficial fascia was the most frequently dominant blood supply in a random fasciocutaneous flap regardless of flap elevation plane. Therefore, the superficial fascia plane could be elevated safely in random fasciocutaneous flaps. In addition, even if without superficial fascia, fasciocutaneous flap can be elevated safely with inclusion of suprafascial plexus of the superficial fascia and this plane could be used as a flap debulking plane.

Key Words: Fasciocutaneous flap, Fascia, Microvasculature, Animal models

INTRODUCTION

In performing flap surgery, inclusion of the deep fascia was first introduced by Bakamjian et al.[1,2] in 1965 and 1967. He identified the importance of the arteries that run laterally in deep fascia and advised inclusion of the deep

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fascia within the flap. In 1981, Pontén[3] described the fasciocutaneous flap as a distinct entity. He discovered that fasciocutaneous flaps could be used with confidence to cover exposed bone and tendons as well as to close large skin defects. Subsequently, the inclusion of deep fascia in fasciocutaneous flaps has been practiced by many surgeons; to date, fasciocutaneous flaps have been used globally in reconstructive surgery[4].

Because of elevation of the flap at the deep fascia plane, fasciocutaneous flaps have many advantages. Dissection of the flap is very simple and no experience or deliberation is required. The fascia is readily freed from the underlying muscle. Since the underlying muscle is left intact, there is no question regarding functional impairment, an important consideration when myocutaneous or muscle flaps are used. Moreover, in the absence of muscle, the flaps are far less bulky, and transposition of a fasciocutaneous flap is considerably easier than transposition of a myocutaneous flap.

The vascular concept of the fasciocutaneous flap states that the fasciocutaneous system consists of vessels arising from along the fibrous septa between muscle bellies and muscle compartments. The vessels then spread out at the level of the deep fascia, both above and below, to form arterial plexuses that in turn send branches to the skin[5]. Therefore, deep fascia was believed to be the main source of a blood supply of the flap and it was essential to include the deep fascia.

However, the actual blood supply of random fasciocutaneous flaps is not yet fully understood. Moreover, when fasciocutaneous flaps remain thick, additional debulking procedures are essential to achieve aesthetic reconstructions. New rising perforator concept made the superficial fascia plane as a new approach of elevation plane. This new plane was considered hemodynamically reliable compared to the deep fascial plane. It was shown in clinical settings that this new plane was able to obtain a thin flap, achieving good functional and aesthetic outcomes[6] with reliable perfusion due to indirect linking vessels and choke vessels[7]. Many surgeons also do debulking procedures at this plane with confidence of hemodynamically safety[8].

Therefore, we designed an animal experiment for evaluate the safety of superficial fascial flaps and to determine the actual arterial organization of random fasciocutaneous flaps.

MATERIALS AND METHODS

1. Fasciocutaneous flap models

Experimental ethics board approval was obtained from the Keimyung University School of Medicine Institutional Animal Care and Use Committee (approval no. KM-2013-16). The experimental animals were two female Micropig® (Medikinetics, Pyeongtaek, Korea) weighing approximately 30 kg at 10 months old. The feeding of the pigs was restricted to 400 g of standardized gamma-irradiated feed and 3 L of water per day for growth control[9]. Under intravenous anesthesia using tiletamine-zolazepam (Zoletil®; Virbac, Carros, France) and xylazine hydrochloride (Rompun®; Bayer, Leverkusen, Germany), we elevated a total of sixteen 3×9 cm proximally based dorsal flank random fasciocutaneous flaps on the back of the pigs. To avoid perforator-rich zones such as the thoracodorsal artery perforators and the deep circumplex iliac artery perforators[10], the flap was only made between the inferior border of the scapula and the posterior superior iliac spine. Each flap was designed as long and slender for prediction of distal flap necrosis. To minimize interference among the flaps, we gave vertically 8 cm, horizontally 6 cm gaps between the flaps (Fig. 1). The flap elevation plane was laid out in three groups; above superficial fascial plane (AS), below superficial fascial plane (BS), and deep fascial plane (D).

In group AS, the flap was elevated just above the superficial fascial plane with inclusion of suprafascial plexus of the superficial fascia. Care was taken not to damage the suprafascial plexus of the superficial fascia. In group BS, the flap was elevated deep to the superficial fascial plane with inclusion of subfascial plexus of the superficial fascia. Care was taken not to damage the subfascial plexus of the superficial fascia. In group D, the flap was elevated deep to the deep fascial plane (Fig. 2).

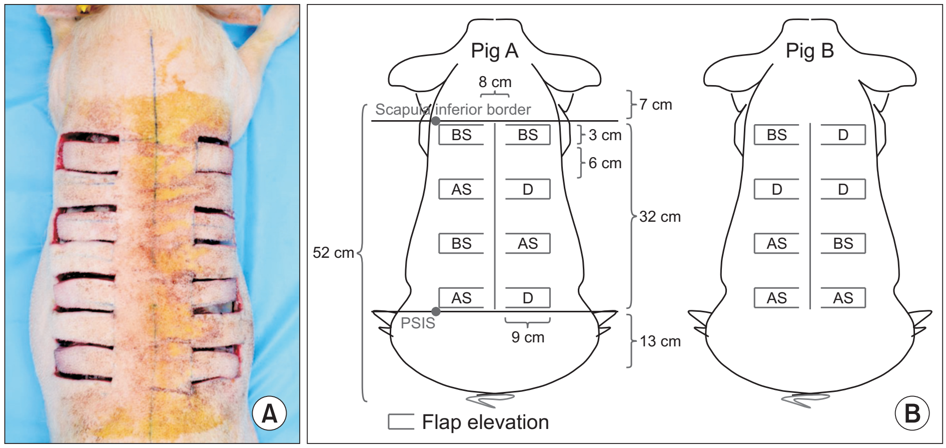

Fig. 1. (A) A total of eight 3×9 cm proximally based dorsal flank random fasciocutaneous flaps were made on the back of each Micropig® (Medikinetics, Korea). 1-cm full-thickness skin and soft tissue defects around the flap margins to prevent the vascular inosculation from adjacent normal skin. (B) Flap locations on the back of Micropigs® (Medikinetics, Korea). The flap elevation planes were selected by random pattern. BS: below superficial fascial plane, AS: above superficial fascial plane, D: deep fascial plane.

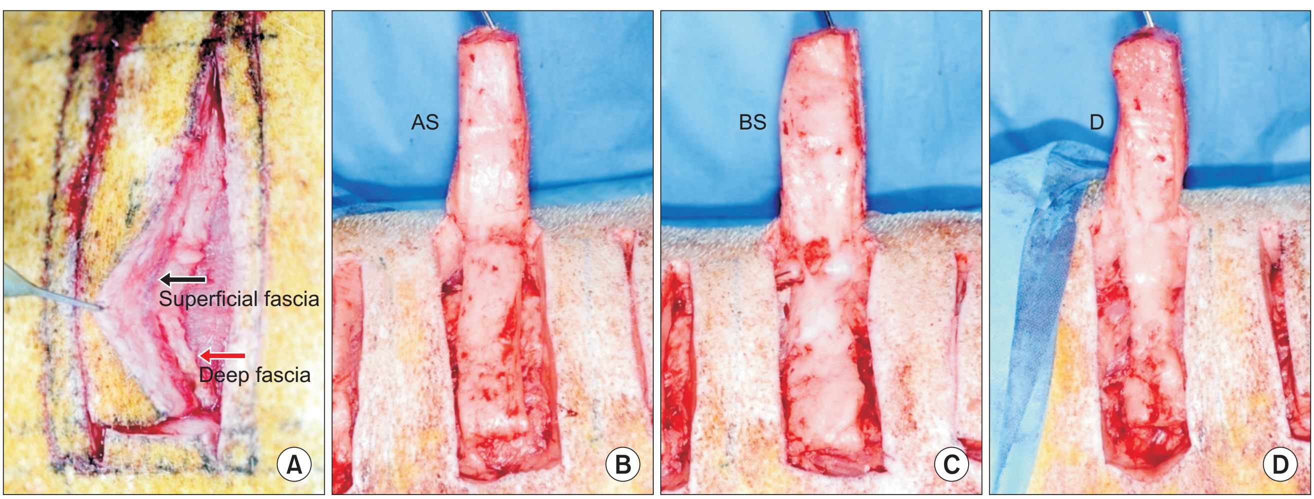

Fig. 2. (A) Skin and subcutaneous layers of Micropig® (Medikinetics, Korea). Superficial fascia (black arrow) was dominant and it divided the superficial and deep fat layers. Deep fascia (red arrow) lay just above the muscle. (B) The flap was elevated just above the superficial fascia. (C) The flap was elevated below the superficial fascia. (D) The flap was elevated below the deep fascia. AS: above superficial fascial plane, BS: below superficial fascial plane, D: deep fascial plane.

We created 6 AS, 5 BS, and 5 D groups by random selection. To evaluate the difference of flap survival according to flap elevation planes, all other blood supplies to the flap except the pedicle were blocked. First, we placed a medical silicone sheet, Silastic® (Dow Corning, Midland, MI, USA) between the flap and flap bed to prevent plasma imbibition from the flap bed (Fig. 3)[11]. Second, we made 1-cm full-thickness skin and soft tissue defects at the flap margins to prevent vascular inosculation from adjacent normal skin. The skin defect was filled with Allevyn® standard (Smith&Nephew, Hull, UK) and was covered with gauze to protect the flap and to prevent the flap from twisting or kinking. Secondary dressing was done by Fixomull® stretch (BSN Medical, Hamburg, Germany) and Tubifast® garment (Mölnlycke Health Care AB, Göteborg, Sweden). The dressing was changed every day.

Fig. 3. Placement of silicone sheet under the flap to prevent plasma imbibition and vascular inosculation from flap beds.

2. Distal flap ischemia and necrosis

Distal flap ischemia was defined as an area of darkish skin color change in the early postoperative period with a slow skin refill test, resulting in inadequate perfusion to tissue, though this was not permanent. Over time, the parts of changed skin color area restore their normal color. This was the breakpoint from flap necrosis that suggested permanent necrosis.

Flap necrosis was defined as permanently demarcated skin, meaning that the necrotic flap showed dark demarcated skin color, no refill and negative skin prick test[12].

Distal flap necrotic areas were measured daily with a Visitrak Digital® device (Smith&Nephew), according to the manufacturer's instructions. Briefly, a two-layered plastic sheet was placed on the top of each flap, and a marker pen was used to trace the demarcated distal flap necrosis edges accurately. The sterilized adhesive layers of the plastic sheet contacting the wound were then separated from the upper transparent layer, which was placed on the Visitrak Digital® device (Smith&Nephew). The outline of the flap necrotic areas was redrawn along the marked line using a special stylus to measure the wound surface. Then, the device showed the exact measurement of the flap necrosis area. The first author measured the necrotic areas three times, and the mean value was used.

We observed serial changes of flap necrosis, and the flap necrosis area on postoperative day 4 was used as the final flap necrosis. This was because we confirmed in a our unpublished preliminary study that flap contracture began at postoperative day 5.

3. Microangiography

To determine the dominant arterial plexuses of random fasciocutaneous flaps, we performed microangiography using lead oxide (Pb_3O_4) mixtures[13]. We divided the arterial plexus into 9 categories from the superficial to deep arterial plexus: 1. subdermal plexus; 2. subcutaneous plexus of the superficial fat; 3. suprafascial plexus of the superficial fascia; 4. superficial fascial plexus; 5. subfascial plexus of the superficial fascia; 6. subcutaneous plexus of deep fat; 7. suprafascial plexus of the deep fascia; 8. deep fascial plexus; and 9. subfascial plexus of the deep fascia (Fig. 4).

Pigs were euthanized at postoperative 2 weeks. Immediately following sacrifice, the heart was exposed by midsternal incision and a 14-Fr Nelatone catheter was inserted into the right atrium and left ventricle. 10 mL heparin mixed 3 L warm saline were irrigated into the pig's left ventricle. Simultaneously, the pig's blood was removed by applying continuous suction through the right atrium catheter until the perfusion of clear saline was observed, then lead oxide injection solution was injected into the left ventricle. The injection solution was prepared by adding 1 kg of lead oxide to 1 L of latex and 1 L of ammoniasolvent. To verify that the injection had reached the peripheral limb arterial circulation, a small incision was made in the distal hind-foot and confirm the pinkish lead oxide mixture had reached to peripheral arterial circulation. Pigs were stored at 4°C for 2 days to allow the latex mixture to stiffen.

For radiologic evaluation, the entire flap including the pedicle was excised en-bloc and vertically trisected. Two were studied for arterial organization by soft X-ray machines (CMB-2; Softex Co., Tokyo, Japan). The acquired X-ray film was compared with gross findings to determine the dominant arterial plexuses and the arterial

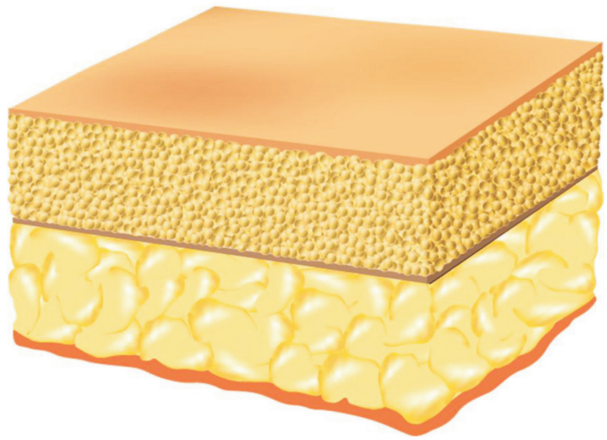

Fig. 4. Nine arterial plexus categories on skin and subcutaneous layers.

organization of the random fasciocutaneous flaps. The other was studied for histologic examination.

4. Histologic examination

Two weeks after surgery, pigs were euthanized. Biopsy was carried out in full-thickness fashion at the 3 sites from the pedicle: distal demarcated zone, middle transition zone, and proximal normal skin zone (Fig. 5). To determine the correlation between vascular organization and soft tissue layers, the specimens were examined and compared with the other groups.

The specimens were fixed with 10% neutral buffered formaldehyde, stained with hematoxylin and eosin and alpha-smooth muscle actin stain and were examined using an optical microscope with a magnifying lens power of 12.5-100.

5. Statistical analysis

Statistical analysis was performed using the Friedman test in SPSS ver. 15.0 (SPSS Inc., Chicago, IL, USA). A p-value <0.05 was considered statistically significant.

RESULTS

1. Distal flap ischemia and necrosis

On postoperative day 1, the distal flap ischemic area was the largest (Fig. 6). From postoperative day 2, the distal ischemic areas began to change to normal skin color starting from the proximal flap. The mean distal flap ischemic area was 1.63 cm^2 (0.8-4.1). In group AS, the mean distal flap ischemic areas were 1.75 cm^2 (1.1-2.9). In group BS, the mean distal flap ischemic area was 1.0 cm^2 (0.8-1.5). In group D, the mean distal flap ischemic area was 2.14 cm^2 (0.8-4.1). The total distal flap ischemic areas are shown in Table 1. Statistically significant differences were not observed between the flap elevation planes and distal flap ischemic areas ($p>0.05$).

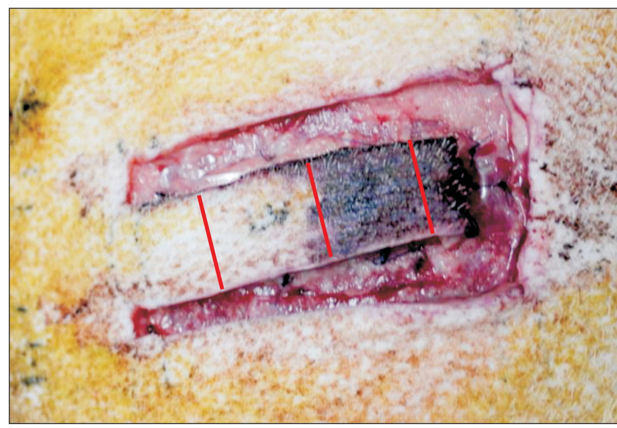

Fig. 5. Full-thickness biopsy was performed at the distal demarcated zone, middle transition zone, and proximal normal skin zone to determine the correlation between arterial organization and skin and soft tissue layers.

At postoperative day 4, the flap necrosis area was demarcated. The boundary between normal skin and necrotic tissue became clarified (Fig. 6). The mean distal

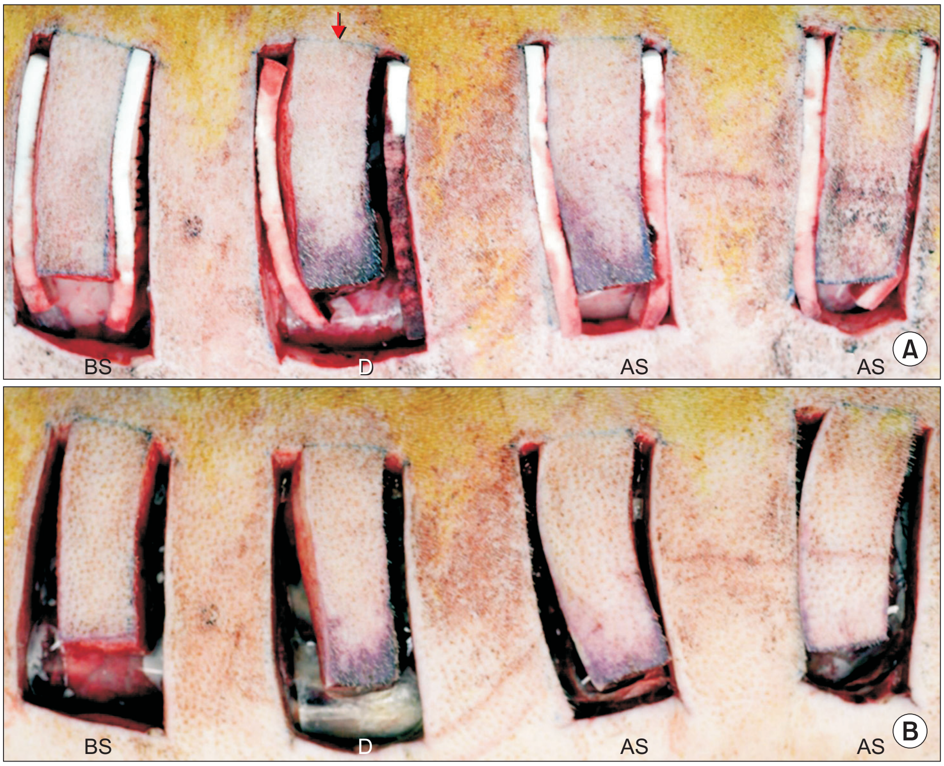

Fig. 6. (A) Distal flap ischemia on postoperative day 1. Left side back of Micropig® (Medikinetics, Korea). Group D showed the largest ischemic area. The ischemic areas were not correlated with flap elevation planes (arrow). (B) Distal flap necrosis on postoperative day 4. Parts of ischemic areas changed to normal skin color, and the necrotic area demarcation became more defined. BS: below superficial fascial plane, D: deep fascial plane, AS: above superficial fascial plane.

Table 1. Measurement of distal flap ischemic areas at postoperative day 1, according to flap elevation planes

Variable	L1*	L2	L3	L4†	R1*	R2	R3	R4†
Pig A								
Group	BS	AS	BS	AS	BS	D	AS	D
Distal ischemia (cm^2)	0.9	1.1	0.9	2.0	1.5	0.8	1.9	0.9
Pig B								
Group	BS	D	AS	AS	D	D	BS	AS
Distal ischemia (cm^2)	0.8	4.1	2.9	1.2	3.0	1.9	0.9	1.4

Values are presented as number only.
L: left side of back, R: right side of back, BS: below superficial fascial plane, AS: above superficial fascial plane, D: deep fascial plane.
*Most cephallic located flap. †Most caudally located flap.

Table 2. Measurement of distal flap necrosis areas at postoperative day 4, according to flap elevation planes

Variable	L1*	L2	L3	L4†	R1*	R2	R3	R4†
Pig A								
Group	BS	AS	BS	AS	BS	D	AS	D
Distal necrosis (cm^2)	0.5	0.9	0.7	1.4	1.2	0.4	1.6	0.5
Pig B								
Group	BS	D	AS	AS	D	D	BS	AS
Distal necrosis (cm^2)	0.5	3.2	2.7	0.7	2.8	1.6	0.5	1.0

Values are presented as number only.
L: left side of back, R: right side of back, BS: below superficial fascial plane, AS: above superficial fascial plane, D: deep fascial plane.
*Most cephallic located flap. †Most caudally located flap.

flap necrotic area was 1.2 cm^2 (0.5-3.2). In group AS, the mean distal flap necrosis area was 1.2 cm^2 (0.7-1.6). In group BS, mean area was 0.68 cm^2 (0.5-1.2). In group D, the mean area was 1.72 cm^2 (0.5-3.2). The total distal flap necrotic areas are shown in Table 2. Distal flap necrosis was the largest in group D, and the smallest was also in group D. Statistically significant differences were not observed between the flap elevation planes and distal flap necrosis areas ($p>0.05$). At postoperative day 5, flap contracture began with distal necrotic skin becoming autoamputated and changing to granulation tissue.

2. Microangiography

Regardless of flap elevation planes, the suprafascial plexus of the superficial fascia was the most frequently dominant arterial plexus in random fasciocutaneous flaps. In group AS, the suprafascial plexus of superficial fascia was the most dominant plexus at 83.3% (n=5/6) of flaps. In group BS, the suprafascial plexus of the superficial fascia and the subcutaneous plexus of the superficial fat were the most dominant plexuses at 40% (n=2/5) of all flaps. In group D, the suprafascial plexus of the superficial fascia was the most dominant plexus at 80% (n=4/5) of flaps, and the subcutaneous plexus of the deep fat comprised the other 20% that was not available in other groups. The other dominant arterial plexus of groups were shown in Table 3. Communicating arterial networks between arterial plexuses were well-developed in and around the suprafascial plexus of the superficial fascia (Fig. 7).

3. Histologic examination

On histological examination, the subcutaneous fat was divided into two layers by the superficial fascia as a

Table 3. Distribution of dominant arterial plexus according to flap elevation plane

Group	AS	BS	D
Subdermal plexus	1	1	
Subcutaneous plexus (superficial fat)		2	
Suprafascial plexus (superficial fascia)	5	2	4
Superficial fascia plexus			
Subfascial plexus (superficial fascia)			
Subcutaneous plexus (deep fat)	N/A*	N/A*	1
Suprafascial plexus (deep fascia)	N/A*	N/A*	
Deep fascia plexus	N/A*	N/A*	
Subfacial plexus (deep fascia)	N/A*	N/A*	
Total	6	5	5

Values are presented as number only.
AS: above superficial fascial plane, BS: below superficial fascial plane, D: deep fascial plane, N/A: not available.
*Arterial plexuses below deep fat was not available in group AS or BS.

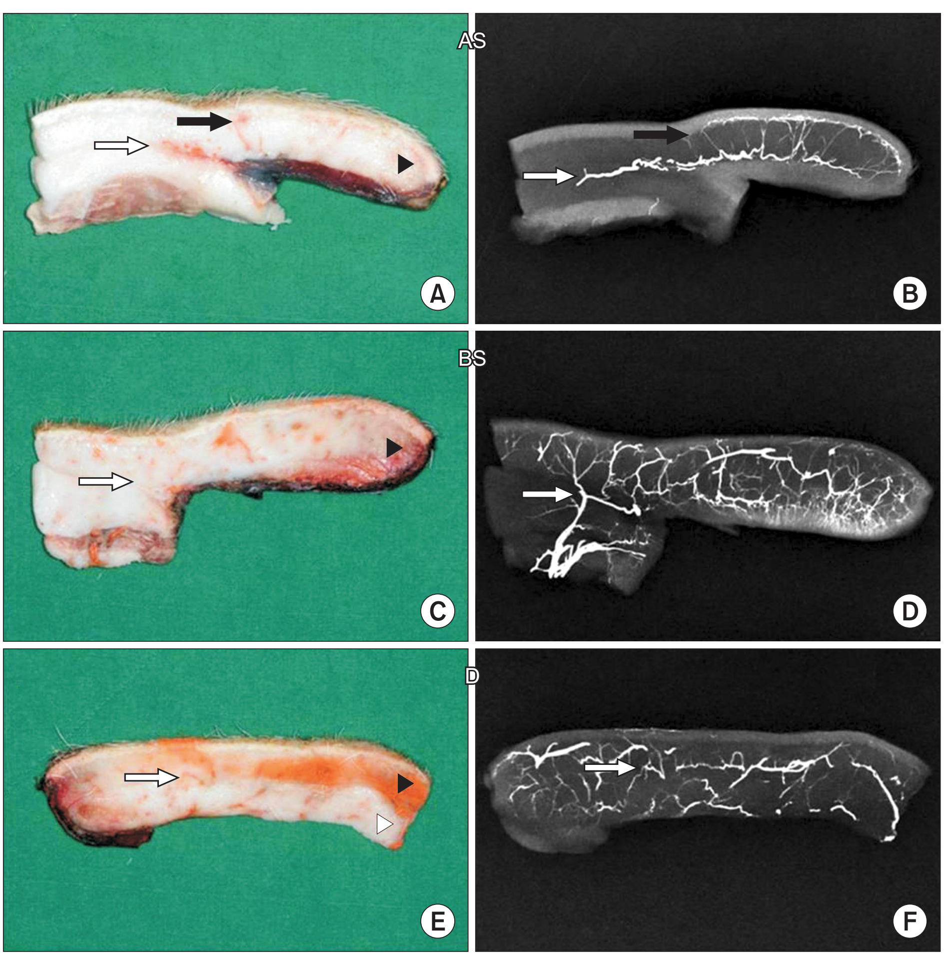

Fig. 7. Results of microangiography. The suprafascial plexus of the superficial fascia (white arrow) was the most frequently dominant arterial plexus in random fasciocutaneousflaps. (A, B) The suprafascial plexus of the superficial fascia was the most dominant arterial plexus and it communicated with subdermal plexus (black arrow). (C, D) The suprafascial plexus of the superficial fascia was the most dominant arterial plexus and it communicated with other arterial plexuses. (E, F) The suprafascial plexus of the superficial fascia was the most dominant arterial plexus. Black arrowhead indicates the superficial fat and white arrowhead indicates the deep fat. AS: above superficial fascial plane, BS: below superficial fascial plane, D: deep fascial plane.

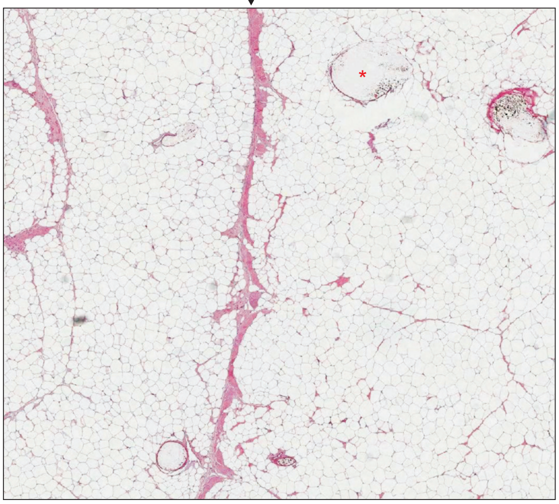

Fig. 8. Histologic findings. Large artery (asterisk) was noted above the superficial fascia layer (hematoxylin and eosin stain, ×25).

dense band of connective tissue. The deep fat layer contained larger fat lobules than the superficial fat layer.

The largest caliber vessels (1 artery and 2 veins) were located just above the superficial fascia, possibly correlating with the suprafascial plexus of the superficial fascia. (Fig. 8).

DISCUSSION

Deep fascia was known to be the main source of a blood supply of random fasciocutaneous flaps[5]. When performing fasciocutaneous flaps, inclusion of the deep fascia was essential and the arterial network of deep fascia gave fasciocutaneous flaps more reliable perfusion[14]. However, our experiment showed that distal flap necrosis showed no significant differences between flaps whether they included deep fascia or not. Even if, without superficial fascia, random fascioucutaneos flap could be elevated safely with inclusion of suprafascial plexus of superficial fascia.

Until now, not only is actual arterial organization in the subcutaneous layer not fully understood[6,7], but controversies remain[8]. Some anatomic reports have stressed the importance of maintaining the deep fascia, as large branches form an arterial plexus at the level of the deep fascia, communicating with the subdermal plexus supplying the skin[8]. Alkureishi and Satoh[7], through superficial anterolateral thigh (ALT) flaps in a cadaveric study, showed that dye perfusion did not reach the distal portions of the subdermal plexus compared with deep fascial ALT flaps. This study concluded that superficial fascial planes may lead to flap ischemia and skin necrosis[7]. However, this was a cadaveric study, ignoring the dynamic vascular territory in vivo. In our study, at postoperative day 1, the distal flap ischemic area was the largest, but from postoperative day 2 on, the distal ischemic areas began to restore normal perfusion. It is widely known that choke vessels have maximal dilation between 24 and 48 hours[15]. Threat to flap survival reinforced the choke vessels and communicating vessels. Therefore, after 24 hours, flaps had restored their perfusion to some degree as a delayed phenomenon.

Saint-Cyr et al.[15] showed that indirect linking vessels of the subdermal plexus maintained reasonable perfusion. The actual flap viability depended on the perfusion of the indirect linking vessels connecting to one other without direct linking vessels[15,16]. Similar to this result, our microangiography showed numerous well-developed communications between each arterial plexuses, maintaining fine perfusion. The large distal ischemic areas restored perfusion over time. This phenomenon may be attributed to the reinforcement of previously connecting arteries from the subdermal plexus to other arterial plexuses. In some studies, identifying the actual blood supply of the fasciocutaneous flap was attempted. Kimura and Satoh[8], proponents of the superficial fascial flap, classified the vascular patterns in adipose layer into three types: in type 1, the vessels extended perpendicularly into the subdermal plexus; in type 2, vessels branched off and extended sideways to the flap; and in type 3, vessels extended across the deep fascia and gradually into the adipose layer. This study concluded that, in the clinical setting, elevating free ALT flaps in the superficial fascia plane is safe in type 1 and 2 vascular patterns and are also possible in type 3 vascular patterns with cautious dissection. Type 1 and 2 vascular patterns comprised over 85% of all patterns[8]. This was similar to the results of our experiment. In group D, which included deep fascia (the same as Kimura and Satoh's[8] study condition), the suprafascial plexus of the superficial fascia was the most dominant arterial plexus in 80% of cases. Microangiography showed similar patterns to Kimura type 1&2 vessel types. There were also Kimura type 3 vascular patterns in our experiments. This may have caused damage to vessels when elevating superficial fascia planes. However, vascular communications between arterial plexuses were intact and the delay phenomenon reciprocally provided perfusion. The interruption of one arterial plexus system was thus not deleterious, because the other could quite easily sustain a good blood supply to its dependent territories. Therefore, the final flap necrotic areas showed no significant differences.

The safety of superficial fascial plane in random fasciocutaneous model naturally prove the safety of superficial fascial plane in perforator flap or free flap. Not only performing superficial fascia flaps in free flap reconstruction[8,13] but also performing superficial fascia flap debulking procedures[17,18] were already begun in clinical settings and our experiment gave theoretical support of these procedures.

We used Micropigs® (Medikinetics) in this experiment. The pig was a good candidate for wound, graft and flap experiment. This is because, first, the blood supply and dermal appendages are the most similar to those of humans, as opposed to other mammals[9,13]. The pigs also had fixed skin without panniculus carnosus, which can lead to true fasciocutaneous flap models[10,13]. Second, the Micropig® (Medikinetics) had white skin color, which allowed good discrimination between flap necrosis and normal skin. Third, we can limit the growth of experimental animals by controlling food intake amounts. Therefore, bias from flap size change due to the growth of the animal can be ignored.

We used dorsal flank flaps in this experiment. Previous studies of vascular flaps in pig used forelimb flaps, hind limb flaps and buttock flaps[19]. However, these flaps are only 2 flaps per pig can be elevated, and the flap length can be short for the ischemic flap model. Furthermore, Son et al.[13] reported that the pig's dorsal flank area had relatively general uniform blood supply in a microangiography study.

We showed that the suprafascial plexus of the superficial fascia was the most frequently dominant arterial plexus in random fasciocutaneous flap, and there were no flap survival differences between flap elevation planes. therefore, inclusion of suprafascial plexus of superficial fascia is more important than inclusion of superficial fascia itself and this plane could be used as a flap debulking plane with cautions not to damage the suprafascia plexus of superficial fascia. In addition, the superficial fasica plane flap is thought to be very safe procedure. Because this procedure means preserving intact superifical fasica itself.

However, to confirm the exact blood supply capacity of the suprafascial plexus of the superficial fascial plexus, a new group must to be compared, i.e., the subdermal plexus only group. This could be an experiment in our next study.

CONCLUSION

There were no flap survival differences between flaps above the superficial fascia plane, below the superficial fascia plane and in the deep fascia plane. On microangiography examination, the suprafascial plexus of superficial fascia was the most frequently dominant arterial plexus in random fasciocutaneous flaps, regardless of flap elevation plane. Moreover, numerous communicating vessels between arterial plexuses were observed that are thought to have capacity for reasonable perfusion.

Therefore, the superficial fascia plane could be elevated safely in random fasciocutaneous flaps. In addition, even if without superficial fascia, random fasciocutaneous flap can be elevated safely with inclusion of suprafascial plexus of the superficial fascia and this plane could be used as a flap debulking and perforator flap elevation plane. The previous concept regarding including the deep fascia when performing random fasciocutaneous flaps should be reappraised, and this study supported an experimental basis for superficial fascial flap surgery.

CONFLICTS OF INTEREST

The authors have nothing to disclose.

REFERENCES

1. Bakamjian VY. A two-stage method for pharyngoesophageal reconstruction with a primary pectoral skin flap. Plast Reconstr Surg. 1965;36:173-84.
2. Bakamjian VY, Culf NK, Bales HW. Versatility of the deltopectoral flap in reconstruction following head and neck cancer surgery. Paper presented at: Transactions of the Fourth International Congress of Plastic and Reconstructive Surgery: Rome, October 1967; 1967 Oct 8-13; Rome, Italy. Amsterdam: Excerpta Medica Foundation, 1969. 808-15.
3. Pontén B. The fasciocutaneous flap: its use in soft tissue defects of the lower leg. Br J Plast Surg. 1981;34:215-20.
4. Tolhurst DE, Haeseker B, Zeeman RJ. The development of the fasciocutaneous flap and its clinical applications. Plast Reconstr Surg. 1983;71:597-606.
5. Gurtner GC, Neligan PC. Plastic surgery. 3rd ed. London: Elsevier Health Sciences; 2012. 1386 p.
6. Hong JP, Choi DH, Suh H, et al. A new plane of elevation: the superficial fascial plane for perforator flap elevation. J Reconstr Microsurg. 2014;30:491-6.
7. Alkureishi LW, Shaw-Dunn J, Ross G. Effects of thinning the anterolateral thigh flap on the blood supply to the skin. Br J Plast Surg. 2003;56:401-8.
8. Kimura N, Satoh K. Consideration of a thin flap as an entity and clinical applications of the thin anterolateral thigh flap. Plast Reconstr Surg. 1996;97:985-92.
9. Kwak M, Son D, Kim J, Han K. Static Langer's line and wound contraction rates according to anatomical regions in a porcine model. Wound Repair Regen. 2014;22:678-82.
10. Mei J, Yin Z, Zhang J, et al. A mini pig model for visualization of perforator flap by using angiography and MIMICS. Surg Radiol Anat. 2010;32:477-84.
11. Zhang F, Fischer K, Komorowska-Timek E, et al. Improvement of skin paddle survival by application of vascular endothelial growth factor in a rat TRAM flap model. Ann Plast Surg. 2001;46:314-9.
12. Giunta RE, Holzbach T, Taskov C, et al. Prediction of flap necrosis with laser induced indocyanine green fluorescence in a rat model. Br J Plast Surg. 2005;58:695-701.
13. Son D, Jeong H, Choi T, Kim J, Han K. A new mechanism associated with compositae graft success. J Plast Reconstr Aesthet Surg. 2010;63:1900-9.
14. Dhar SC, Taylor GI. The delay phenomenon: the story unfolds. Plast Reconstr Surg. 1999;104:2079-91.
15. Saint-Cyr M, Wong C, Schaverien M, Mojallal A, Rohrich RJ. The perforasome theory: vascular anatomy and clinical implications. Plast Reconstr Surg. 2009;124:1529-44.
16. Saint-Cyr M, Schaverien M, Wong C, et al. The extended anterolateral thigh flap: anatomical basis and clinical experience. Plast Reconstr Surg. 2009;123:1245-55.
17. Tsai FC, Yang JY, Mardini S, Chuang SS, Wei FC. Free split-cutaneous perforator flaps procured using a three-dimensional harvest technique for the reconstruction of postburn contracture defects. Plast Reconstr Surg. 2004;113:185-93; discussion 194-5.
18. Yang WG, Chiang YC, Wei FC, Feng GM, Chen KT. Thin anterolateral thigh perforator flap using a modified perforator microdissection technique and its clinical application for foot resurfacing. Plast Reconstr Surg. 2006;117:1004-8.
19. Thomson JG, Kerrigan CL. Fasciocutaneous flaps: an experimental model in the pig. Plast Reconstr Surg. 1989;83:110-7.

돼지 동물모델에서 얕은 혹은 깊은근막층으로 일으킨 피판의 안정성

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목적: 근막피부피판을 일으킬 때 깊은근막층을 반드시 포함시켜야 안전하다고 한다. 이 연구의 목적은 돼지 피판모델을 이용하여 얕은근막층으로 피판을 일으켰을 때 피판의 혈류역학적 안전성을 알아보는 것이다.

방법: 돼지의 등에 3×9 cm 크기의 근막피부피판을 총 16개 만들었다. 피판은 무작위로 배치하고 거상층은 얕은근막층 위면 및 아래면과 깊은근막층 아래면으로 하였다. 원위부 피판괴사, 미세혈관조영술, 조직학적 검사로 평가하였다.

결과: 피판거상층과 원위부 피판괴사 면적 간의 통계학적 유의성은 없었다. 미세혈관조영술에서 얕은근막의 근막위동맥얼기가 피판거상층에 관계없이 가장 우세한 혈류공급을 보였으며 조직학적 검사에서도 얕은근막층 바로 위로 굵은 혈관들이 위치하였다.

결론: 깊은근막층을 포함할 필요 없이 얕은근막층에서 피판을 일으켜도 혈류역학적으로 안전하게 근막피부피판을 만들 수 있으며, 얕은근막층의 표층동맥얼기를 포함시킨다면 얕은근막층 위 면으로도 안전하게 근막피부피판을 만들 수 있다.

색인단어: 천공지 근막피부피판, 얕은근막층 피판술, 혈류공급, 돼지모델

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