学　位　論　文

Rotation Arc of Pedicled Antero-Lateral Thigh Flap for Abdominal Wall Reconstruction: How Far Can It Reach?

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Abstract

Purpose: To elucidate the extent to which pedicled antero-lateral thigh (ALT) flaps can reach in reconstruction of abdominal wall defects.

Methods: 60 pedicled ALT flaps were raised from cadavers and were experimentally transferred to the abdominal region. The distance between the umbilicus and the most cranial point of the flap after transfer was defined as **CRD** (Cranially Reachable Distance). Three issues were evaluated: 1. the difference in the CRD when the flap pedicle was positioned superficial or deep to the rectus femoris (**RF**) and Sartorius (**SA**) muscles. 2. The difference in the CRD in those cases where the main artery of RF arises from the descending branch of the lateral femoral circumflex artery, and is preserved or severed. 3. Maximum values of CRD.

Results: 1. CRD was significantly greater when the pedicle passed deep to the muscles (-2.5±3.8 SD cm) compared with superficial (-5.8±3.3 SD cm), indicating placement of pedicles beneath the two muscles enables additional extension. **2.** CRD was significantly greater for the severed condition (-0.3 ± 4.0 SD cm) than for the preserved condition (-3.3 ± 4.1 SD cm), indicating severing the main artery of RF allows additional extension. **3.** Out of the 60 specimens the

CRD was cranial to the umbilicus in 17 flaps, indicating pedicled ALT flaps can reach the umbilicus in less than one-third (17/60) of cases.

Conclusion: Pedicled ALT flaps can reliably reach regions inferior to the umbilicus. However, for defects superior to the umbilicus, other reconstructive options should be considered.

Introduction

Whole-thickness abdominal wall defects may arise following injury or tumour resection. When the defects cannot be directly closed, coverage requires flaps—such as external oblique abdominal muscle [1], groin [2-4], tensor fascia lata [5-7], and anterior lateral thigh [8-13]. Among these reconstructive options, this study focuses on the antero-lateral thigh flap (ALT flap), which can achieve simultaneous reconstruction of the skin and fascial defect with limited donor morbidity. The ALT flap can be transferred to the abdomen in two ways—as a pedicled flap or free. The former is simpler since it avoids vascular anastomoses and saves operative time and costs. However, for defects located in the upper abdominal region, coverage cannot be achieved with pedicled flaps. Here the operating team must plan in advance the need for a free-flap and not find themselves in a position of having to alter plans during surgery. For effective performance, the operator should predict whether or not the defect can be covered with a pedicled ALT flap.

Information on how far a pedicled ALT flap can reach in the abdominal region is useful in making such a prediction. Hence, this study aims to elucidate the extent to which pedicled ALT flaps can reach in the cranial direction.

Materials and Methods

1. Experimental Conditions

(1) Specimens

Of the 62 preserved lower limbs (32 male and 30 female) donated to the department of anatomy at our institute for ALT dissection, 2 (both female) were unsuitable because of absent perforators. 60 ALT flaps raised from the 60 limbs were involved in the present study.

(2) Flap Elevation

The skin and deep fascia were incised in the anterior midline of the middle-third region of each cadaver's thigh medial to the anticipated line of perforators. The subfascial dissection was developed to identify perforators. Having determined the largest perforator, a skin paddle was then designed symmetrically with the perforator at its central point. (**Figure 2**). The length of the skin island was arbitrarily decided to be one-third of the length of the line drawn from the Antero-superior Iliac Spine (ASIS) to the supero-lateral margin of the patella. For instance, for a thigh in which the distance between the ASIS and the lateral margin of the patella was 39 centimeters, the length of the skin paddle was set as

13 centimeters. The more distal the main perforator, the more distal is the flap and consequently the longer its arc of rotation. Distances between the ASIS and lateral margin of the patella were 41.8±2.8 SD cm and 37.1±1.9 SD cm for male (n=32) and female limbs (n=28), respectively. Dissection proceeded along the main perforator to its source from the descending branch of the lateral circumflex femoral artery. The isolation of the vascular pedicle enables mobilization of the flap in the cranial direction.

(3) Measurement of Reachable Distances

After complete mobilization of the pedicle, flaps were transferred to the abdominal region through a subcutaneous tunnel made in the inguinal region. Flaps were transferred in the cranial direction as far as possible, while taking care not to apply excessive tension on their vascular pedicles. The distance between the most cranial point of the flap (=the tip of the skin paddle) and the umbilicus was defined as **CRD** (**Cranially Reachable Distance**). When the tips of the skin paddles could be extended beyond the umbilicus, positive values were given to the measured distances; when the tips of the skin paddles didn't reach the

umbilicus, negative values were given. For instance, when the tip of the skin paddle reached a point more cranial than the umbilicus by 5 cm, CRD for the flap was evaluated as +5 cm; when the tip fell short of the umbilicus by 2 cm, CRD for the flap was evaluated as -2 cm. Thus, CRD is a parameter that indicates how far a flap can reach in the cranial direction. That is, the greater CRD, the more cranially the flap can be transferred.

2. Data Evaluation

The data collected in the above-stated measurement system were evaluated to clarify three issues, itemized as follows.

(1) Influence of Pedicle Positioning on Reachable Distances

In transferring pedicled ALT flaps, the vascular pedicles can be positioned using two approaches. In the first, vascular pedicles are positioned superficial to the rectus femoris and sartorius muscles (**Figure 3A**). Herein, this positioning method is defined as **Superficial Positioning**. In the second approach, vascular pedicles are placed beneath the two muscles (**Figure 4**) to avoid hindrance of the pedicles by the two muscles during cranial transfer. This positioning approach

was defined as **Deep Positioning (Figure 3B)**. Each of the 60 flaps was transferred to the abdominal region via both approaches, and CRD was measured for each transfer. Thereafter, the data for the two differing approaches were compared.

(2) Influence of Anatomical Variations on Reachable Distances

Vascular pedicles of ALT flaps present two anatomical types. In the first type, the feeding artery of the rectus femoris muscle directly branches out from the lateral circumflex femoral artery (**Figure 5 Left**). Herein, this anatomical type is defined as **Type 1**. In the second type, the feeding artery of the rectus femoris muscle arises more inferiorly from the descending branch of the lateral femoral circumflex artery (**Figure 5 Right**) and hence creates a pivot point for the pedicle more distally in the thigh. This anatomical type is defined as **Type 2**. In reference to these anatomical types, evaluation was conducted regarding the following issues:

A. Ratios of Anatomical Types

To evaluate occurrence ratios, the number of specimens belonging to each type was counted for the 60 lower limbs.

B. Relationship between Anatomical Types and CRD

For limbs presenting Type 1 anatomy, a vascular pedicle can be extended to its maximum length without severing the feeding artery to the rectus femoris muscle. ALT flaps raised from these lower limbs were simply transferred to the abdominal region as shown in **Figure 6**.

With lower limbs presenting Type 2 anatomy, transfer of ALT flaps is restricted by the main artery of the rectus femoris muscle. This restriction can be eliminated by severing this artery, and further extension can be achieved. Taking this into consideration, CRD was measured for lower limbs belonging to Type 2 under two conditions. In the first condition—which is termed **RF-Branch Preserving Condition**, the main artery of RF was preserved (**Figure 7 Right Above**); in the second condition—which was termed **RF-Branch Severing Condition**, RF's main artery was severed to achieve additional advancement of the flap (**Figure 7 Right Below**). To evaluate the effect of severing RF's main artery, CRDs were compared between the two conditions.

(3) Evaluation of Maximum reach of ALT Flaps.

As stated in the preceding paragraph, the conditions under which

CDRs are maximized differ depending on the anatomical type the operated limb. When an ALT flap is raised from a limb belonging to Type 1, CRD can be maximized without severing the feeding artery of the rectus femoris muscle; when the flap elevation is conducted on a limb belonging to Type 2, the feeding artery of the rectus femoris muscle needs to be severed to maximize CRD. After performing appropriate maneuvers according to the anatomical types, CRD was measured for the 60 ALT flaps. Thereafter, the number of flaps that could reach above the umbilicus (meaning CRD greater than zero) was counted.

Statistical Analyses

Comparison of CRD between Superior Positioning Style and Deep Positioning Style was conducted with a paired t-test. Comparison of CRD between the anatomical types was conducted with one-way ANOVA with post-hoc Turkey HSD. Stata SE 13.1 (Stata Corp. College Station, TX, USA) was used for all analyses. P-values less than 0.05 were considered to be statistically significant.

Results

Relationship between pedicle positions and CRD

Distributions of CRD for Superficial Positioning and Deep Positioning are shown in **Table 1**. CRD was significantly greater for Deep Positioning (-2.5±3.8 SD cm) than for Superficial Positioning (-5.8±3.3 SD cm) ($p<0.0001$). This finding indicates that pedicled ALT flaps can be advanced further in the cranial direction by about 3 centimeters, by placing the vascular pedicle deep to rectus femoris and sartorius muscles.

Anatomical Types of Vascular Pedicles

Among the 60 flaps, 30 flaps belonged to Type 1; 30 flaps belonged to Type 2.

CRD for Anatomical Types

Distribution of CRDs for limbs with Type 1 and Type 2 anatomies is shown in **Table 2.** The averages and standard deviations of CRDs for each type are shown in **Table 3.** With flaps raised from Type 2 limbs, CRD was significantly greater for the **RF-Branch Severing Condition** (-0.3 ± 4.9 SD cm) than for the **RF-Branch Preserving Condition** (-3.3 ± 4.1 SD cm). This finding indicates

that with limbs where the main artery of the rectus femoris muscle derives from the descending branch of the lateral circumflex femoral artery, ALT flaps can achieve additional extension of about 3 centimeters by severing the branch to the muscle.

Maximum Extent Flaps Can Reach

In 30 flaps raised from limbs with Type 1 anatomy, 5 flaps exhibited positive CRD values. In 30 flaps with type 2 anatomy, 12 flaps exhibited positive CRD values—when branches to the rectus femoris muscle were severed. That is, among 60 flaps altogether, 17 flaps could reach the umbilicus. This finding indicates that in less than one-third of cases, pedicled ALT flaps can reach the umbilicus.

Discussion

Repair of abdominal wall defects can be achieved by using pedicled flaps from the abdominal or non-abdominal regions. External abdominal oblique muscle flaps[1], rectus abdominis muscle flaps[14,15], and groin flaps[2-4] are examples of the first group. Such flaps further weaken the abdominal wall and risk herniation at the donor sites. Furthermore, for cases where the defects are caused by colorectal tumors, simultaneous stoma reconstruction can be compromised. The second group includes tensor-fascia lata (TFL) flaps[5-7] and ALT flaps[8-13,16-20]. Both of these methods enable secure reconstruction of the abdominal wall by providing vascularised fascia. However, usage of TFL flaps is accompanied by damage to a considerable length of the ilio-tibial ligament, which potentially affects knee stability during ambulatory function[7]. Hence, we prioritize ALT flaps over TFL flaps. In performing abdominal wall reconstruction using pedicled ALT flaps, advancement of the flap in the cranial direction can be restricted by the length of the flap pedicle. To achieve effective reconstruction of abdominal wall defects, it is helpful to understand the degree to which the flaps can be transferred. Motivated by this clinical consideration, we initiated the present study.

The study first elucidated how the difference in positioning of vascular pedicles affects the distance to which the flaps can be transferred. In raising ALT flaps, access to their pedicle—the descending branch of the lateral femoral circumflex artery—is through the space between the rectus femoris and vastus lateral muscles. Hence, the flap can be delivered from the space and transferred in the cranial direction by draping its pedicle over the superficial surface of the rectus and sartorius muscles. We define this as Superficial Positioning. Assuming that the main perforator is at the mid level of the thigh the result is that the average CRD for Supeficial Positioning is -5.8 centimeters, indicating that the skin paddle falls about 6 centimeters short of the umbilicus. Additional extension of about 3 centimeters can be achieved by placing the vascular pedicle beneath the rectus femoris and sartorius muscles, Deep Positioning. However, even with the additional extension, the flap still does not reach the umbilicus.

To obtain further transfer of the flap, additional mobilization of the vascular pedicle may be achievable by severing its branches. Hence, the present study next elucidates the effect of severing branches to the rectus femoris muscle. The result is that in 50 percent of the cases, additional advancement of 3 centimeters

can be achieved by severing the main artery of the rectus femoris muscle. Thereby, the flaps could closely reach the level of the umbilicus (CRD=0.27 cm, **Table 3**). However, in severing branches to the rectus femoris muscle, care must be taken not to impair the muscle's viability and function. The rectus femoris muscle belongs to Type 2 in the classification of Mathes and Nahai[21], where a muscle receives blood supply from one dominant vascular pedicle with additional smaller vascular pedicles. Since the branch from the descending branch of LCFA is the dominant vessel of the rectus femoris muscle, severing the branch can induce ischemia of the rectus femoris muscle[22,23]. Hence it is recommended to evaluate the blood supply to the rectus femoris muscle by applying a clamp on the branch prior to its division.

By positioning pedicles appropriately and severing the branches when needed, maximum advancement of flaps can be achieved. Under these conditions and applying the arbitrary caveats that in this series the center of the flap is sited over the main perforator and the flap length is one third the length of the line from the ASIS to the patella, 17 flaps out of 60 reached the umbilicus (**Table 3**). This finding can be translated to mean that in more than two-thirds of cases, pedicled

ALT flaps will not reach the umbilicus.

In order to substantiate our findings, existing studies of abdominal wall reconstruction with ALT flaps are reviewed. Friji [9] and Kayano[12] reported a series of abdominal wall reconstruction cases using ALT flaps, and state that ALT flaps are an effective tool for the reconstruction of abdominal wall defects. However, quantitative evaluation regarding the extent to which the flaps could be advanced is lacking in their studies. Kimata[8] presenting cases where defects located in regions superior to the umbilicus were reconstructed with pedicled ALT flaps, states that pedicled ALT flaps reach up to 8 cm superior to the umbilicus. Kimata achieved this advancement by increasing the mobility of the flap pedicle by severing the horizontal branch of the lateral femoral circumflex artery. However, the horizontal branch is the dominant vessel of the tensor fascia lata. Furthermore, the tensor fascia lata belongs to Type 1 in Mathes and Nahai's classification[21], where a muscle receives blood supply only from one dominant vessel. Hence, severing the horizontal branch can impair the blood supply to the tensor fascia lata, and negatively affect ambulatory functioning. Therefore, it is our opinion that the maneuver should be performed only in special conditions.

Besides severing muscle branches of the flap pedicles, CRD can be extended by modifying the positional relationship between the perforator and the flap and or extending the length of the flap in a distal direction so that a propeller flap is created. In our flap design, the main perforator is sited at the center of the flap. If the position of the flap is shifted or lengthened by a certain distance in the distal direction, CRD of the flap increases by that distance.

In the present study's specimens, the average lengths of the flaps were 13.9 centimeters for males and 12.4 centimeters for females (These data correspond to the one-third of the length of the line between the ASIS and the lateral margin of the patella which are presented in the Material and Methods section). Accordingly, the average distances between the distal end of the flap and the perforator are 7.0 centimeters and 6.2 centimeters for males and females, respectively. On the assumption that ALT flaps survive up to 9 centimeters from the perforator[24,25], the flaps could be shifted in the inferior direction by 2.0 centimeters for males and 2.8 centimeters for females, respectively. When these additional distances are taken into consideration, 11 of 30 flaps with Type 1 anatomy and 20 of 30 flaps with Type 2 anatomy (on the RF-Branch Severing

Condition) present positive CRD values. However, coverage of full thickness abdominal wall defects demand secure primary healing and stretching the viability of flaps to achieve this purpose is inherently risky. To assure safe coverage of the defects, a CRD value of at least 5-6 cm is needed. Hence, it is our opinion that coverage with pedicled ALT flaps remains a tricky option for abdominal defects located above the umbilicus.

In the present study, flaps were designed so that the largest perforator is situated at their centers. However, other perforators are often available besides the main perforator, since 2.31 perforators on average exist on the antero-lateral aspect of the upper thigh[26]. For cases where available perforators are present at positions more distal to the main perforator, we can increase CRD by placing the flap to capture more distally located perforators. In performing such distal-shift of the flap, we should take great care about the blood supply to the flap. This is because the diameters of distally positioned perforators are smaller than those of main perforators and their angiosomes are accordingly smaller. Hence, in situations where we need to employ distally located perforators to earn additional CRD, we should carefully examine during the operation whether or not

the flap has sufficient blood supply. We can perform this examination by using such techniques as indocyanine green angiography[27,28].

This study was conducted with cadavers fixed with formalin, which hardens tissues. Therefore, there might be criticism that the measured extension of the flaps is likely to be shorter than it should be, and that the flaps can be transferred to more cranial positions in actual operations. However, the range of the flaps' pedicle length range was 9.8 to 21 cm in this study (data not presented in Results or Tables), which is almost equivalent to existing studies conducted with fresh cadavers (reported as 4 to 20 cm)[29]. Hence, we believe the data obtained in this study are applicable to actual clinical cases.

In summary, judging from the fact that less than one-third of pedicled ALT flaps can reach the umbilicus, we conclude that although they are applicable to abdominal defects in regions inferior to the umbilicus, ALT flaps should not be considered as the first-choice method for defects located more cranial than the umbilicus. Hence, for defects located in the upper regions of the abdomen, methods other than pedicled ALT flaps—such as free ALT flaps or local flaps

combined with artificial mesh grafting—should be considered.

This study is unique in that it quantitatively evaluates the reach of pedicled ALT flaps using significant numbers of specimens. The authors believe the findings of the present study should be helpful for surgeons in making plans for abdominal wall reconstruction; by referring to the findings of the present study, surgeons can perform abdominal wall reconstruction more effectively. It is desirable that multicenter studies be conducted in the future to verify the clinical applicability of the present study.

Financial Disclosure/ Conflict of Interest: The authors report no conflict of interest. The authors alone are responsible for the content and writing of paper.

Acknowledgement

We extend our special gratitude to Professor Wayne Morrison (O'Brien Institute in Melbourne) for his kind advice in organizing the present paper.

References

1) Hersey F. B., Butcher H. P. Repair of defects after partial resection of the abdominal wall. Am J Surg. 1964; 107:586-591.

2) Guneren E., Orak I., Dervisoglu A. Reconstruction of a wide abdominal wall defect using extended groin flap. Br J Plast Surg. 2005; 58:845-848.

3) Bogart J. N., Rowe D. S., Parsons R. W. Immediate abdominal wall reconstruction with bilateral groin flaps after resection of a large desmoids tumor. Plast Reconstr Surg. 1976; 58:716-718.

4) Ohnishi K., Maruyama Y. Bilateral groin VY advancement flaps for the repair of lower abdominal defects. Eur J Plast Surg. 1996; 19:136-138.

5) Nahai F., Hill H. L., Hester T. R. Experiences with the tensor fascia lata flap. Plast Reconstr Surg. 1979; 63:788-799.

6) Caffee H. H. Reconstruction of the abdominal wall by variation of the tensor fasciae latae flap. Plast Reconstr Surg. 1983; 71:348-351.

7) Williams J. K., Carlson G. W., deChalain T., Howell R., Coleman J. J. Role of tensor fasciae latae in abdominal wall reconstruction. Plast Reconstr Surg. 1998; 101:713-718.

8) Kimata Y., Uchiyama K., Sekido M., Sakuraba M., Iida H., Nakatsuka T., Harii K.

Anterolateral thigh flap for abdominal wall reconstruction. Plast Reconstr Surg. 1999; 103:1191-1197.

9) Friji M. T., Suri M. P., Shankhdhar V. K., Ahmad Q. G., Yadav P. S. Pedicled anterolateral thigh flap: A versatile flap for difficult regional soft tissue reconstruction. Ann Plast Surg. 2010; 64:458-461.

10) Gravvanis A. I., Tsoutsos D. A., Karakitsos D., Panayotou P., Iconomou T., Zografos G., Karabinis A., Papadopoulos O. Application of the pedicled anterolateral thigh flap to defects from the pelvis to the knee. Microsurgery. 2006; 26:432-438.

11) LoGiudice J. A., Haberman K., Sanger J. R. The anterolateral thigh flap for groin and lower abdominal defects: A better alternative to the rectus abdominis flap. Plast Reconstr Surg. 2014; 133:162-168.

12) Kayano S., Sakuraba M., Miyamoto S., Nagamatsu S., Taji M., Umezawa H., Kimata Y. Comparison of pedicled and free anterolateral thigh flaps for reconstruction of complex defects of the abdominal wall: Review of 20 consecutive cases. J Plast Reconstr Aesthet Surg. 2012; 65:1525-1529.

13) Neligan P. C., Lannon D. A. Versatility of the pedicled Anterolateral thigh flap. Clin Plastic Surg. 2010; 37:677-681.

14) Mathes S. J., Steinwald P. M., Foster R. D., Hoffman W. Y., Anthony J P. Complex abdominal wall reconstruction: A comparison of flap and mesh closure. Ann Surg. 2000; 232:586-596.

15) Mathes S. J., Bostwick J. A rectus abdominis myocutaneous flap to reconstruct abdominal wall defects. Br J Plastic Surg.1977; 30: 282-283.

16) Wei F.C., Jain V., Celik N., et al. Have we found an ideal soft-tissue flap? An experience with 672 anterolateral thigh flaps. Plast Reconstr Surg. 2002; 109: 2219-2226.

17) Kimata Y., Uchiyama K., Ebihara S. et al. Versatility of the free anterolateral thigh flap for reconstruction of head and neck defects. Arch Otolaryngol Head Neck Surg. 1997;123: 1325-1331.

18) Lannon D.A., Ross G.L., Addison P.D. et al. Versatility of the proximally pedicled anterolateral thigh flap and its use in complex abdominal and pelvic reconstruction. Plast Reconstr Surg. 2011; 127: 677-688.

19) Ting J., Trotter D., Grinsell D. A pedicled anterolateral thigh (ALT) flap for reconstruction of the epigastrium. Case report. J Plast Reconstr Aesthe Surg. 2010; 63: e65-67.

20) Wang X., Qiao Q., Burd A., Liu Z., Zhao R., Wang C., Zeng A. Perineum

reconstruction with pedicled anterolateral thigh fasciocutaneous flap. Ann Plast Surg. 2006; 56:151-155.

21) Mathes S. J., and Nahai F. Classification of the vascular anatomy of muscles: experimental and clinical correlation. Plast Reconstr Surg 1981; 67: 177-187.

22) Kimata Y., Uchiyama K., Ebihara S. et al. Anterolateral thigh flap donor-site complications and morbidity. Plast Reconstr Surg. 2000; 106: 584-589.

23) Collins J., Ayeni O., Thoma A. A systematic review of anterolateral thigh flap donor site morbidity. Can J Plast Surg. 2012; 20:17-23.

24) Nojima K., Brown S.A., Acikel C., Arbique G., Ozturk S., Chao J., Kurihara K., Rohrich R.J. Defining vascular supply and territory of thinned perforator flaps: part I. Anterolateral thigh perforator flap. Plast Reconstr Surg. 2005;116:182-193.

25) Kimura N., Satoh K., Hosaka Y. Microdissected thin perforator flaps: 46 cases. Plast Reconstr Surg. 2003;112:1875-85.

26) Kimata Y., Uchiyama K., Ebihara S., Nakatsuka T., Harii K. Anatomic variations and technical problems of the anterolateral thigh flap: a report of 74 cases. Plast Reconstr Surg. 1998;102:1517-1523.

27)Valerio I., Green J.M. 3rd, Sacks J.M., Thomas S., Sabino J., Acarturk T.O.

Vascularized osseous flaps and assessing their bipartate perfusion pattern via intraoperative fluorescence angiography. J Reconstr Microsurg. 2015;31:45-53.

28) Monahan J., Hwang .BH., Kennedy J.M., Chen W., Nguyen G.K., Schooler W.G., Wong A.K. Determination of a perfusion threshold in experimental perforator flap surgery using indocyanine green angiography. Ann Plast Surg. 2014;73:602-606.

29)Valdatta L., Tuinder S., Buoro M., Thione A., Faga A., Putz R. Lateral circumflex femoral arterial system and perforators of the anterolateral thigh flap: an anatomical study. Ann Plast Surg. 2002; 49:145-150.

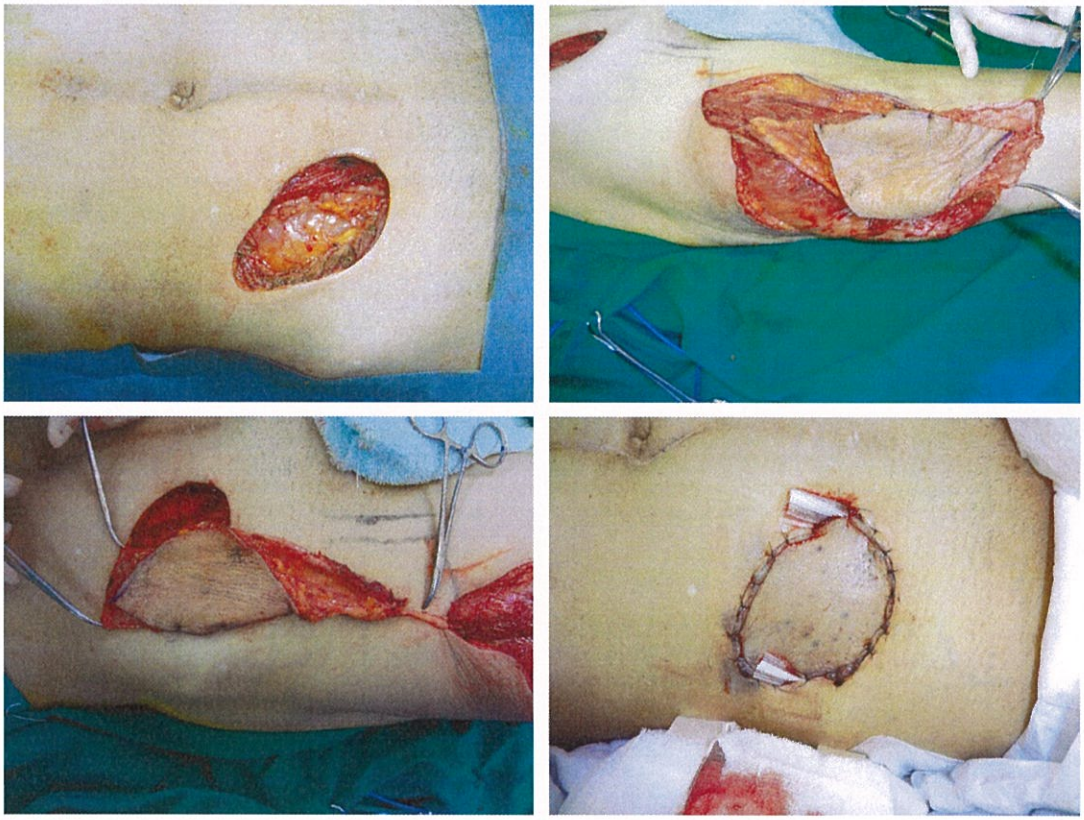

Fig. 1

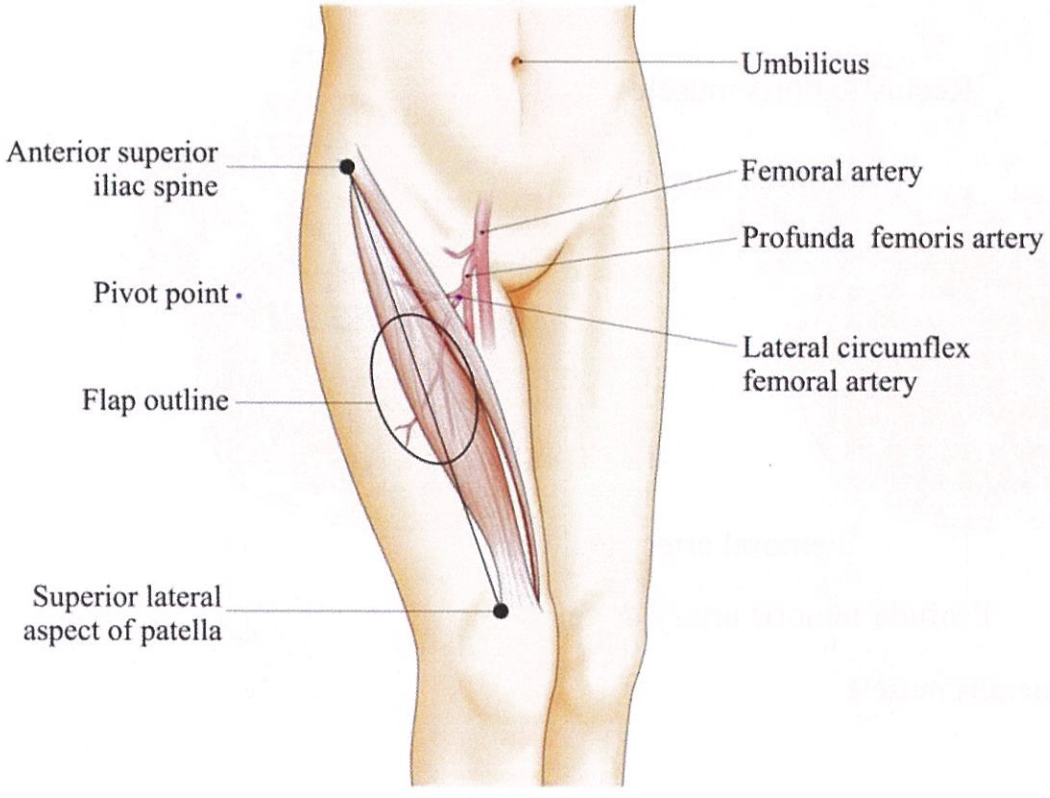
Umbilicus
Anterior superior iliac spine
Femoral artery
Profunda femoris artery
Pivot point
Lateral circumflex femoral artery
Flap outline
Superior lateral aspect of patella

Fig. 2

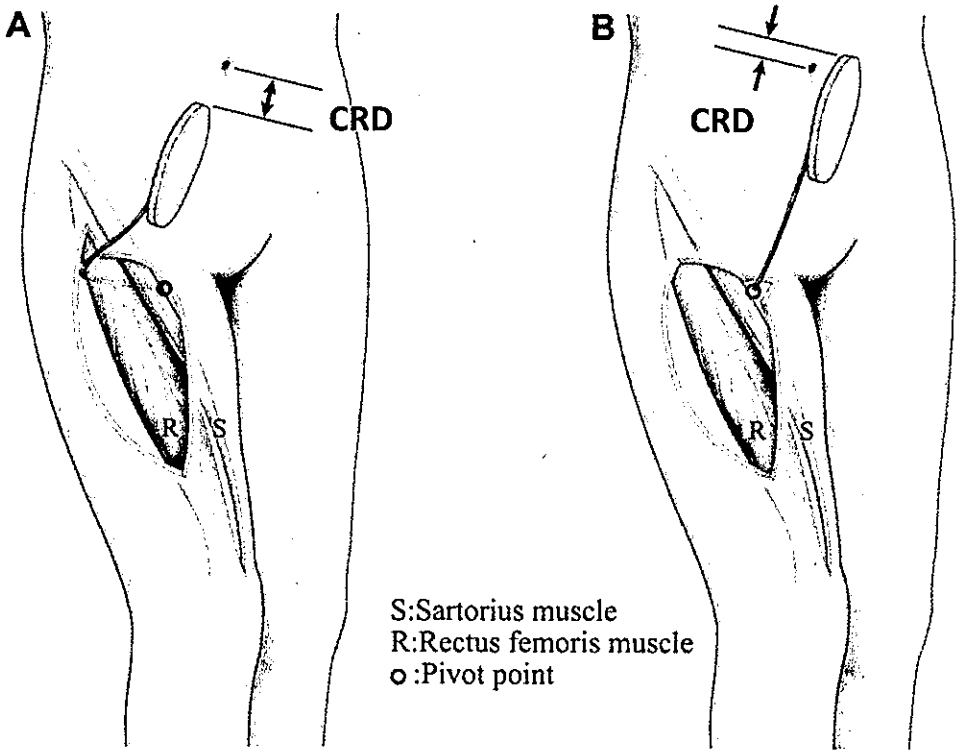
A
CRD
R
S
B
CRD
R
S
S:Sartorius muscle
R:Rectus femoris muscle
o :Pivot point

Fig. 3

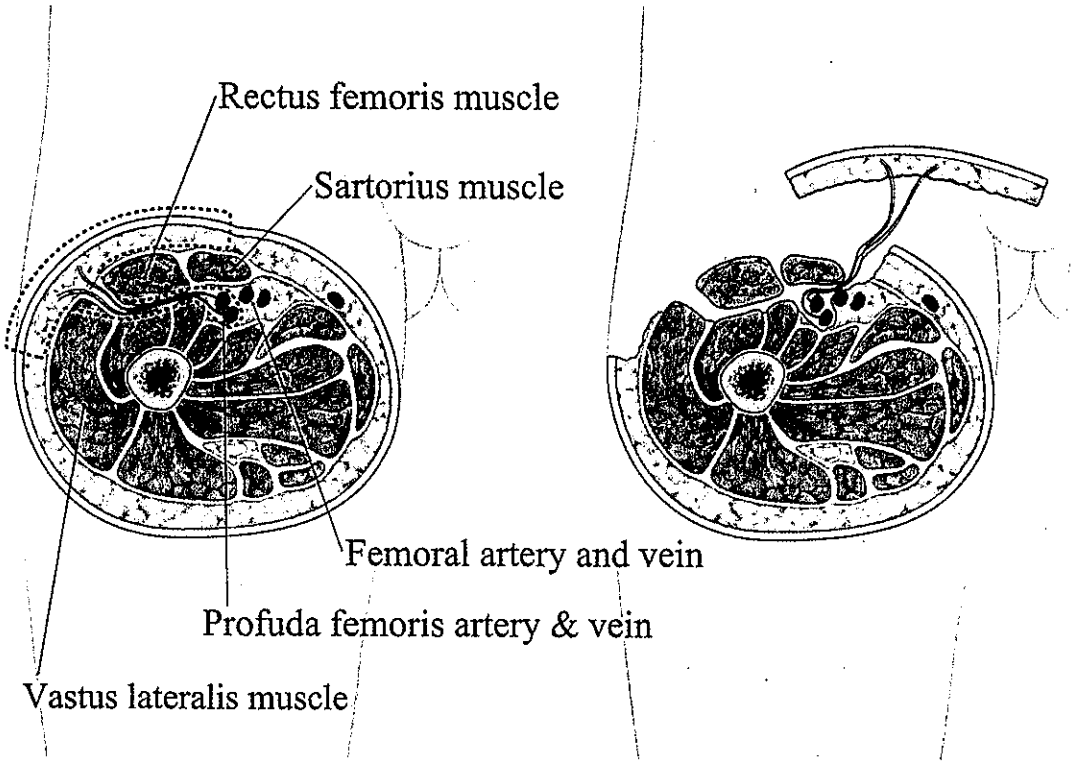
Rectus femoris muscle
Sartorius muscle
Femoral artery and vein
Profuda femoris artery & vein
Vastus lateralis muscle

Fig. 4

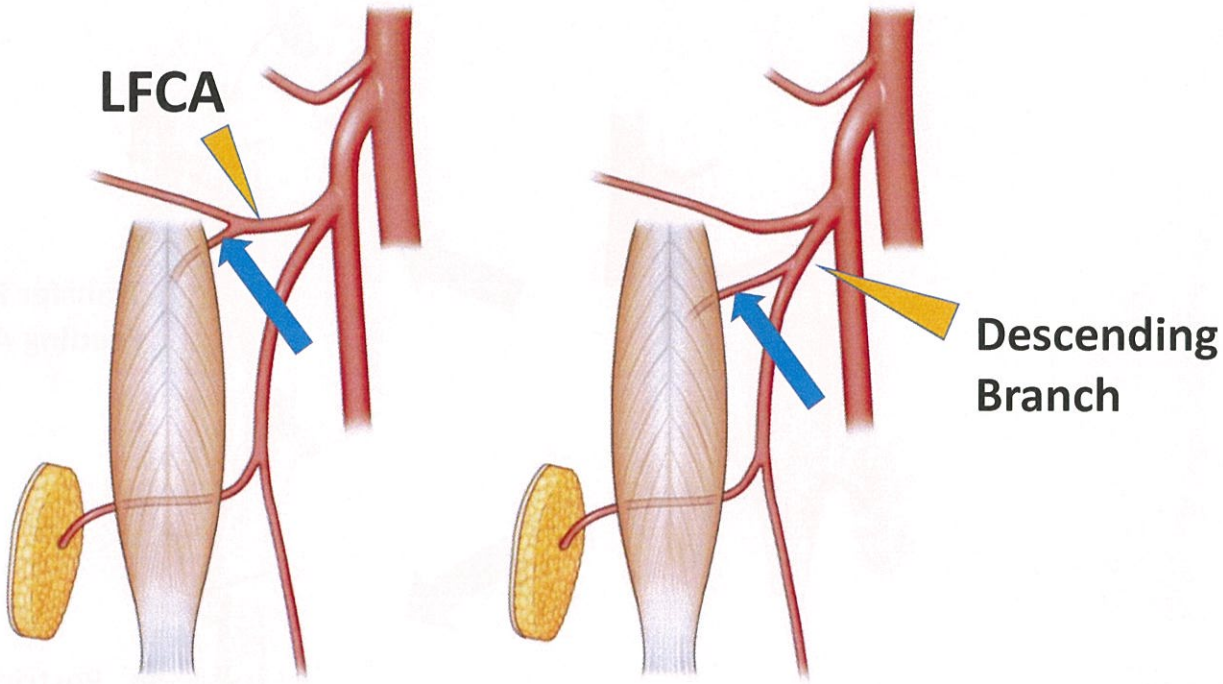

Fig. 5

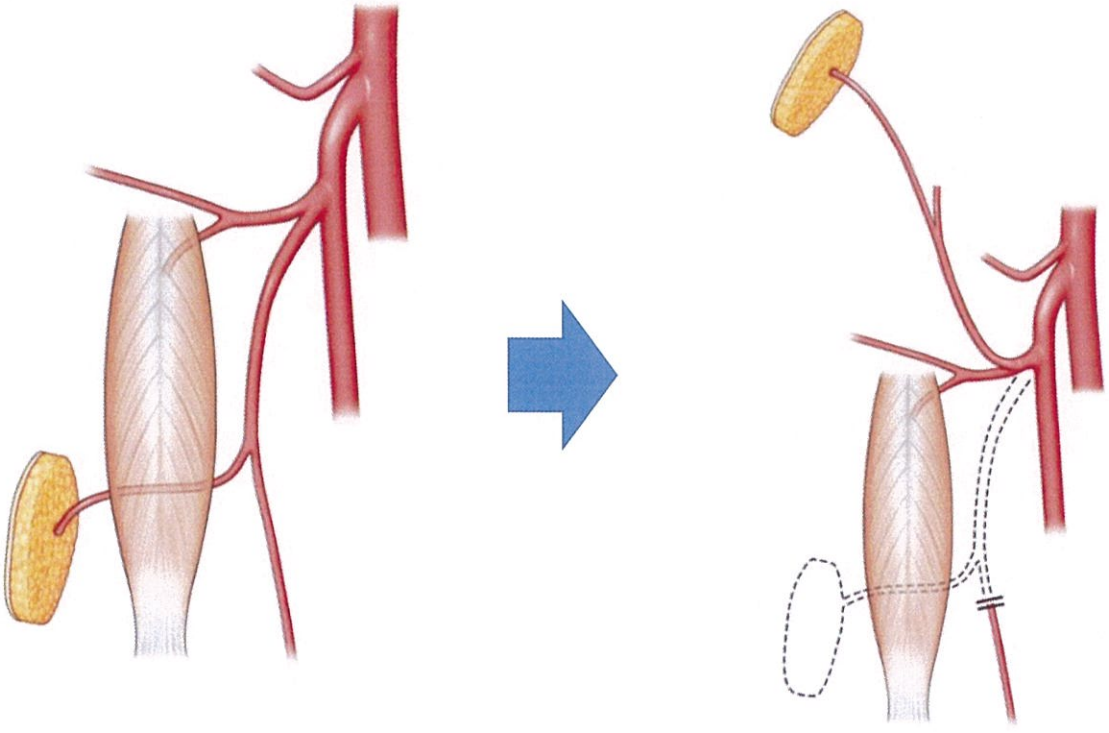

Fig. 6

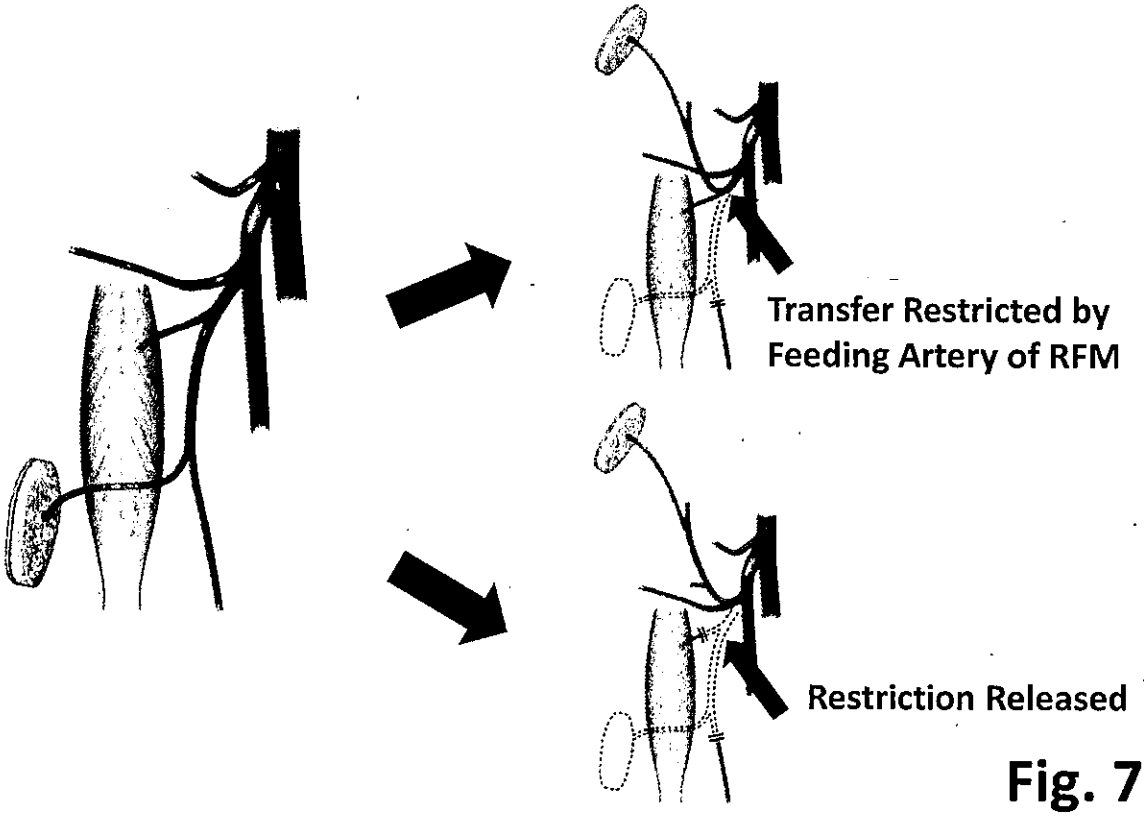
Transfer Restricted by
Feeding Artery of RFM
Restriction Released

Fig. 7

Table 1: CRD Distribution According to Pedicle Positioning

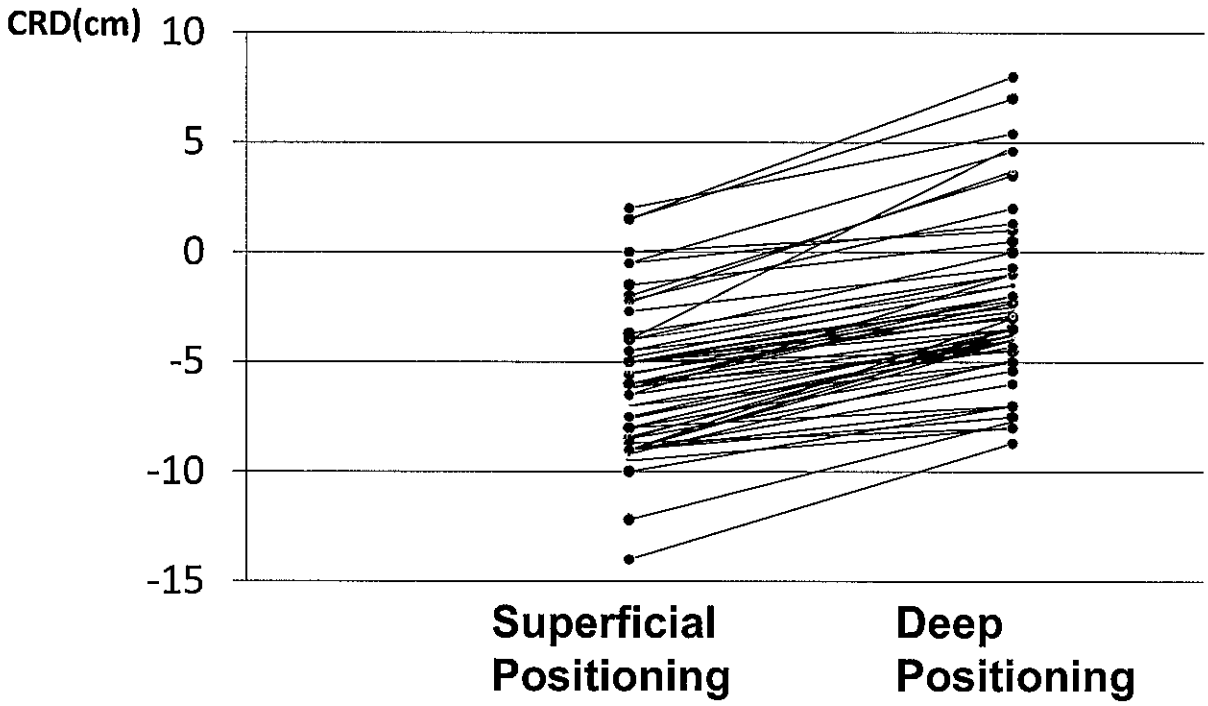

Table 2: CRD Distribution According to Anatomical Types

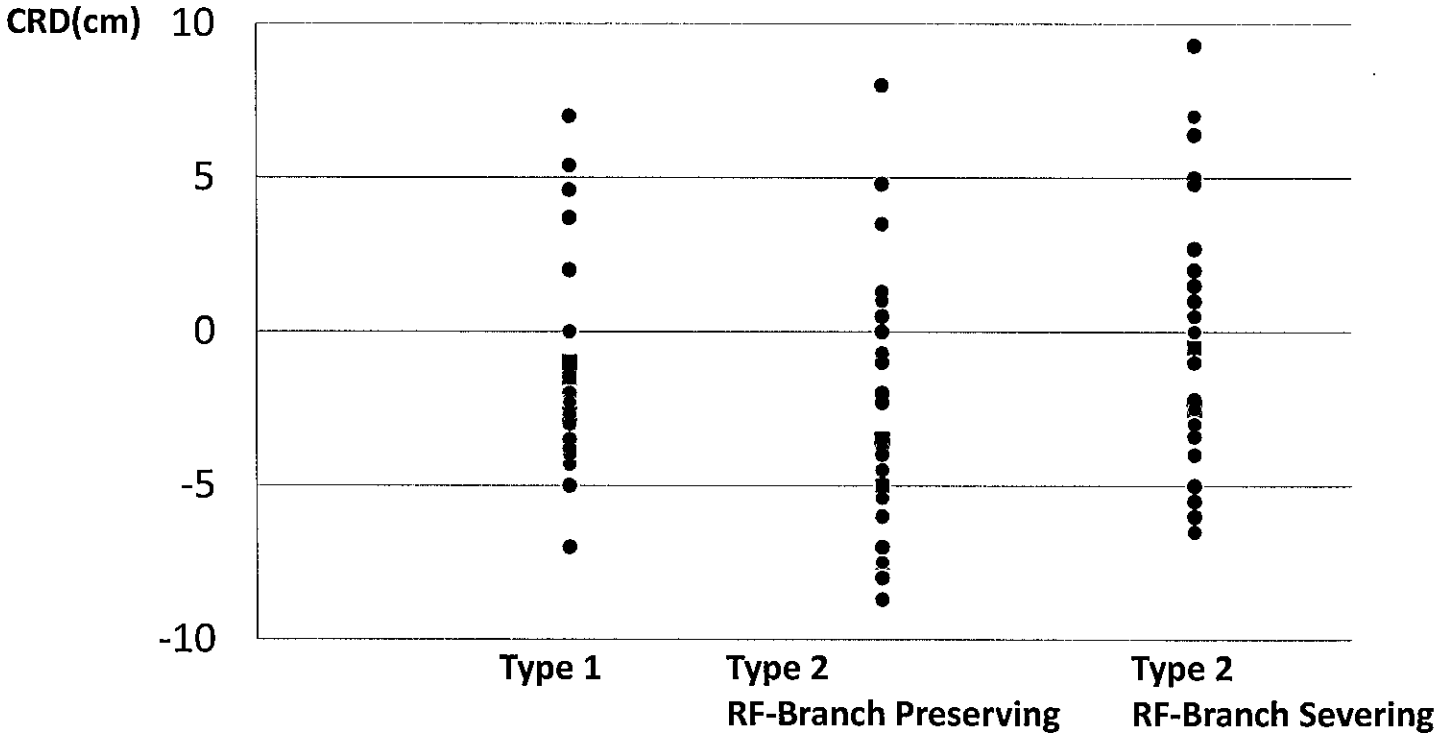

Table 3: Averages and Standard Deviations of CRD According to Anatomical Types

Anatomical Types		CRD (cm)	CRD Positive Ratios
Type 1(n=30)		-1.75±3.25SD	5/30
Type 2(n=30)	RF-Branch Preserving	-3.25 ± 4.13SD	6/30
	RF-Branch Severing	-0.27 ± 3.96SD	12/30