The blood and nerve supply of the long head of the biceps femoris muscle; its possible use in dynamic neoanal sphincter

***W. G. Elbarrany[1], Abdulmonem Al-Hayani[2] and S. Softa[3]**

Departments of [1]Anatomy and [3]Surgery, Faculty of Medicine, Umm Al-Qura University, Makkah Almokarramah and Department of [2]Anatomy, King's Abdulaziz University, Jeddah, Kingdom of Saudi Arabia

E-mail:ssofta@yahoo.com

Summary

Objectives: **Dynamic graciloplasty is used commonly as a neoanal sphincter to reconstruct the damaged anal sphincter. However, infection of the transposed gracilis and consequent failure of anal reconstruction has been recorded in some cases. An alternative to gracilis muscle should be searched for to reconstruct and replace the anal sphincter.**
Study design: **30 fresh cadavers (20 adult, 10 stillborns) had been used in this study.**
Materials and methods: **The external and common iliac arteries were injected with a mixture of 50% lead oxide and 50% red latex. The long head of biceps femoris was exposed to identify its neurovascular bundle and estimate the whole length of the thigh, the whole length of the long head of biceps and the dominant neurovascular pedicles of the long head of biceps muscle. The functional length of the biceps muscle that is used during the muscle rotation was also calculated. The diameter of the arteries supplying the muscle was measured at their proximal and distal ends using a Swiss mechanic caliber. The thighs of both sides of each cadaver were X-rayed in order to study the vascular architecture of the muscle, and then the biceps muscle was dissected and removed then X-rayed to study the internal vasculature and anastomosis.**
Results: **The study showed that there were four dominant arterial pedicles to the long head of biceps femoris muscle in addition to several minor arterial branches in 90% of the studied cases. In all cases, the inferior gluteal artery gave one major arterial pedicle to the proximal end of the muscle. The radiological study of the vasculature of the long head of biceps muscle during the current study showed the presence of anastomosing arterial loops between the internal iliac, external iliac, femoral and profunda femoris arteries. It also showed the presence of extensive intramuscular anastomosis between the intramuscular branches of the major arterial pedicles inside the long head of biceps femoris muscle. During the present study, it was found that the muscle received a single nerve supply in 97% of the dissected cadavers. This means that about in 58% of the cases, the muscle is available for transposition to wrap the anal canal. The available length of the muscle for rotation was about 57% of the length of the thigh.**
Conclusion: **It can be concluded that, the long head of the biceps muscle can be safely rotated to wrap around the anal canal without serious effect on the main vascular pedicles and its nerve supply.**

Key-words: ***Neoanal sphincter, Biceps femoris, Arterial pedicle, Nerve.***

Résumé

Objectifs: Ordinairement, on utilise la gracilopa tie dynamique comme un sphincter néoanal afin de reconstitu er le sphincter anal endommagé. Toutefois, l'infection du gracilis transposé et l'échec conséquent de la reconstruction an le a été notée dans certains cas. C'est nécessaire de trouver un alternatif par rapport au muscle gracilis afin de reconstit er er replacer le sphincter anal.
Plan d'étude: 30 cadavres frais (20 adultes, 1(mort-nés) ont été utilisés dans cette étude.
Matériels et méthodes: Les artères iliaques externes et ordinaires ont été injectées avec une mixture de 50% oxyde au plomb et 50% latex rouge. La tête longue du femoris biceps était exposé afin d'identifier son tas neu ovasculaire et calculer toute la longueur de la cuisse, la longe ır entière de la tete longue du biceps et les pédicles neurc vasculaire de dominante de la tête long du muscle biceps. La longueur fonctionnelle du muscle biceps utilisé pendan la rotation du muscle était également calculée. On a déterm né le diamètre des artères qui amènent le sang au muscle dans leurs bouts proximaux et distaux, avec l'utilisation du calibre mécanician du Swiss. On a fait l'examen radiographique des deux côtés des cuisses de chaque cadavre afin d'étudier l'architecture vasculaire du muscle et puis le muscle biceps a été disséqué et enlevé puis on a fait le radiodiagnostic af n d'étudier le vasculature et l'anastomose interne.
Résultat: Cette étude a indiqué qu'il y avait qu atre pédicules artères de dominantes vers la tête longue du muscle de femoris biceps en plus de plusieures branches des artères secondaires en 90% des cas étudiés. Dans tous es cas, l'artère gluteal inférieur a donné une artère pédicle majeur vers l'extrémité proximale du muscle. L'étude radio ogique du vasculature de la tête longue du muscle du bice os au cours de cette étude a indiqué la présence des boucles des anastomose artères entre l'iliaque interne, iliaque externe, artères fémoris profunda et fémoral. Il a également indiqué la présence d'une vaste anastomose intramusculaire entre les branches des pèdicles intramusculaires entre les branches des pèdicles intramusculaires d'artère majeure dans la tête longue du muscle du biceps fémoris. Au cours de cette étude, nous nous sommes rendu compte que le muscle a reçu un seul approvisonnement nerveux en 97% des cas de cadavres disséqués ça signifie environ 58% des cas, le muscle est disponible pour la transposition pour pouvoi envelopper le conduit anal. La longueur de muscle disponible pour la rotation était environ 57% de la longeur de la cuisse.
Conclusion: En conclusion, la tête longue du muscle biceps pourrait être tourné sans danger afin d'envelopper le conduit anal sans un effet négatif ou sérieux sur le péd cles vasculaire

* *Correspondence*

principale et son approvisionnement nerveux.

Introduction

Treatment of patients with faecal incontinence and after surgical resection of the anal sphincter may necessitate replacing the anal sphincter. It is necessary to have a structure which posses resting tone and is able to mount a sustained maximum contraction capable of resisting intra-abdominal pressure. In addition, such a neosphincter needs to retain its ability to dilate and stretch so that evacuation can proceed[1-3]. Previous work in animals had suggested that chronic frequent electrical stimulation of rapid twitch muscle, (Type II) would convert it to a slow twitch muscle (Type I)[4,5].

Dynamic graciloplasty has been demonstrated to be a reliable option in the treatment of end-stage faecal incontinence with stable results after long-term evaluation studies with a long-term success rate of 75%. Continence restoration varies from 40 to 65% depending on incontinence etiology and surgical experience. Key features for a good postoperative contractile response were identified in a careful gracilis mobilization, in a meticulous identification of nervous pedicle and in the prudent early postoperative operative stimulation. Early failures of graciloplasty were shown to be linked mainly to postoperative septic complications, while good long-term results were significantly related to the efficacy of muscular recruitment and careful patients selection[6]. It has been reported[7] that the artificial anal sphincter is a more convenient technique than dynamic graciloplasty. However, technical failures and complications during follow-up that require reoperation are very high in both types of treatments[7]. Moreover, in some patients, the gracilis muscle may be unsuitable or unavailable for muscle transposition[8].

Recently, it was reported that, defecography and a manometeric study showed that the patient could contract the transposed gracilis muscle independently. He can maintain excellent continence without stimulation. They concluded that, electrical stimulation is therefore not always necessary for a good function after dynamic graciloplasty[9].

For a muscle to be used to replace the striated anal sphincter, certain requirements should be fulfilled and include[10, 11]:

1. The dominant vascular pedicles must permit surgical manipulation of the muscle around the anal canal.
2. The nerve supply to the muscle should be such that enmasse contraction of the transposed muscle occurs when the nerve is electrically stimulated.
3. The muscle should be of sufficient length to wrap around the anal canal.
4. The muscle should be expendable.

The aim of the present work is to study the neurovascular bundle of the long head of the biceps to assess its suitability for dynamic neoanal sphincter as an alternative to gracilis muscle.

Material and methods

The material used in this study was 30 fresh cadavers (20 adults and 10 stillborns). The femoral arteries or the common iliac arteries in the pelvis were exposed by vertical incisions below the midinguinal points or by lower paramedian incisions in the abdominal walls.

The arteries were proximally ligated, then canulated and irrigated with normal saline to dislodge blood clots. A dye consisting of a mixture of 50% lead oxide and 50% red latex was injected with moderate maintained pressure using suitable 20 ml syringes. Injection was continued until resistance was encountered or back flow of the dye occurred. The amount of the injected mixture was ranging from 60 to 80 ml (at a mean of 50±2 ml).

Anatomical study

Dissection was started 24 hours following the injection through a posterior midline incision passing from the gluteal region till the middle of the popliteal fossa. The dissection exposed the posterior compartment of the thigh and the gluteal region. The long head of biceps femoris was then exposed to identify its neuro-vascular bundle.

The lengths of the thigh (measured from the uppermost point of the greater trochanter of the femur to the level of the corresponding knee joint) together with the length of the long head of biceps femoris muscle (from the ischial tuberosity till the level of the head of the fibula) were measured.

The following measurements were taken from the inferior border of the ischial tuberosity to:

1. Point of entry of each dominant vascular pedicles of the long head of biceps femoris.
2. Point of exit of venous drainage from the head of the biceps femoris muscle.
3. The point of entry of the nerve supply.
4. The anal verge.
5. The distance between both ischial tuberosities and the distance between the anus and the ischial tuberosity were measured then related to the length of the muscle.
6. The functional length of the biceps muscle that was used during the muscle rotation (the muscle length between the last pedicle sacrificed and the insertion into the head of the fibula).

The diameters of the arteries supplying the muscle were measured at their proximal and distal ends using Swiss mechanic (Vernier) caliber type 6902 with 0.05 mm accuracy. Their mean diameters were also calculated. The lengths were measured using a metallic ruler graduated in millimeters. The intramuscular vasculature and anastomosis were recorded during dissection.

The long head was detached from its insertion and rotated with an upward curve preserving its nerve supply and the dominant vascular pedicles to determine whether or not this muscle could reach and wrap the anal canal.

Radiological study

The biceps muscle was dissected and removed. It was X-rayed to show the internal vasculature and anastomosis. In 10 of the studied adult cadavers, the external iliac artery was ligated and the common iliac artery was injected with the mixture of lead oxide and red latex. The long head of biceps brachii muscle was then dissected and isolated to be X-rayed. This was done to study the efficacy of the anastomosis between the inferior gluteal artery and the perforators of the profunda femoris artery.

Muscle rotation to wrap the anal canal

Each cadaver was put in the lithotomy position with abduction of both thighs. The long head of the biceps femoris muscle was then mobilized and its tendon was divided close to its insertion to the head of fibula. The muscle was then withdrawn and clockwisely rotated upwards with an upward concavity to wrap the anal canal in a gamma configuration and was sutured to the opposite ischial tuberosity.

Results

The arterial blood supply of the long head of biceps

The long head of biceps was supplied mainly by two sources: the inferior gluteal artery and the perforating branches of the profunda femoris artery (Fig. 1).

The inferior gluteal artery

In all the dissected cadavers, the inferior gluteal artery gave one constant major arterial pedicle to the upper part of the proximal third of the long head of the biceps muscle (Fig. 1). It had a diameter of 0.8 mm ± 0.02 (ranging 0.7 to 1.9 mm). The length of this pedicle was 4.2 mm ± 0.15 (ranging 3.6 to 4.9 mm).

In 90% of the studied cases, the pedicle entered the muscle at a distance of 4.5 cm ± 0.09 (ranging from 4.2 to 4.5 cm) from the ischial tuberosity, and at a distance of 38.3 cm ± 1.4 (ranging from 36 to 39.8 cm) from the level of the head of the fibula. In the remaining 10% of the cases, the inferior gluteal artery gave its arterial pedicle to the proximal portion of the muscle at a distance of 3 cm ± 0.4 (ranging from 2.8 to 3.5 cm).

The perforating branches of the profunda femoris artery (PFA)

In 27 of the studied cases (90%), the long head of the biceps femoris received 3 major arterial pedicles with an average diameter of 2.2 mm ± 0.2 (ranging from 1.8 to 2.6 mm) arising from the profunda femoris artery (Fig. 1). The first major arterial pedicle entered the anteromedial surface of the upper third of the muscle while the second and the third pedicles entered the middle third of the same surface of the muscle. Three perforating branches arose from the lateral aspect of the profunda femoris artery. The first branch arose in the femoral triangle above the adductor brevis muscle. It pierced the adductor magnus muscle then passes through the tendinous arches on the medial aspect of the femur to enter the posterior compartment of the thigh. The second and the third pierced the adductor magnus at the level of the part of the adductor canal. In all of the studied cases, the major arterial pedicles were distributed to the proximal and the upper half of the middle thirds of the biceps femoris muscles.

The first, second and third perforating branches gave the upper, middle and lower co-dominant arterial pedicles respectively. Their mean distances from the ischial tuberosity, diameters and lengths are shown in Table I.

In 3 studied specimens (10% of cases), only two perforating arteries passed through the adductor magnus and ramified in the posterior compartment of the thigh. They supplied the middle third of the long head of biceps while the inferior gluteal arterial pedicle passed to the upper third of the muscle.

The long head of the biceps muscle received also many small arterial branches from the musculocutaneous and septocutaneous arteries, the nearby muscles and 8 of the studied cases (26.7%) from one of the major pedicles. There was a small arterial pedicle between the lower third of the long head and the short head of biceps femoris muscle.

Venous drainage of the long head of biceps femoris muscle

Each major arterial pedicle was accompanied by two vena comintantes. Those accompanying the pedicle from the inferior gluteal artery drained into the inferior gluteal vein while those accompanying the pedicles of the perforators of the PFA drained into the profunda femoris vein (Fig. 2).

The extramuscular arterial anastomoses

There was an extensive arteriolar anastomosis on the external surface of the long head of biceps muscle and on the nearby fascia (Fig. 3). Such anastomoses were between branches from the major arterial pedicles to the muscle and also were between branches of these pedicles and the branches of the nearby arteries of the neighboring muscles. Moreover, there was a large anastomotic artery between the three major arterial pedicles of the perforating branches of the profunda femoris artery in all of the studied specimens (Fig. 2)

Nerve supply to the long head of biceps femoris muscle

The nerve supply to the long head of biceps femoris muscle arose from the sciatic nerve in all of the studied specimens. In 21 cases (70%) of the specimens, the nerve entered the proximal third of the long head with the upper major arterial pedicle of the first perforator of the profunda femoris artery or near it (Figs. 1). In 9 cases (9%), the nerve entered the middle third of the muscle.

In 21 of the studied cases (70%), the nerve was single and in 8 cases (27%), there was a single trunk that divided into two branches. One of these branches entered the proximal third while the other entered the middle third of the long head of the biceps femoris muscle.

In 1 case, the nerve gave one branch to the upper third and two branches to the middle third. In this case, the lowest branch reached the upper half of the middle third of the long head of the biceps muscle.

The nerve arose from the sciatic nerve at an average distance of 6 ± 1.1 cm (ranged from 5.5 to 7 cm) from the ischial tuberosity. Its length from the origin to its site of its entry at the muscle was at a mean of 14.4 ± 2 cm (ranged from 14 to 16.3 cm).

The calculated lengths

The length of the long head of the biceps muscle in the adult cadavers (measured from ischial tuberosity to the head of the fibula) was a mean of 42 ± 1.7 cm (ranged from 38 to 46 cm). The thigh length was at a mean of 43 ± 1.6 cm (ranged from 36 to 45 cm). The length of the muscle that was available for rotation around the anal canal was at a mean of 25±1 cm

Table 1 The mean diameters of the proximal, distal ends and the overall mean of the three major arterial pedicles of the perforating branches of the profunda femoris artery

Pedicles of the perforating branches of the PFA	Mean proximal diameter (mm)	Mean distal diameter (mm)	Mean overall diameter (mm)
Proximal	2mm± 1.1	1.8mm ± 0.8	1.9mm ± 0.9
Middle	1.6mm ± 1.1	1.4mm ± 0.4	1.5mm ± 0.6
Distal	2.6mm ± 1.8	2.4mm ± 0.93	2.5mm ± 1.3

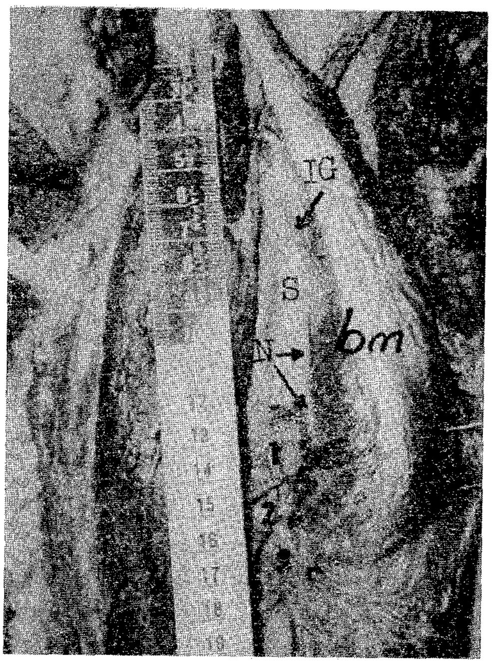

Fig. 1 *A photograph of the back of the upper part of the right thigh of an adult fresh cadaver that shows the three perforating branches of the profunda femoris artery (1, 2, 3). The perforators give branches (r) to supply the biceps femoris muscle (bm). The nerve (N) enters the middle third of the muscle with the aterial pedicle of the first perforator (1). The inferior gluteal artery gives an arterial pedicle (IG) to the upper third of the muscle. G, gluteus maximus muscle, S, sciatic nerve.*

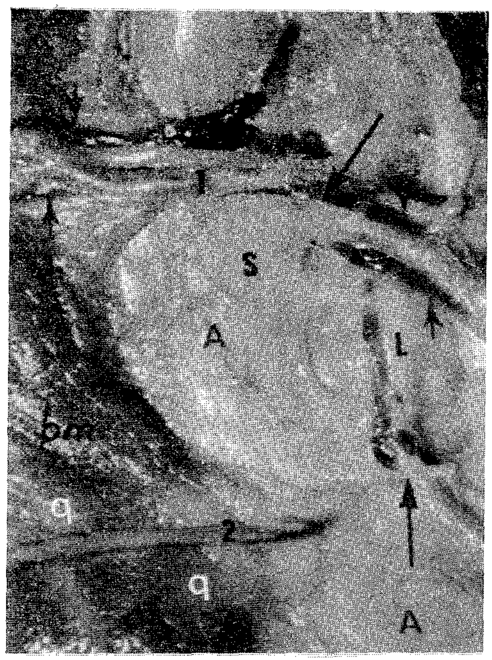

Fig. 2 *A photograph of the back of the right mid-thigh of an adult fresh cadaver. It shows a large arterial anastomotic channel (L) between the perforating branches of the profunda femoris artery (long arrows). It also shows the extensive anastomosis (A) between the branches (q) of the major arterial pedicles (1, 2) to biceps femoris muscle (bm). Short arrows indicate the two venae comitants surrounding the major arterial pedicles.*

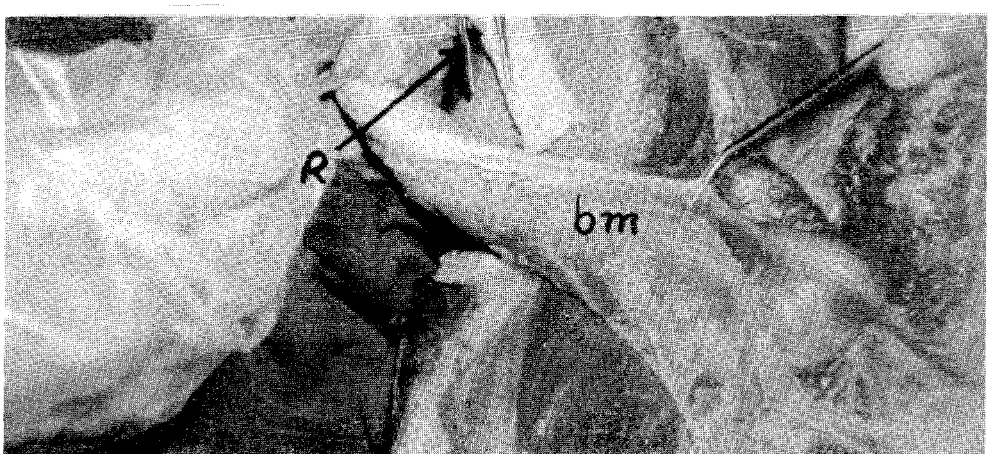

Fig. 3 *A photograph of the back of the right thigh of an adult fresh cadaver. The long head of biceps muscle (bm) is rotated in an upward direction to wrap the anal verge (R). I, ischial tuberosities, S, siatic nerve.*

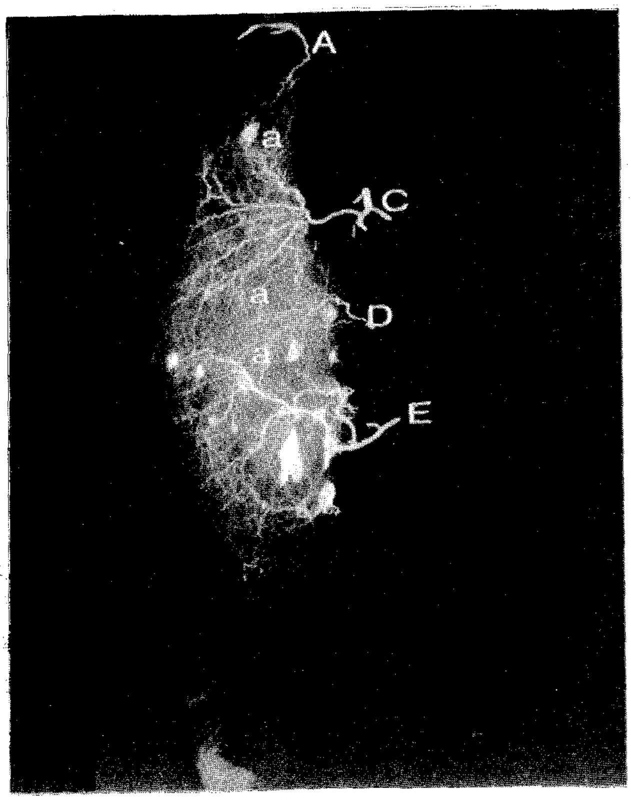

Fig. 4 *An arteriograph of the arterial pedicles of the long head of biceps femoris muscle following the common iliac artery. It shows an arterial pedicle from the inferior gluteal artery (A) and three arterial pedicles of the profunda femoris artery (C, D & E). It also demonstrates the fair intramuscular anastomoses (a) between the four pedicles.*

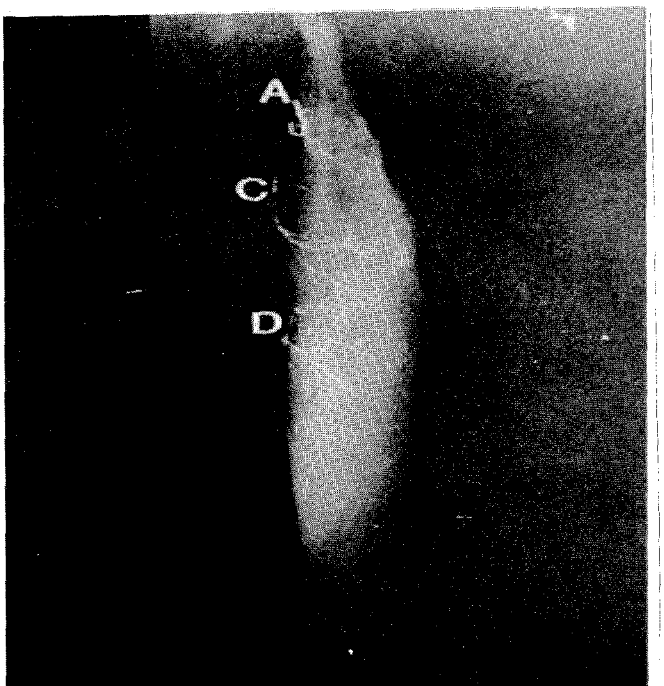

Fig. 5 *An arteriogram of the common iliac artery after occlusion of the external iliac artery to show filling of the arterial pedicles of the long head of biceps femoris muscle. It shows three arterial pedicles of the perforators of the profunda femoris artery (A, C, D). It also demonstrates the fair intramuscular anastomoses between the pedicles.*

(ranged from 20.4 to 27.7 cm).

The distance between the ischial tuberosities was at a mean of 23±1 cm (ranging from 20.4 to 27.7 cm). The distance measured from the last major arterial pedicle to the anal verge was at a mean of 13 ± 1.5 cm (ranged from 11.6 to 15 cm).

Wrapping of the long head

It was possible in all the cadavers to mobilize the long head of the biceps muscle and rotate it with an upward curvature to wrap around the anal canal and reach the opposite ischial tuberosity without stretching the main neurovascular pedicles (Fig. 3). It was necessary to sacrifice the minor blood vessels entering the lower third of the muscle in all cases of transposition. In 3 cases only (10%), it was necessary to divide the lower major pedicle leaving the upper two three arterial pedicles to facilitate the rotation of the muscle to wrap the anal canal. The nerve supply to the muscle did not suffer stretching during muscle transposition.

Radiological examination of the muscle

Radiological studies showed the perforating branches of the profunda femoral artery, which were three in number. Posteriorly they anastomosed with each other in longitudinal chains. Radiological studies also showed the presence of arterial loops connecting the perforating branches of the profunda femoris artery and branches of the femoral, the external iliac, internal iliac, popliteal and tibial arteries. These loops connected the previous vessels with the trochanteric and cruciate anastomosis.

Injection of the common iliac artery showed the three main vascular pedicles to the long head of biceps femoris muscle (one from the inferior gluteal artery and the other two from the perforating branches of the profunda femoris artery). It also showed the extensive intramuscular anastomosis between these pedicles (Fig. 4).

On the other hand, injection of the common iliac artery with red latex after occlusion of the external iliac artery showed that the dye filled the three main arterial pedicles arising from the perforators of the profunda femoris. It also showed the intramuscular branches of the pedicles with a fair number of intramuscular anastomoses (Fig. 5).

Tendino-muscular junction of the long head of biceps muscle

The length of the fleshy portion of the long head of biceps femoris muscle was at a mean of 28 ± 2.4 cm (ranging from 24 to 33 cm). The ratio of the length of the fleshy portion to the whole lengths of the muscle was about 67%. The tendinous portion of the muscle had 33% of the whole length of the muscle and about 49% of the fleshy part of the muscle.

The length of the rotated portion of the muscle in relation to the thigh length and the distance from the last major pedicle to the anal verge:

The calculated lengths of the rotated portions of the long head of biceps femoris muscles were at a mean of 25±3.1 cm (ranging from 22.4 to 27.5 cm). The thigh length was at a mean of 43± 1.3 cm (ranging from 36 to 45 cm). Thus, the length of the rotated portion was at a mean of 0.60 ± 0.005 of the length of the thigh (range from 0.60 to 0.61).

The distance from the last major pedicle to the long head of biceps femoris muscle to the anal verge was at a mean of 13 cm ± 1.3 (ranging from 11.6 to 15 cm). On the other hand, the distance between the two ischial tuberosities was at a mean of 9 cm ± 1.2 (ranging from 7.4 to 10.8 cm). Thus, the length between the last major pedicle and the contralateral ischial tuberosity passing-by the anal verge was at a mean of 11.5 ± 1.3 cm (ranging from 9.5 to 12.9 cm). Consequently, the length of the muscle left to wrap the anal canal was at a mean of 7.5 cm.

Discussion

Graciloplasty is the most famous surgical intervention for neoanal sphincter reconstruction. Results of gracilis transposition for anal incontinence have been conflicting Pickrell et al.[1]. The success of the muscle flaps in reconstructive surgery is based on reliable blood supply. The knowledge of the locations of the vascular pedicles to muscle would help the surgeon to rotate it safely as a flap. Consequently, the pattern of blood supply to each muscle determines the amount of safe transposition and its usefulness for coverage in reconstructive surgery[13-15].

In the present study, there were four dominant arterial pedicles supplying the long head of biceps muscle in addition to several minor arterial branches in 90% of the studied cases. The four dominant arterial pedicles were, one pedicle from the inferior gluteal artery and three pedicles from the upper three perforators of the profunda femoris artery. In 10% of the cases, there were three dominant arterial pedicles supplying the long head of biceps muscle in addition to several minor arterial branches. In all cases, the inferior gluteal artery gave one arterial pedicle to the proximal third of the muscle. According to Mathes and Nahai classification[16], the biceps muscle was classified to be of the type II. However, the current study showed that the long head received multiple dominant arterial pedicles beside several minor arterial branches. Consequently, the long head of biceps femoris cannot be considered to be of type II. This is in agreement with the results obtained by Shanahan et al,[15].

The radiological study of the vasculature of the long head of biceps femoris muscle during the current work showed the presence of anastomosing arterial loops between the internal iliac, external iliac, femoral and profunda femoris arteries. It also showed the presence of extensive intramuscular anastomosis between the intramuscular branches of the major arterial pedicles inside the long head of biceps muscle. Consequently, the vascularity of the long head of biceps muscle may not be jeopardized if one or two of the arterial pedicles are sacrificed during the transposition of the muscle to wrap the anal canal. On the other hand, gracilis muscle is supplied segmentally[6] with several arterial pedicles. Division of any of these pedicles can affect the vascularity of the part of the muscle supplied by it leading to its necrosis and subsequent infection of that part. This can explain the recorded infection in the majority of the failed or complicated graciloplasty.

Injection of the lead oxide mixed in red latex through the common iliac artery after occlusion of the external iliac artery showed that, the dye passed to the major arterial pedicles arising from the upper three perforators of the profunda femoris artery. This means that the latex by-passed the occluded segment of the external iliac artery indicating that the inferior gluteal arterial pedicle is capable for maintaining sufficient arterial supply to the muscle if one or two of the perforators of the profunda femoris artery have been occluded. It also showed that at least one major pedicle from the perforators of the profunda femoris artery should be left during transposition of the long head of biceps femoris.

Recent researches[15-20] showed that the function of the gracilis flap could be improved by ensuring total wrapping of the neoanus with the muscular part of the gracilis, but this can only be achieved by dividing the main blood vessels, which are considered essential for blood supply to the segmentally supplied flap. The researchers advised a vascular delay technique to preserve the flap without these vessels, which they performed first experimentally, then clinically, with promising results. They concluded that dissection of the main vessels of the gracilis muscle with vascular delay and long-term electrical stimulation may optimize the gracilis flap in patients requiring dynamic graciloplasty. Consequent to the current study, even sacrificing the main arterial pedicles of the perforators to the long head will not seriously affect the vascularity of the flap since the blood can pass through the inferior gluteal arterial pedicle and the intramuscular anastomosis to the devascularized segment of the muscle. In this respect, the long head of biceps muscle, as a new anal sphincter, could be superior to gracilis muscle.

During the current study, the dissection study of the blood supply of the muscle showed the presence of extensive extramuscular anastomosis between the major arterial pedicles of the long head of the biceps femoris muscle. Such anastomosis had been seen by the naked eye running on the external surface of the muscle and could be, at least partially, responsible for by-pass of the injected latex to the occluded segment of the external iliac artery in the present study.

Previous researches[17-19] proved that the vascularity of the gracilis muscle after transposition and electrical stimulation was increased. They attributed such an increase to opening of the anastomosing intra- and extramuscular vessels. Consequently, it would be expected that transposition of the long head of biceps femoris muscle would result in opening of the anastomosing loops and the intramuscular anastomosis. Thus, the vascularity of the transposed head would not be jeopardized if it was transposed with sacrificing one or more of the lower major pedicles.

The presence of extensive intramuscular anastomosis inside the long head of biceps muscle as shown in the current study might signify that the muscle is not supplied segmentally. Thus, the arterial supply of the muscle could not be classified as type IV according to the standard classification of the blood supply of the muscles described by Mathes and Nahai[16]. Consequently, biceps muscle does not follow the criteria of any of the four types in the Mathes and Nahai classification of muscles.

Clinical experience with the electrically stimulated gracilis flap as an anal sphincter has demonstrated that, ligation of the minor distal vessels increases the viability and muscle function for transposition and electrical stimulated graciloplasty[20,21]. Ligation of the distal arterial pedicles of the long head of biceps femoris prior to its transposition is expected to reduce the blood flow to the muscle. However, such ligation would open the extra-and intramuscular extensive anastomosis as experienced in electrically stimulated graciloplasty. Consequently, the possibility of necrosis of the electrically stimulated transposed portion of the muscle is expected to be less compared to the results obtained by transposition of the gracilis muscle. Consequently, the surgeon can sacrifice one or two pedicles in order to reach the adequate length of the muscle to wrap the anal canal without being worried about the blood supply of the transposed portion.

Dynamic graciloplasty is the most famous surgical intervention for the neoanal sphincter reconstruction. Failure of this graciloplasty has been attributed to deficient blood supply after transposition. This leads to necrosis and postoperative infection of the transposed gracilis[1, 8, 20, 22-24]. In this respect, the long head of biceps might be a suitable alternative for electrically stimulated neoanal sphincter reconstruction.

During the present study, it was found that the muscle got a single nerve supply in 97% of the cadavers dissected. In only 3% of the cases, two separate nerves supplied the muscle. Accordingly, the nerve to the long head of biceps femoris can be stimulated selectively in 97% of cases and the remaining 3% would require stimulation of the terminal branches of their innervating nerve or intramuscular stimulation when used for neoanal sphincter.

The present study showed the presence of extensive extra and intramuscular anastomosis between branches of the major arterial pedicles to the biceps muscle in addition to the arterial loops that connect the major arteries of the thigh. These anastomoses are expected to open if minor vessels of the muscle are occluded similar to that of the transposed gracilis[20, 21, 24].

Our study showed that the length of the thigh was at a mean of 43 cm. Thus the muscle length available for rotation is about 67% of the length of the thigh. Consequently, surgeons can calculate the possible length of the transposed part of the muscle before the operation by measuring the length of the thigh. They also can give precise judgments for the suitability of the use of the long head of biceps femoris in patients to be operated upon.

The distance between the last major pedicle and the anal verge was ranging from at a mean of 13.5 cm. If this distance is added to the mean distance between the anal verge and the opposite ischial tuberosity, it will be 18 cm. This means that there will be an average of 6.5 cm left from the transposed portion of the muscle that are suitable to wrap the anal canal without significant stretch of the lower major pedicle. Therefore, transposition of the long head of biceps muscle appeared to be convenient since the blood supply to the muscle would not be severely affected and consequently, postoperative necrosis and infection might be remote. Thus, the long head of biceps femoris muscle could be superior in this respect to the transposed gracilis muscle.

In the current study, it was possible in 90% of the studied cases to mobilize the long head of biceps to wrap the anal canal without stretching the main vascular pedicles or its nerve supply. However, in 10% of the cases it was possible to rotate and transpose the muscle after sacrificing the lowest pedicle, thus preserving the nerve with two main arterial pedicles that supply the upper third of the muscle. This may not affect the vascularity of the muscle because of the presence of intramuscular and extramuscular anastomosis between the pedicles. Therefore, the blood from the existing pedicles is expected to by-pass the divided one. Such by-pass was confirmed in the radiological studies done in the present work since the injected dye was shown to visualize all the three major pedicles after occlusion of the external iliac artery. Consequently, division of one or two major pedicles that arise from the perforators of the profunda femoris artery during muscle transposition would not affect the vascularity of the transposed portion. Thus, postoperative complication especially necrosis and infection of the transposed muscle will be minimized.

It can be concluded that, the long head of biceps femoris can be safely rotated to wrap around the anal canal without adverse effects on its vascularity and nerve supply. Moreover, it is also suitable for electrically stimulated neoanal sphincter. The available length of the muscle for rotation in any person is about 57% of the length of his thigh.

Acknowledgment

The authors thank Mr. Mustafa Mobeen Romi for his help in preparing the results and figures.

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