Weakness of extensor hallucis longus after removal of non-vascularised fibula as an autograft

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The upper three-quarters of the fibula is commonly used as a non-vascularised autograft. Subsequent to this isolated weakness of extensor hallucis longus may occur. We have studied 26 patients in whom the upper and middle thirds of the fibula had been harvested as a graft through Henry’s posterolateral approach.

Isolated weakness of extensor hallucis longus was found after operation in ten patients but not in the remainder. EMG and nerve-conduction studies confirmed injury of the nerve to extensor hallucis longus in those with weakness. We dissected 40 cadaver limbs and found that those in which the nerve to extensor hallucis longus ran close to the fibular periosteum were at risk. The injury is mostly incomplete and recovery occurs within four to six months.

The fibula is commonly used as an autograft, and is the main source of graft for bridging defects in long bones resulting from tumour or trauma in centres in which allografts are not available.

As the distal quarter of the fibula is necessary to maintain a stable ankle mortise, it is the proximal three quarters which is usually removed as a graft.1,2 The procedure is associated with few complications although muscle weakness may occur. Some authors attribute this to alteration or loss of muscle attachments.3 Weakness of extensor hallucis longus is seen most often.4,5

In November 2000, we observed isolated weakness of extensor hallucis longus in two patients in the immediate post-operative period after removal of a non-vascularised graft from the fibula. This led us to carry out a prospective study of 26 patients from December 2000 to April 2003 in whom this procedure was undertaken. EMG and nerve-conduction studies of the donor and opposite limb were carried out after operation. We also dissected 40 cadaver limbs to study the peroneal nerve and its branches to the extensor muscles of the leg.

Patients and Methods

Clinical study. Between December 2000 and April 2003 we studied 26 patients (16 women and ten men) prospectively. The two patients with isolated weakness of extensor hallucis longus who had aroused our initial interest were not included. The mean age of the study group was 28.5 years (22 to 50). The reasons for harvesting a fibular graft were for core decompression and grafting for avascular necrosis of the head of the femur in 12 patients, resection arthrodesis of the knee in 11, reconstruction of the distal radius in two and reconstruction of traumatic bone loss in one. Fifteen grafts were taken from the right side and nine from the left.

A thorough clinical examination was carried out before surgery. No patient had any motor or sensory impairment in the leg before harvesting the graft. In each case the operation was performed by the same team of surgeons.

The standard posterolateral approach of Henry was used in all cases.1 The fibula was approached in the plane between peroneus longus and soleus. Medium-sized right-angled retractors were used for retracting the peronei anteriorly and soleus posteriorly. The peroneal and extensor muscles were reflected gently from the fibula by subperiosteal dissection using a periosteal elevator starting at the distal end. The length of fibula required was measured and small multiple drill holes were made at the proximal and distal ends of the graft. Bone-cutting forceps were used to complete the osteotomy. Neither a saw, osteotome, cautery nor tourniquet were used. Direct subcuticular and skin sutures were applied to prevent a compartment syndrome.

The mean length of the fibula harvested was 17.6 cm (7.2 to 26) (Fig. 1). In four cases the head of the fibula was also removed and used.
as autograft. In the other patients the middle and upper thirds of the fibula were excised, preserving the most proximal and distal portions (Fig. 1).

In the immediate post-operative period, a detailed neurological examination of the donor and opposite limb was carried out by an orthopaedic surgeon who was not aware of the purpose of study. The strength in each group of muscles was graded clinically from grade 0 to V. All patients had EMG and nerve-conduction studies in both legs three weeks after operation.

They were followed up every two weeks for the initial four months and then monthly until the end of study. Progress in the recovery of the weakness was recorded.

The mean follow-up was 18 months (6 to 28). Patients in whom weakness was observed after operation had further EMG and nerve-conduction studies after three months.

**Cadaver study.** Between June 2002 to April 2003 we dissected and studied 40 specimens of unselected cadaver limbs. Of these, 22 were from formalin-preserved bodies and 18 were fresh above-knee amputations. In each specimen, the anatomy of the extensor muscles, the common peroneal nerve and its branching pattern, the branch supplying extensor hallucis longus, and its relation to the tibia and fibula were studied in detail. Measurements were taken with reference to the head of the fibula. After studying this branching pattern in each specimen the procedure for harvesting the fibula was carried out on the cadaver specimen. During this procedure it was noted if there was any excessive stretch or direct injury to the branches of the peroneal nerve.

**Results**

**Clinical study.** Of the 26 patients, ten developed isolated weakness of extensor hallucis longus (EHL), in the donor limb (Fig. 2) ranging from grade 0 to grade IV. The power in the other groups of muscles in the leg was of grade V in all cases, with no sensory loss. Of these ten patients, six were women and four were men. In eight patients the power was grade II, in one patient grade IV and in the other grade 0. The proximal third and the head of the fibula had been removed in one patient but in the remainder only the middle portion had been excised.

In the 16 patients without muscle weakness, the EMG and nerve-conduction studies were normal. In the ten in whom weakness of EHL had been observed the velocity of nerve conduction in the branch to this muscle was reduced, ranging from 21.1 to 26 m/s (Fig. 3). EMG studies showed a denervation fibrillation pattern in EHL in these patients (Fig. 4). The nerve-conduction and EMG studies in other branches of the peroneal nerve and the muscles supplied by them were normal. These investigations were repeated after three months in these ten patients. Nine showed signs of recovery with a polyphasic response indicating re-innervation and an increase of nerve conduction velocity; they made a complete recovery in a mean of 5.5 months (4 to 6). One patient did not show any sign of recovery and had not improved when reviewed even after 25 months.

No patient had weakness in any other groups of muscles. There was no evidence of sensory deficit.

**Cadaver study.** All the specimens had a common peroneal nerve running close to the head of the fibula and dividing into superficial and deep branches.
The superficial peroneal nerve arises on the lateral side of the neck of the fibula and descends through the peroneal muscles, supplying them. It enters the superficial fascia at the junction of the middle and distal thirds of the leg. The deep peroneal nerve arises from the common peroneal nerve between the neck of the fibula and peroneus longus. It enters the anterior compartment by piercing the anterior intermuscular septum. It continues between tibialis anterior and extensor digitorum longus, then lies on the interosseous membrane and enters the dorsum of the foot midway between the malleoli.

We studied the branching pattern of the deep peroneal nerve in detail and found that most of the branches to the muscles of anterior compartment are given off in its proximal third. The extensor digitorum longus and tibialis anterior each received two or three branches in all the specimens. In all 40 dissections a single branch was found supplying extensor hallucis longus. There were two variations in its course and site of entry into the muscle (Fig. 5). In 26 limbs the branch ran close to the tibia and entered extensor hallucis longus on the tibial side. In 14 limbs it ran close to the fibula before entering the muscle on its fibular side.

The mean length of this branch from its origin from the deep peroneal nerve to its entrance into extensor hallucis longus was 72 mm (60 to 82). The mean distance of origin of the branch from the head of the fibula was 75 mm (58 to 93).

We harvested the fibula from these limbs using Henry’s posterolateral approach. The nerve to extensor hallucis longus was stretched when the periosteum was elevated and the muscle stripped and this was most marked when it ran close to the fibula in the 14 cases noted above. In two instances the nerve was damaged by the periosteal elevator. However, in the 26 cadavers in which the nerve ran adjacent to the tibia no stretching or damage occurred. The
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Discussion
Extensor digitorum longus, peroneus longus and extensor hallucis longus are attached to the upper and middle thirds of the anterior aspect of the fibula while peroneus brevis and tertius are attached to its lower part. Soleus and flexor hallucis longus are attached to the proximal and middle parts posteriorly. Although the fibula is a good source of autograft, it is necessary to determine whether its partial removal results in dysfunction.2,4,5,8-10 Gore et al3 observed weakness in the dorsiflexors and in the peronei after fibulectomy. They attributed this to the loss of their bony attachment. We also found isolated weakness of extensor hallucis longus after harvesting the fibula, but the other muscles which were attached to the same portion of the bone showed no loss of power. If this weakness was due to loss of the bony attachment, associated weakness of the other attached muscles would be expected. We were extremely careful in harvesting the fibula but encountered weakness of extensor hallucis longus in ten patients. EMG and nerve-conduction studies showed damage to the nerve supply of this muscle.

Dissection of the peroneal nerve and its branching in cadavers demonstrated two patterns of distribution of the nerve to the EHL. Similar studies were carried out by Kirgis and Albrecht11 although they described three variants. If the nerve passes close to the tibia it will not be damaged when the fibula is removed but if it is adjacent to the fibula, it may be compromised when the periosteum is stripped from the bone.

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References