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Neurotization of femoral nerve using the anterior branch of the obturator nerve

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SUMMARY

Nerve transfer is nowadays a standard procedure for motor reinnervation. There is a vast number of articles in the literature which describe different techniques of neurotization performed after brachial plexus injuries. Although lower limb nerve transfers have also been studied, the number of articles are much limited. The sacrifice of a donor nerve to reinnervate a disrupted one causes morbidity of whichever structures that healthy nerve innervated before the transfer. New studies are focused on isolating branches or fascicles of the main donor trunk that can also be useful for reinnervation in order to limit donor site motor dysfunction.

Femoral nerve injury due to trauma or surgery cause loss of function of the iliopsoas and quadriceps muscles, which impairs normal gait. In this article we present two clinical cases of femoral nerve injury that were successfully treated with the anterior branch of the obturator nerve.

Key words: Femoral nerve injury – Obturator nerve – Nerve transfer – Lower limb trauma – Quadriceps dysfunction

INTRODUCTION

Femoral nerve injuries are an infrequent pathology but quite invalidating. These might be secondary to trauma or abdominal surgery.

The aim of the surgical treatment is to achieve muscle reinnervation through a nerve transfer or nerve graft in order to regain adequate gait.

Nerve transfer or neurotization is a surgical technique which consists on sectioning a nerve or a fascicle of it and then anastomose it to a distal stump of an injured nerve. The donor nerve will necessarily lose its function in order to provide innervation to the receptor nerve (Narakas, 1984).

Initially this treatment was only indicated when direct neurorraphy or nerve graft were not possible. Nowadays, indications have begun to change due to the fact that they have proved to produce faster and better recovery in comparison with the other classical techniques (Mackinnon, 2018).

MATERIALS AND METHODS

Anatomical Key

The femoral nerve is a branch of the plexus lumbalis that is originated in the anterior branch of the 2nd to 4th lumbar nerves. The femoral nerve is the largest branch of the lumbar plexus. It provides considerable sensory innervation to the anterior aspect of the thigh and knee, and motor innervation to the quadriceps muscles. As it emerges from

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Fig 1. Anatomical schema. Note the obturator nerve and its division in two motor branches at the medial aspect of the muscle. Femoral nerve located next to the femoral artery and vein.

the pelvis between the psoas and the iliacus muscles, crosses the crural arch next to the femoral artery or vein. Finally, the femoral nerve is divided into 4 branches: quadriceps nerve; external musculocutaneous nerve, which innervates the sartorius muscle; internal musculocutaneous nerve, which innervates pectineus muscle, and internal saphenus nerve.

The obturator nerve emerges from the anterior division of the lumbar nerves 2nd to 4th. It descends on the posterior part of the abdomen to enter the muscle through the obturator canal and then divides into four branches (Figs. 1 and 2):

- An anterior branch that lies above the adductor brevis and underneath pectineus and adductor magnus muscles and innervates them.
- A posterior branch that lies under the adductor brevis and above the adductor magnus and also innervates them, although part of the adductor magnus muscle is innervated by the sciatic nerve.
- A nerve branch for the knee joint.
- A cutaneous nerve branch.

Two anatomical dissections were performed in order to confirm adequate length of the anterior branch of the obturator nerve. After proper internal neurolysis of this branch, termino-terminal neurraphy was performed tension-free both in anatomical dissections and clinical cases. Internal

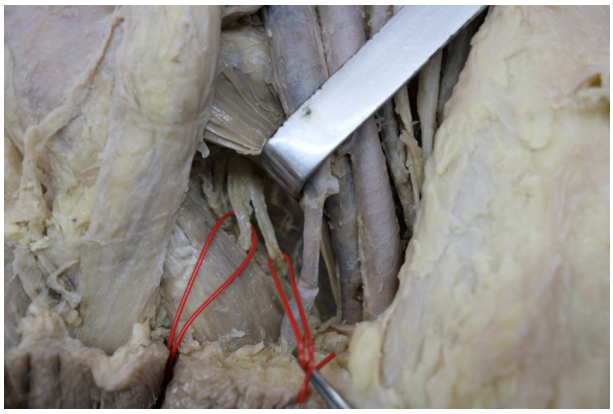

Fig 2. Anatomical dissection where the obturator nerve is shown. Notice its two motor branches (red vessel loop). Femoral neurovascular bundle is also evident.

neurolysis of the quadriceps motor branch up to the Scarpa triangle could also have been performed in case the length had proved to be insufficient.

Clinical cases

We report two cases of neurotization of the quadriceps branch of the femoral nerve with the anterior branch of the obturator nerve. Both patients agreed to consent to the operation once they were properly informed of possible complications and the unavoidable consequences of the donor nerve sacrifice.

An inguinal approach is necessary to identify the anterior branch of the obturator nerve at the medial aspect between the pectineus and adductor brevis muscles. It was dissected from the obturator foramen down to its entrance at the muscle belly. The presence of motor neurons is proved in both the anterior and posterior branches of the obturator nerve with the help of a neurostimulator device before transection. The femoral nerve can also be identified through this approach at the lateral aspect, and can be traced down to find the branch corresponding to the quadriceps muscle. In this case neurostimulation is not possible and the subdivisions of this nerve must be correctly identify as they proceed into the quadriceps muscle. A termino-terminal neurorraphy is then performed. The hip must be kept with 10º flexion and a slight internal rotation for 6 weeks.

- First Case

A 73-year-old patient who underwent left inguinal herniorraphy. She suffered from a large and irreducible hernia for several years before the intervention.

Intervention was uneventful, placing the usual polypropilene mesh. In the immediate postoperatory, the patient started to feel severe pain which irradiated to the left lower limb, over the thigh and internal aspect of the leg. Functional defect of the flexion of the hip and extension of the knee was evident. An ultrasound of the area re-

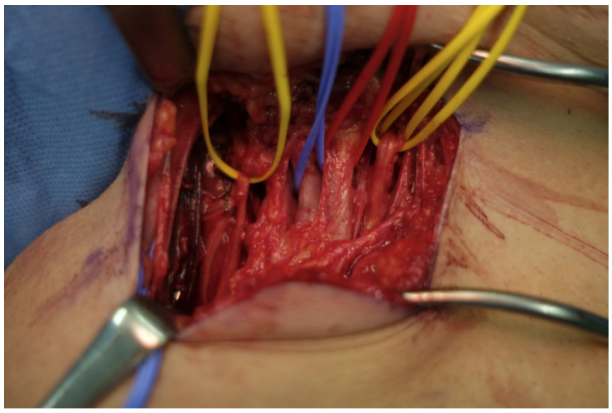

Fig 3. Intraoperatory image. From medial to lateral: Obturator nerve (yellow vessel loop), femoral vein (blue vessel loop), femoral artery (red vessel loop) and femoral nerve (yellow vessel loop).

vealed a local hematoma. Surgical exploration was done in order to evacuate the hematoma.

Once this complication was sorted, the patient still complained of pain at the internal saphenus territory, and the functional defect was still present. Orthopaedic surgeons were then consulted in order to reassess the case and an EMG was then performed. Strength examination showed the following: left iliopsoas 2/5, left quadriceps 0/5 while the remaining muscle groups were a 5/5. Rotulian reflex was missing and presented hypoesthesia of the internal aspect of the leg and distal third of the thigh.

The EMG resolved that it was an acute severe proximal injury of the left femoral nerve (neurotmesis).

Neurotization technique was performed three months after the herniorraphy. Inguinal approach was elected and the neurovascular femoral group was explored. The branch for quadriceps muscle was isolated but no muscle contraction was obtained with neurostimulator. A timid stimuli of the sartorius muscle was only evident. At this level no injury was identified and therefore it was assumed that this injury had to be proximal to the femoral triangle.

At this point we decided to perform the neurotization using the anterior branch of the obturator nerve as donor. This was localized at the medial aspect between the pectineus muscle and adductors. Functionality of this branch was confirmed positive contraction of the adductor brevis and magnus occurred when using the neurostimulator (Fig. 3, intraoperatory image, from medial to lateral: Obturator nerve -yellow vessel loop-, femoral vein -blue vessel loop-, femoral artery -red vessel loop- and femoral nerve -yellow vessel-loop-).

Eventually a termino-terminal suture-free neurorraphy was done using fibrine-sealant (Figs. 4 and 5).

One year after the surgery, the patient scored 3/5 in quadriceps MRC strength scale (Medical Research Council), whereas adduction function was

Fig 4. Picture of the described neurotization: anterior branch of the obturator nerve to the quadriceps femoral nerve branch.

reduced to 4/5. She needed a crutch for medium and long distances and still could not go upstairs. She was wearing no assisting orthesis.

- Second case

A 29-year old male who suffered from a severe wound caused by a bull's horn. The inflicted injury affected the femoral triangle with complete section of the neurovascular bundle which had to be intervened urgently. In the post-operatory period the injury of the femoral nerve was evident and a neu-

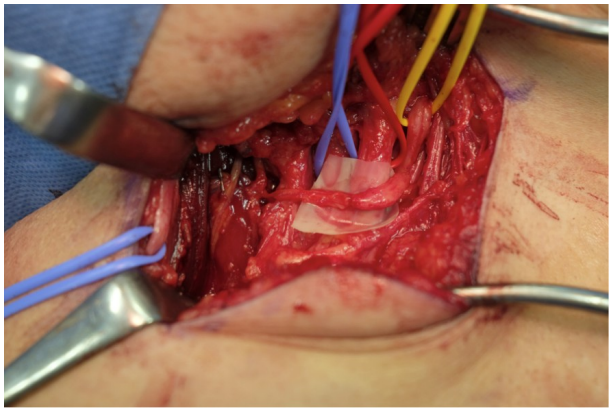

Fig 5. Intraoperatory image of the described neurotization: anterior branch of the obturator nerve to the femoral branch for the quadriceps muscle.

rotization, similar to one described previously, was performed in order to avoid surgery at the groin where technical difficulties and possible risks were higher and scar tissue was already contracting the area.

The following year he scored a MRC strength of 4/5 and was able to perform basic activities of daily living without assistance. The adductor function resulted in a 4/5 MRC score.

DISCUSSION

Nerve injuries are surgical complications which cause pain, paresthesias, loss of sensitivity and strength. Frequent causes of these are (Gray, 2017):

- Iatrogenic section of the nerve inflicted with scalpel, laparoscopy ports or thermal injury caused by the monopolar/bipolar electrocautery.
- Nerve crushing due to sutures, ligatures or clamps.
- Compression or traction of the nerves due to patient position, forceps or hematoma.

Depending on the severity of the lesion and its etiology, symptoms might be temporary or permanent and if so, they will require specific treatment.

The most frequent etiologies of the femoral nerve lesion are inguinal traumas and abdominal gynecological surgeries such as hysterectomy (Irvin et al., 2004). Up to 10% of patients have been described to develop femoral nerve lesions secondary to a laparotomy approach (Chan and Manetta, 2002).

Frequent complications of inguinal hernioraphies are: hematomas, seromas, urinary retention, iatrogenic lesions of the bladder or testicles, superficial and deep wound infections, hernia recurrence, mesh migration and nerve lesions (Brooks, 2018).

Femoral nerve injuries may cause sensory or motor disfunction in terms of anaesthesia of the anteromedial territory of the thigh or quadriceps, and iliopsoas muscles weakness. Most of the femoral neuropathies are self-limited in time and resolve spontaneously. Otherwise they will cause severe incapacity due to impaired hip flexion and knee extension, and subsequently this will limit the capacity of the patient to walk (Sajid et al., 2011).

Two types of surgical treatment have been described: nerve grafting and nerve transfer. The sural nerve was the most common donor nerve used in literature for this type of lesions and satisfactory results have been described (Kim et al., 2004).

Nerve transfer to femoral nerve is a much less frequent surgery. The main trunk of the obturator nerve was used to reinnervate a femoral nerve after a retroperitoneal schwanomma tumor resection (Campbell et al., 2010). Adductor function was then sacrificed, but good functionality of the knee and hip was recovered and this allowed the patient to walk again.

Partial transfer of the obturator nerve to the femoral nerve was performed in a similar case of retroperitoneal schwanomma (Inaba et al., 2018). The same functional results were obtained, but no loss of adductor function was reported.

Eventually, the transfer of the anterior branch of the obturator nerve to the femoral nerve trunk was described (Tung et al., 2012). An inguinal approach was then chosen, which differed from the previous pelvic approach. They described a good recovery of femoral function with partial loss of adductor strength.

A similar publication described the transfer of the anterior branch of the obturator nerve to reinnervate the motor branch of the femoral nerve for the rectus femoris muscle. This transfer was necessary after performing a malignant tumor resection at the Scarpa triangle, which included the whole neurovascular bundle (Rastrelli et al., 2018).

Conversely, there is another publication which describes a reinnervation of the obturator nerve with the motor branch of the femoral nerve that innervates the proximal portion of the quadriceps muscle. In this case the iatrogenic damage of the obturator nerve had occurred after surgical resection of a malignant tumor inside the pelvis (Spiliopoulos and Williams, 2011).

We describe two cases where the anterior branch of the obturator nerve is used to reinnervate the femoral nerve through an inguinal approach. This approach was much more appropriate, as we avoided postoperative scar tissue of the abdominal area, reduced surgical time, minimized the length to the neuromuscular plate and directed the donor branch to the specific fascicles of the quadriceps muscles.

The nerve transfer was performed directly to the main trunk of the quadriceps motor branch, as this branch and the anterior branch of the obturator nerve presents similar diameter, which is normally a sign of similar axonal charge. If there was a case where a quadriceps branch is found to be much larger, the rectus femoris branch (the first branch to emerge from the quadriceps motor branch) can then be used as the recipient nerve in order to find a more similar diameter. This reinnervation in this specific situation might provide us with the best results in terms of balanced extension of the lower limb.

The exact point of division of the obturator nerve into anterior and posterior may vary. Still, the most frequent site is located inside the obturator canal (51.78%) (Anagnostopoulou et al., 2009). The anterior branch is divided in three different branches which innervate the adductor longus, the adductor brevis and gracilis muscles; the posterior branch is divided in two branches, one for the adductor brevis and one for the adductor magnus. The articular branch for the hip joint normally comes from the common obturator nerve. Since there is a high frequency of anatomic variability, careful dissection

must be performed and pre-operatory planning might potentially include an MRI tractography.

We conclude that the anterior branch of the obturator nerve should be regarded as a new surgical option to reinnervate the femoral fascicles to the quadriceps muscle in order to recover the lost function without causing severe morbidity. Further studies and more clinical cases should be reported to provide evidence of the effectiveness of this technique.

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