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Technical note

Collection and reconstruction after harvesting donor tissues from the musculoskeletal system: Technique specific to the lower limbs

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ABSTRACT

The lack of available musculoskeletal grafts in France forces us to import a very large quantity of these tissues to use in complex reconstruction procedures. The goal of this article is to describe methods for collecting donor tissues from the musculoskeletal system and for reconstructing the harvested areas. We also provide a summary of the collection procedures performed, harvested grafts and available tissues. While tissue collection requires a significant time investment, the emergence of dedicated teams may be a solution for increasing the number and quality of human musculoskeletal allograft tissues.

1. Introduction

Massive bone, ligament, tendon and meniscus grafts are not commonly used in France, contrary to virus-inactivated bone allografts, which have reliable outcomes [1]. According to the French Biomedicine Agency's latest report [2], 94 massive bone grafts were collected from deceased persons in 2015 in France (out of 66 million inhabitants). Since the French need is not met, 90% of tendons and ligaments used in France in 2015 were imported—mainly from Belgium. In comparison, in Catalonia, according to the Health Department [3], there were 312 donors in 2016 for 7.5 million inhabitants, which is 29 times more than in France.

To increase the number of available grafts and make collection easier, we developed a collection kit that ensures good reproducibility, and a reconstruction kit that ensures the body looks as normal as possible when it is returned to the family (deceased can be moved for dressing; limbs are of equal length), with a low-cost, reproducible collection method that also limits the risk of bacterial contamination during harvesting [4]. The goal of this article was to describe the method used for harvesting musculoskeletal tissues from the lower limbs and for their reconstruction that meets the above requirements.

2. Collection method

The samples must be collected in a set order to be able to harvest all the musculoskeletal tissues required, without damaging the body too much, so it can be returned to the family looking as normal as possible. These procedures were first validated on cadaver specimens—both the collection methods and the use of the reconstruction kit. They were then revalidated with the tissue bank team.

Typically, limb tissues are harvested after the thoracic and abdominal organs. The chest and abdominal cavity must have been reclosed and a new set of surgical drapes placed around the lower limbs. The tissues are collected in the same room after the visceral organs have been collected from the patient. The time elapsed after cardiac arrest is a few hours and it depends on how many organs are harvested. The collection from the lower limbs can be carried out collaboratively with vascular surgeons if blood vessels will be removed (Fig. 1). If the femoral and popliteal vessels are being collected, an anteromedial approach is used. Otherwise, a pure anterior approach is used as this requires less tissue detachment.

Tissues are collected in the following order: hamstring tendons, fascia lata, extensor mechanism [5] (consisting of the tibial tuberosity, patellar tendon, patella and quadriceps tendon), menisci and tibial plateaus [6,7], and femur from bottom to top. By using a tendon stripper, the collected hamstring tendons will be as long as possible. The entire length of the fascia lata must be collected, typically 300 mm. The extensor mechanism is collected with an at least 6-cm long tibial block; the menisci must be healthy and preserved meticulously to ensure they are not damaged during harvesting.

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Fig. 1. Configuration of surgical drapes around the body. Here, an anteromedial approach was used (arrow on right leg). It is extended distally if the tibia and meniscus will be collected.

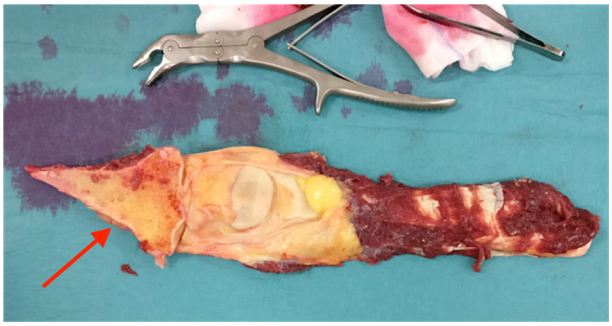

Fig. 2. Extensor mechanism collected as one piece from the quadriceps tendon to 6–7 cm above the tibial tuberosity (arrow).

Lastly, the patella and quadriceps are harvested. At least 12 cm of the quadriceps tendon must be collected; longer samples can often be collected, which will be useful during reattachment. The best method to collect the proper length of quadriceps tendon is to cut the quadriceps muscle mid-thigh, then to remove the muscle fibers and to preserve the tendon portion (Fig. 2).

The menisci are collected with the tibial plateaus, which will allow the implantation to be done with or without a bone block. The tibial plateau must be at least 1 cm thick. The meniscus must then be separated from the femur by cutting the cruciate and peripheral ligaments; at this point, the tibial plateau can be split in half. The femur can be collected from distal to proximal by detaching muscles and fascia until the proximal end of the femur is exposed. It is important to keep as much of the gluteus medius tendon on the greater trochanter and the iliopsoas tendon on the lesser trochanter for future proximal femur allografting during femoral stem revision.

The collection process then continues with the pelvis (rarely) or more often the tibia, fibula and calcaneus with the Achilles, tibialis anterior and peroneal tendons. Nerve collection is not common in France, but it is possible to collect the saphenous or common fibular nerve at this point.

In our practice, we collect all the tissues from one leg to ensure the parts are not mixed up. We take photos of the tissues with a small ruler to help document their size. Measurements are taken during the collection and recorded by the organ donation team. All grafts are tested at least once for microbial contamination.

3. Reconstruction technique

3.1. Development of kit

The kit was developed to help manage leg length. Based on anthropology data of the skeleton [8], a femur ranges in length from 350 mm to 580 mm. Due to its modularity, our construct can be used to reconstruct femurs 360 to 600 mm in length. The length is set using self-tapping wood screws in plastic tubes that make up the shaft of the bone. The kit can configure the knee to be either mobile or fixed, depending on where the tibial plateau fixation screws are placed (in the U or the T section).

3.2. Use of kit

As an example, the kit is used in a patient in whom the femur was removed from the femoral head to the tibial plateaus. Since the reconstruction kit is not sterile, all the tissues must have been collected and packaged beforehand, and the microbiological sampling described in the collection procedures performed (Fig. 3).

The kit is used from proximal to distal by interlocking the parts and screw fixation. First the plate is screwed to the acetabulum; the elbow (which serves as the femoral neck and restores the femoral offset) is fit into it, then the proximal and distal shaft portions. The U can be screwed directly into the tibial plateaus or through the distal femoral T, depending on whether the knee needs to be mobile or fixed. Once the two reconstruction kits have been implanted into the two limbs, the assistant pulls on the feet along the leg axis to restore the length, while applying some external rotation (symmetrical). The final position can set by tightening the screws in the shafts. Compresses are added to reproduce the shape of the patella (Figs. 3 and 4).

4. Results

We have been using this collection method since late 2015 in our surgery unit. The results are summarized in Table 1. Tissues were collected from about half of the donors, since not every family agreed to the donation. The collection time was important issue since an operating room was used, which delayed scheduled procedures. There is a learning curve, but one of the surgeons (RE) who performed more than half the collections has gotten faster over time. Any contaminated tissues must be destroyed as there is currently no validated processing method for these tissues. The redistributed tissues are preserved by freezing, without processing [9,10]. Contamination varies depending on the number of tissue collected; however, it appears the tissues collected later in the procedure are more likely to be contaminated. The quality of the reconstruction was deemed good in every case by the organ donation team. Table 2 lists the grafts that were collected and redistributed.

5. Discussion

The collection procedure for musculoskeletal allografts is long and requires practice to obtain good quality grafts. This can be explained by the fact that collection is carried out by a senior surgeon and assistant; small grafts are packaged dry in cryokits and larger grafts in sterile double pouches. The initial time in the operating room could be shortened through secondary optimization of collected tissues in a clean room; however we do not have this facility available. Redistribution of grafts after harvesting can only occur in the context of a tissue bank. The samples must be confirmed as being free of biological contamination first. The contamination rate may appear high, but it is