

## *Anatomic bases of medical, radiological and surgical techniques*

### **Anatomic basis for use of a gracilis muscle flap**

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**Summary.** The aim of this study was to specify certain anatomic features of the gracilis m. with a view to the use of muscular or myocutaneous flaps. It was based on dissection of 84 gracilis muscles in 42 subjects as well as selective injection of the main pedicle of 20 muscles. This established the following points : 1) The arterial supply is abundant, consisting of several pedicles reaching the muscle on its deep aspect. The main neurovascular pedicle arises from the deep vessels of the thigh, via either the a. of the adductors (73%), the medial circumflex a. (19.2%) or as a double supply from both arteries (7.7%); 2) The cutaneous vascularisation over the gracilis m., derived from the solitary main pedicle, is inconsistent. In 20 injections, it was satisfactory in 11 cases, poor in 5 and absent in 4; 3) The distal tendon of the gracilis m. is closely related to the posterior branch of the saphenous n. to the leg, which it crosses in an elongated X; 4) A simple method of calculation based on the distance between the upper border of the pubis and the

medial femoral epicondyle allows quite precise determination of the point of entry of the main pedicle into the gracilis m. 5) Complete dissection of the main pedicle adds to the available length of the muscle flap.

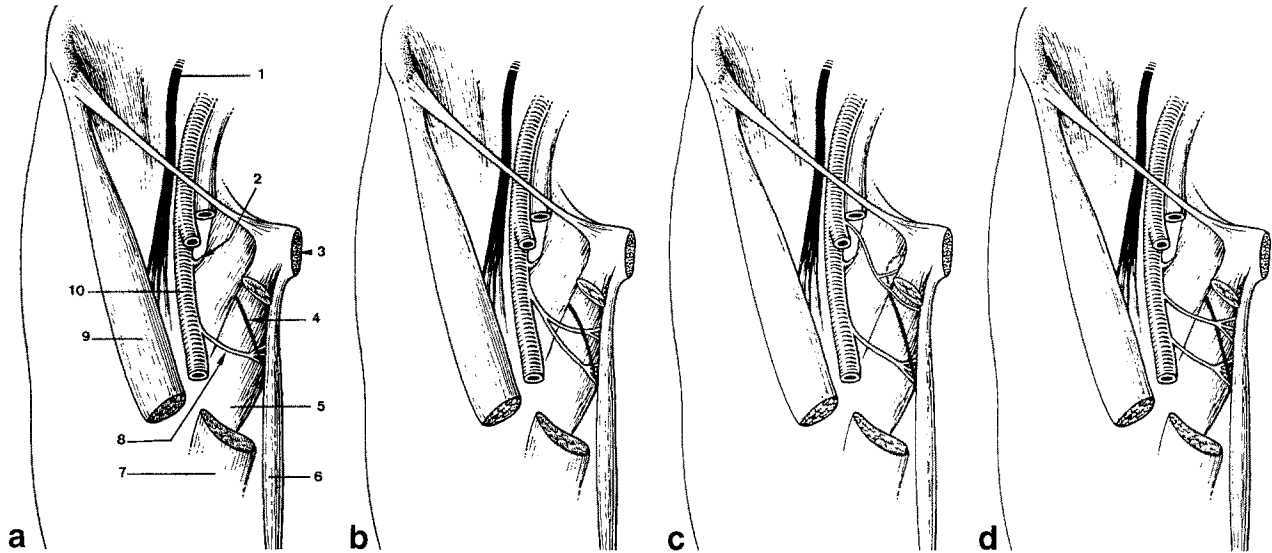
#### **Bases anatomiques de l'utilisation d'un lambeau du muscle gracile**

**Résumé.** Cette étude a pour objet de préciser certains aspects anatomiques du muscle gracile en vue de l'utilisation de lambeaux musculaires ou musculo-cutanés. Elle repose sur la dissection de 84 muscles graciles chez 42 sujets ainsi que l'injection sélective du pédicule principal de 20 muscles graciles. Elle a permis de préciser les points suivants : 1) L'irrigation artérielle est riche, faite de plusieurs pédicules abordant le muscle par sa face profonde. Le pédicule principal vasculo-nerveux est issu des vaisseaux profonds de la cuisse soit par l'artère des adducteurs (73 %), soit par l'artère circonflexe médiale (19,2 %), soit par un double apport de ces deux artères (7,7 %); 2) La vascularisation cutanée en regard du muscle gracile à partir du seul pédi-

cule principal est inconstante. Sur 20 injections elle est satisfaisante 11 fois, pauvre 5 fois et absente 4 fois; 3) Le tendon distal du muscle gracile est étroitement en rapport avec la branche postérieure jambière du nerf saphène qu'il croise en X allongé; 4) Une méthode de calcul simple à partir de la distance entre le bord supérieur du pubis et l'épicondyle médial permet de déterminer avec une bonne précision le point de pénétration du pédicule principal dans le muscle gracile; 5) La dissection complète du pédicule principal améliore la longueur disponible du lambeau musculaire.

**Key words :** Gracilis muscle — Myocutaneous flap — Anatomy

Muscular or myocutaneous flaps of the gracilis m. are widely used in reconstructive surgery, with varied applications including facial reanimation after paralysis [10, 11], covering of scars of the pelvic region [2, 3, 17, 19, 36-38], vaginoplasty [1, 14, 27] and reconstruction of the penis [28]. Its anatomic position on the medial



**Fig. 1a-d**

Diagram of type I main pedicle. 1 femoral n. 2 medial circumflex a. 3 pubic symphysis 4 n. to gracilis m. 5 adductor brevis m. 6 gracilis m. 7 adductor longus m. 8 a. of the adductors 9 sartorius m. 10 profunda femoris a.

Schématisation du type I du pédicule principal du m. gracile. 1 n. fémoral 2 a. circonflexe médiale 3 symphyse pubienne 4 n. du m. gracile 5 m. court adducteur 6 m. gracile 7 m. long adducteur 8 a. des adducteurs 9 m. sartorius 10 a. profonde de la cuisse

aspect of the thigh makes it particularly suitable for reconstructive surgery of the perineum. Its use for the construction of puborectal slings in fecal incontinence led us to carry out a previous study by anatomic dissection [15]. We report here on certain practical aspects. Since partial or total necrosis of the cutaneous portion of the myocutaneous flap has been reported in the literature, this study was complemented by an investigation of the cutaneous vascularisation derived from the dominant pedicle of the gracilis m. by means of selective injection of the artery in fresh cadavers.

## Material and methods

84 dissections were performed on 42 subjects, of which 24 were injected with a formalised solution and 18 were fresh. In addition, 20 selective injections of the main a. of the gracilis m. using a solution with a Baryx base were made in 12 subjects. The

gracilis m. was then removed with the overlying skin territory for radiography with and without the muscle. This allowed a study of the presence and position of perforating or fasciocutaneous arteries as well as the extent of the territory they supplied.

## Results

### Muscle supply

Several arteries reach the lateral or deep aspect of the gracilis m. and supply it. There are regularly found one or two proximal arteries of greater caliber than the other vessels, which may be called the dominant or main pedicle. Also constant is a distal artery reaching the muscle at the junction of its belly and tendon. The origin and configuration of the main arterial pedicle was studied in 52 dissections. It usually derives from the deep femoral a., by way of either the a. of the adductors or the medial circumflex a., or as a double supply

derived from both arteries. The different patterns of the main pedicle can be classified into 3 types (Figs. 1-3):

Type I (Fig. 1a-d): a main pedicle arising from the a. of the adductors (38 cases = 73%),

Type Ia: a solitary artery (27 cases),

Type Ib: two arteries derived from a precocious bifurcation of the a. of the adductors, itself arising near the femoral bifurcation (2 cases),

Type Ic: a main artery given off by the a. of the adductors and a branchlet usually arising from the common femoral a. or, rarely, from the obturator a. (8 cases),

Type Id: two arteries arising from the deep femoral a. (1 case),

Type II (Fig. 2a, b): the main pedicle arises from the medial circumflex a. (10 cases = 19.2%),

Type IIa: a solitary artery (7 cases),

Type IIb: two arteries arising from a precocious bifurcation (3 cases),

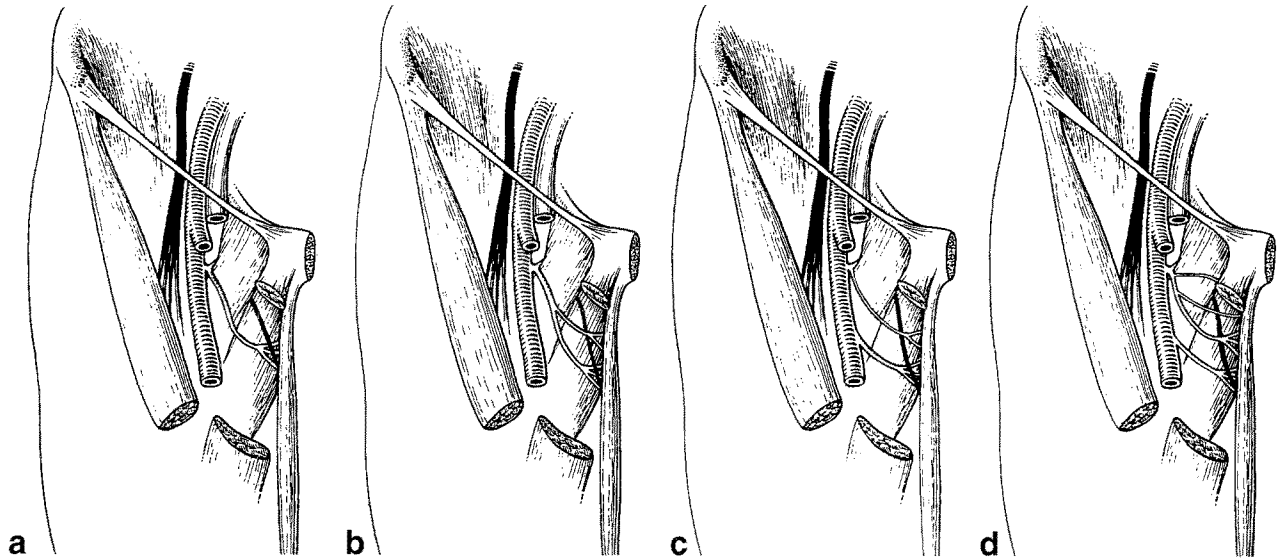


Fig. 2a, b, 3a, b

2a, b Diagram of type II of main pedicle of gracilis m. 3a, b Diagram of type III of main pedicle of gracilis m.

2a, b Schématisation du type II du pédicule principal du m. gracile. 3a, b Schématisation dy type III du pédicule principal du m. gracile

**Table 1.** To show the cutaneous vascularisation over the gracilis m., after injection of the main pedicle. The type of artery (*P* perforating, *F* fasciocutaneous) as well as its size (*P* and *F* large caliber, *p* and *f* small) are related to an arbitrary division of the belly of the muscle into thirds

Représentation graphique de la vascularisation cutanée en regard du m. gracile après injection du pédicule principal. Le type des artères (*P* perforante ou *F* fascio-cutanée) ainsi que leurs importances (*P* et *F* gros calibre ou *p* et *f* petit calibre) sont représentés selon un découpage arbitraire du corps charnu du m. gracile en trois tiers

Nu. N°	1/3 upper		1/3 middle	1/3 lower
	1/3 sup.		1/3 moyen	1/3 inf.
1		<i>p</i>		
2		<b>P</b>		
3				
4				
5		<i>f</i>		
6	<b>P</b>	<b>F</b>	<b>P</b>	
7				
8	<i>p</i>	<i>p</i>	<i>p</i>	
9			<i>p</i>	
10		<b>P</b>	<i>f</i>	
11		<b>P</b>	<b>F</b>	<b>F</b>
12				
13	<b>P</b>	<i>f</i>		
14	<b>P</b>	<i>p</i>	<i>p</i>	
15		<b>P</b>		
16		<b>P</b>		<b>P</b>
17	<b>P</b>	<i>p</i>		
18		<b>P</b>		
19	<i>p</i>	<i>p</i>		
20	<b>P</b>	<b>P</b>		

Type III (Fig. 3a, b): the main pedicle is composed of two arteries, one arising from the artery of the adductors and one from the medial circumflex a. (4 cases = 7.7%),

Type IIIa: the artery of the adductors is dominant (3 cases),

Type IIIb: both arteries are of equal size (1 case).

The main pedicle runs between the adductor brevis and adductor longus mm., giving off short collaterals to these muscles. On reaching the deep aspect of the gracilis m., it usually divides into 3 branches which are distributed in ladder pattern along the axis of the muscle belly and anastomose with branches of the middle pedicle.

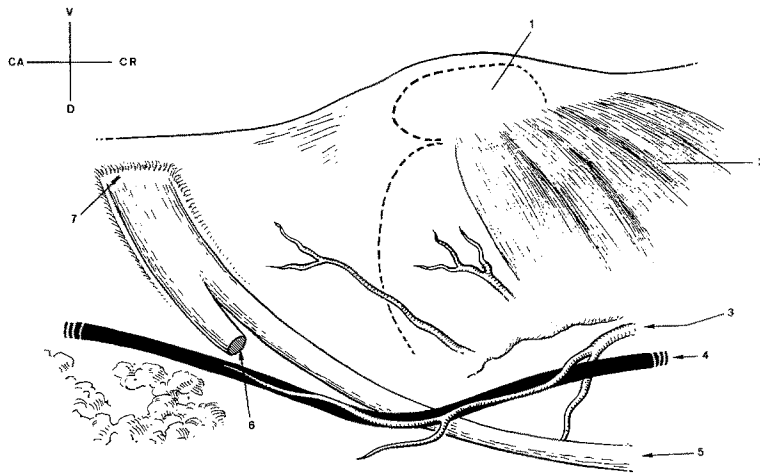
*Cutaneous supply*

This has three origins: by way of the perforating arteries, the fasciocutaneous arteries, or by contiguity through the subcutaneous and dermal plexuses. The skin supply over the gracilis m. based on the dominant pedicle is ensured by perforating arteries and, more rarely, by collateral fasciocutaneous arteries of the main

pedicle (Figs. 5-7). In the 20 injections performed, cutaneous vascularisation over the muscle was completely absent in 4 cases, present but poor in 5, and satisfactory in 11 (Table 1).

*Relations with the saphenous n.*

The saphenous n., the terminal branch of the femoral n., descends on the medial aspect of the thigh in the adductor canal, accompanying the femoral a. It leaves the canal in front of the tendon of the adductor magnus m. and perforates the aponeurosis stretching between the vastus medialis and adductor magnus mm., accompanied by the superficial branch of the descending genicular a., to lie on the deep aspect of the sartorius m. Then it divides into two terminal branches, to the patellar region and the leg. The infrapatellar branch of the saphenous n. usually perforates the fleshy belly of the sartorius m. at the level of the medial femoral condyle and reaches the superficial planes of the medial aspect of the knee. The branch to the leg passes between the deep aspect of the sartorius m. and the superficial aspect of



**Fig. 4**

Relations between tendon of gracilis m. and saphenous n. branch to leg at medial aspect of knee. 1 patella 2 m. vaste médial 3 br. superficielle de l'a. descendante du genou 4 n. saphène 5 gracilis tendon 6 semitendinosus tendon 7 zone of insertion of sartorius tendon

Rapports entre le tendon du m. gracile et la branche jambière du n. saphène à la face médiale du genou. 1 patella 2 m. vaste médial 3 br. superficielle de l'a. descendante du genou 4 n. saphène 5 tendon du m. gracile 6 tendon du m. semi-tendineux 7 zone d'insertion du tendon du m. sartorius

the tendon of the gracilis m., which it crosses in an elongated X just behind the medial femoral epicondyle. It becomes superficial at the level of the upper border of the tibial condyle, where it joins the great saphenous v. (Fig. 4).

*Correlation between the distance separating the upper border of the pubis and the medial femoral epicondyle and the distance between the upper border of the pubis and the point of entry of the main pedicle into the gracilis m.*

In 57 dissections, the distance between the upper border of the pubis and the medial femoral epicondyle was measured. The mean value was  $44.3 \text{ cm} \pm 0.82 \text{ cm}$  ( $\pm$  twice the standard deviation from the mean). Similarly, the distance between the upper border of the pubis and the point of entry of the main pedicle into the muscle was measured; it was  $16.3$

$\text{cm} \pm 0.32 \text{ cm}$ . The ratio between these two distances is  $0.37 \pm 0.0008$ . The correlation assessed by the test of independence is good, with a coefficient  $r = 0.45$  and with  $p < 0.0007$ .

#### *Mobilisation of the main pedicle*

After freeing of the muscle and section of the accessory pedicles, extensive dissection of the main pedicle between the adductor longus and brevis mm. without dividing the branches to these muscles allows a greater arc of rotation for employment of the flap. The average gain obtained in 48 dissections was 6 cm (range 3 to 10 cm).

### **Discussion**

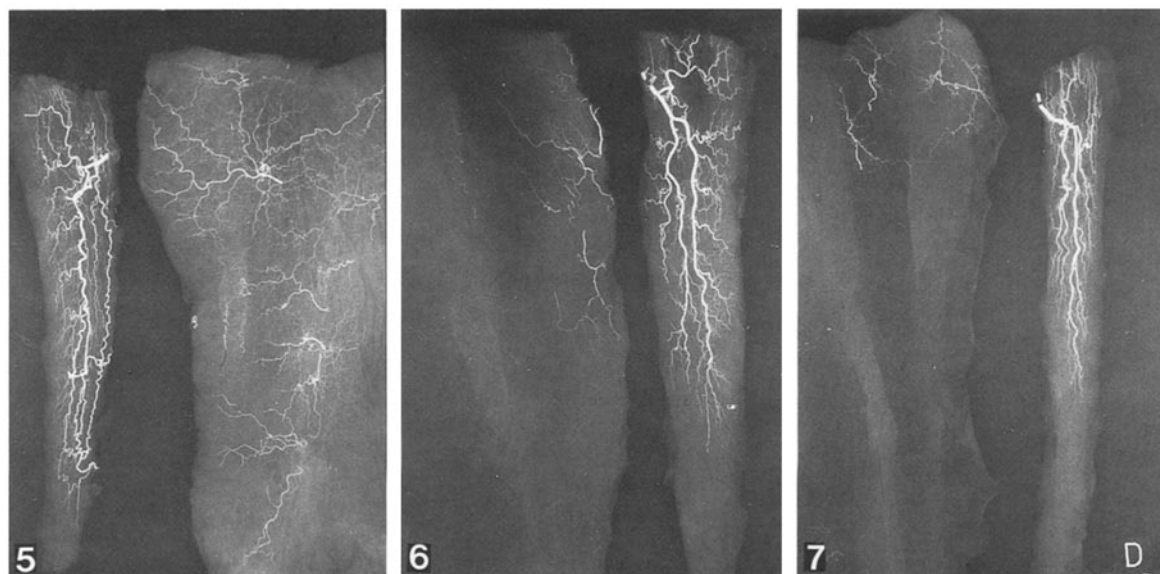
#### *Arterial supply*

Authors generally agree in describing a main pedicle at the upper part of the muscle. This has been

particularly well studied by Mathes [22-24], who propounds a classification for the vascularisation of muscles. The gracilis m. is an example of his type II, which includes a main pedicle and several accessory pedicles. For most authors [8, 23, 25, 28, 33], the main pedicle derives from the deep femoral a. via the medial circumflex a., but we found this arrangement in only 19% of cases. Most often, the main pedicle arose from the a. to the adductors [11, 19, 31]. McCraw [26, 27] describes two arteries and four veins in the composition of the main pedicle, and we found this pattern in 10 cases. Besides the main pedicle, the presence of several accessory pedicles is usually reported. The existence of a proximal accessory pedicle is described as constant by Rouffet [31] and Paturet [29], notably by way of the medial circumflex a. This may correspond to our type IIIa, but was found by us in only 3 cases. Further, we found the supply by a branch of the obturator a., described elsewhere [9, 24, 30, 32, 34], in only 3 out of 8 cases, whereas in the other 5 cases there was a branchlet originating from the common femoral a. The distal artery to the junction of the fleshy belly and the tendon has been reported only by Rouffet [31].

#### *Cutaneous vascularisation*

While purely muscular flaps of the gracilis m. present no problem as regards vascularisation, the arterial supply of the cutaneous portion of myocutaneous flaps is more hazardous. Among 192 myocutaneous gracilis m. flaps collected from the literature [1, 2, 5-8, 12-14, 16, 17, 19-21, 24, 29, 30, 35-38] 13 total cutaneous necroses (6.8%) were reported as well as 25 partial necroses (13%), mainly distal. Furthermore, 10% of wound dehis-



**Figs. 5-7**

Radiographs of the gracilis myocutaneous flap after selective injection of the main pedicle. The muscle has been removed and placed beside the skin flap, the "shadow" of the muscle being clearly visible. Fig. 5 corresponds to No. 11 in Table 1, Fig. 6 to No. 12 and Fig. 7 to No. 20.

Radiographies du lambeau musculo-cutané du m. gracile après injection sélective du pédicule principal. Le muscle a été prélevé et posé à côté du lambeau cutané où l'"ombre" du muscle est parfaitement visible. La fig. 5 correspond au No. 11 de la table 1, la fig. 6 au No. 12 et la fig. 7 au No. 20

cences were reported, in the genesis of which insufficient vascularisation cannot be excluded. The existence of perforating vessels, situated mainly at the upper part of the muscle, has been reported by Mathes [22, 23] and McCraw [26], and most authors agree on the poverty of distal cutaneous viability [2, 3, 7]. The anatomic studies of Cormack [4], who constructed a map of the cutaneous vascularisation of the thigh, and of Giordano [8] confirm these findings. However, no author has recorded the possible absence of cutaneous vascularisation derived from the main pedicle of the gracilis m., whereas this situation was found in 3 of our 20 injections.

#### *Relations with the saphenous n.*

Few authors specify the relations of the saphenous n. with the gracilis tendon and the sartorius m. at the

medial aspect of the knee. Lazorthes [18] and Rouvière [32] describe the two terminal branches of the nerve and especially its infrapatellar branch, which perforates the sartorius m, but do not define the passage of the branch to the leg between the sartorius and gracilis mm. This is of practical importance, since any approach to the gracilis m. at the medial aspect of the knee incurs a risk to the saphenous n. with the possibility of sensory disorders. The inferior incision at the medial aspect of the thigh to reach the gracilis m. must be placed above the crossing of the sartorius and gracilis mm., ie at about two fingerbreadths above the medial femoral epicondyle.

#### *Location of the main pedicle*

The position of the main pedicle in relation to the proximal attachment

of the muscle is fairly constant, between 8 and 10 cm away [8, 15, 19, 22]. However, the proximal attachment of the muscle is not palpable; hence the value of measuring the distance between the upper border of the pubis and the medial femoral epicondyle, and multiplying this by a factor of 0.37 to localise the main pedicle in relation to the upper border of the pubis. This gives the level of the superior incision required to mobilise the muscle on its main pedicle.

#### *Mobilisation of the main pedicle*

Dissection of the main pedicle provides a significant increase in its arc of rotation, especially towards the perineum, and of the length available. Some authors even recommend ligation and section of the collateral branches to the adductor longus and brevis mm. [7].

## Conclusion

This study of the gracilis m. by dissection and injection allows us to specify the following points:

1) The main pedicle originates from the deep vessels of the thigh, via either the a. of the adductors (73%), the medial circumflex a. (19.2%) or by a double supply from both these arteries (7.7%).

2) The cutaneous vascularisation over the gracilis m. derived from the main pedicle is inconstant, and is poor or absent in half the cases.

3) The relation between the tendon of the gracilis m. and the saphenous n. at the medial aspect of the knee calls for careful dissection during raising of the flap.

4) A study of the measurements determines a coefficient of 0.37, which, applied to the distance between the upper border of the pubis and the medial femoral epicondyle, gives the point of entry of the main pedicle into the muscle with reasonable accuracy.

5) This study also shows that extended dissection of the main pedicle allows greater mobilisation of the muscle.

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## References

- Abes M, Bourgeon Y, Graglia JC (1991) Reconstruction vaginale et périnéale après excision pour cancer. *Ann Chir Plast Esthet* 36 : 54-60
- Bostwick J, Hill HL, Nahai F (1979) Repairs in the lower abdomen, groin, or perineum with myocutaneous or omental flap. *Plast Reconstr Surg* 63 : 186-194
- Cariou JL, Bouet JL, Schoofs M, Baudet J, Panconi B (1983) Notre expérience de la couverture des escarres ischiatiques par lambeaux musculo-cutanés. *Ann Chir Plast Esthet* 28 : 337-47
- Cormack GC, Lamberty BGH (1985) The blood supply of thigh skin. *Plast Reconstr Surg* 75 : 342-54
- Dargent D, Pegaz-Fiomet M (1987) L'utilisation du muscle droit interne dans la réparation des grands délabrements pelviens et périméaux chez la femme. *Lyon Chir* 83 : 53-6
- De Ranieri J, Crouet H, Andre M, Ollivier JM, Desdoits JM, Bouvet A, Souloy J (1985) Les lambeaux de droit interne dans la couverture des pertes de substance périnéale en chirurgie carcinologique. *Presse Med* 38 : 1967-9
- Gholam D, Trevidic P, Kleimann P, Hautefeuille P, Nicoletis C (1991) Le lambeau musculo-cutané de droit interne; bilan de 20 cas. *Ann Chir Plast Esthet* 36 : 424-9
- Giordano PA, Abbes M, Pequignot JP (1990) Gracilis blood supply: anatomical and clinical re-evaluation. *Br J Plast Surg* 43 : 266-72
- Gregoire R, Oberlin G (1977) Précis d'anatomie, 9e edn. JB Baillères, Paris
- Harii K, Ohmori K, Sekiguchi J (1976) The free musculocutaneous flap. *Plast Reconstr Surg* 57 : 294-303
- Harii K, Ohmori K, Torii S (1976) Free gracilis muscle transplantation, with microvascular anastomoses for the treatment of facial paralysis. *Plast Reconstr Surg* 57 : 133-43
- Heath PM, Woods JE, Pobratz KC, Arnold MD, Irons GB (1984) Gracilis myocutaneous vaginal reconstruction. *Mayo Clin Proc* 59 : 21-4
- Heckler FR, Aldridge JE, Songcharoen S, Jabeley ME (1980) Muscle flaps and musculocutaneous flaps in the repair of urinary fistulas. *Plast Reconstr Surg* 66 : 94-101
- Selin C, Graber P, Gumener R (1991) Lésion urétrale associée à un délabrement périnéal: reconstruction combinée immédiate par le lambeau musculo-cutané du gracilis. *J Urol Paris* 97 : 199-202
- Juricic M, Vaysse Ph, Visentin M, Guitard J, Moscovici J, Becue J, Juskiewenski S (1992) Muscle gracile chez l'homme. *Bull Assoc Anat* 76 : 35-42
- Kalisman M, Sharzer LA (1981) Anal sphincter reconstruction and perineal resurfacing with a gracilis myocutaneous flap. *Dis Col Rectum* 24 : 529-31
- Kauer Ch, Andourah A (1991) Complications périnéales et lambeau musculo-cutané de droit interne chez le paraplégique: a propos de dix neuf cas. *Ann Chir Plast Esthet* 36 : 347-52
- Lazorthes G (1971) Le système nerveux périphérique, 2e edn. Masson, Paris
- Lesavoy MA, Dubrow TJ, Korn HN, Cedars MG, Castro DJ (1990) "Sensible" flap coverage of pressure sores in patients with myelomeningocele. *Plast Reconstr Surg* 85 : 390-4
- Mathes SJ, Alpert BS, Chang N (1982) Use of the muscle flap in chronic osteomyelitis: experimental and clinical correlation. *Plast Reconstr Surg* 69 : 815-28
- Mathes SJ, Feng LJ, Hunt TK (1983) Coverage of the infected wound. *Ann Surg* 198 : 420-9
- Mathes SJ, Nahai F (1981) Classification of the vascular anatomy of muscles: experimental and clinical correlation. *Plast Reconstr Surg* 67 : 177-87
- Mathes SJ, Nahai F (1982) Clinical applications for muscle and musculocutaneous flaps. Mosby, St Louis
- Mathes SJ, Nahai F, Vasconez LO (1978) Myocutaneous freeflaps transfer; anatomical and experimental considerations. *Plast Reconstr Surg* 62 : 162-6
- Michel-Bechet R (1967) La sphincteroplastie anale au moyen des droits interne. *Presse Med* 75 : 977
- McCraw JB, Dibell DG (1977) Experimental definition of independent myocutaneous vascular territories. *Plast Reconstr Surg* 60 : 212-20
- McCraw JB, Massey FM, Shanklin KD, Horton CE (1976) Vaginal reconstruction with gracilis myocutaneous flaps. *Plast Reconstr Surg* 58 : 176-183
- Orticochea M (1972) The musculocutaneous flap method: an immediate and heroic substitute for the method of delay. *Br J Plast Surg* 25 : 106-10
- Paturet B (1951) *Traité d'anatomie humaine*. Masson, Paris
- Pers M, Medgeysi S (1973) Pedicle muscle flaps and their application in the surgery of repair. *Br J Plast Surg* 26 : 313-21
- Rouffet F, Honnart F, Calmat A (1977) La vascularisation des muscles de la patte d'oie et ses applications chirurgicales. *J Chir* 114 : 193-200
- Rouviere H (1970) *Anatomie humaine descriptive et topographique*, tome II, 10e edn. Masson, Paris
- Salmon M, Dor J (1933) *Les artères des muscles des membres et du tronc*. Masson, Paris
- Testut L (1900) *Anatomie humaine*. Doin, Paris
- Wheless CR, McGibbon B, Dorsey JH, Maxwell P (1979) Gracilis myocutaneous flap in reconstruction of the vulva and female perineum. *Obstet Gynecol* 54 : 97-102
- Wingate GB, Friedland JA (1978) Repair of ischial pressure ulcers with gracilis myocutaneous island flaps. *Plast Reconstr Surg* 62 : 245-8
- Woods JE, Beart RW (1983) Reconstruction of nonhealing perineal wounds with gracilis muscle flaps. *Ann Plast Surg* 11 : 513-6
- Woods JE, Irons GB, Masson JK (1977) Use of muscular, musculocutaneous and omental flaps to reconstruct difficult defects. *Plast Reconstr Surg* 59 : 191-9

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