Most injuries to the femoral nerve are iatrogenic in origin and occur during resection of large retroperitoneal tumours. When the defect is considerable a nerve graft is mandatory to avoid tension across the suture line. We describe two cases of iatrogenic femoral nerve injury which recovered well after reconstruction with long sural nerve grafts.

The probable reasons for success were that we performed the grafting soon after the injury, the patients were not too old, the nerve repairs were reinforced with fibrin glue and electrical stimulation of the quadriceps was administered to prevent muscle atrophy. Good functional results may be obtained if these conditions are satisfied even if the length of a nerve graft is more than 10 cm.

Injury to the femoral nerve is most commonly iatrogenic in origin.\(^1,2\) It may occur during surgery, particularly during resection of a large retroperitoneal tumour. If the nerve has been transected and the defect is short, it is best repaired by end-to-end suture. If the defect is too long for direct suture, a nerve graft is required to avoid tension across the suture line.

We describe two cases of iatrogenic injury to the femoral nerve from resection of a schwannoma in which good functional recovery was obtained after sural nerve grafting.

Case reports

Case 1. In October 1996 a 40-year-old male judo instructor had a retroperitoneal tumour resected. Paralysis of his right quadriceps with disturbance of gait was apparent immediately after the surgery, and he was referred to our department. His pre-operative MR scans revealed a tumour measuring 8 cm × 6 cm in front of the right iliopsoas muscle (Figs 1a and 1b). According to the operation notes and photographs, it arose from the femoral nerve and was excised along with the entire trunk of the nerve. Histology revealed a benign schwannoma. Three weeks later, there was marked atrophy of the quadriceps femoris muscle, whose strength was graded 0 by the Medical Research Council (MRC) system.\(^3\) However, his hip flexion was rated at MRC grade 5. The front of the thigh was numb. Before the operation, motor action potential had disappeared from the quadriceps femoris.

The femoral nerve was reconstructed one month after resection of the tumour. First, the sural nerves were harvested from both legs. The proximal stump of the femoral nerve was found in front of the iliopsoas muscle and the distal stump beneath the inguinal ligament. Both stumps were adherent to the surrounding tissue, and each had formed an amputation neuroma. As the defect in the femoral nerve was 12 cm long, we made a four-strand 13 cm graft reinforced with fibrin glue. The neuromas were resected and the composite nerve graft laid across the defect. A microscopic epineural repair was carried out at each end using 8/0 nylon and fibrin glue (Fig. 1c).

The hip and knee joints were fixed in 30° of flexion and held in a full-leg hip spica for three weeks, to reduce the tension across the suture lines. The patient had neither pain nor hyperaesthesia after the surgery. After two weeks, he received low-frequency electrical stimulation of the quadriceps femoris (50 Hz for 15 minutes) three times a day for two years to prevent further muscle atrophy. He started to walk, fully weight-bearing in a knee brace, after four weeks.

Contraction of the quadriceps femoris muscle was first seen after 15 months. After three and a half years, his muscle strength had recovered to MRC grade 4 (Fig. 1d). After three and a half years the numbness of the front of his thigh had improved to 7/10, using the test described by Strauch and Lang,\(^4\) and he returned to work in April 2000.
Case 2. In January 2003 a 57-year-old policeman underwent resection of a benign retroperitoneal schwannoma. Paralysis of the left quadriceps femoris was noted immediately after the operation and he complained of difficulty in walking. He was diagnosed as having a femoral nerve palsy, and was seen in our department two months later. The pre-operative MR scans showed a tumour 6 cm × 7 cm lying in front of the left iliopsoas muscle. When seen in our department, there was marked atrophy of the left quadriceps femoris muscle with a strength graded as MRC grade 0, hip flexion was graded at MRC grade 5. The front of his left thigh was numb. The nerve action potentials had disappeared from the left quadriceps femoris before surgery.

Reconstruction of the femoral nerve was performed three months after resection of the tumour using the same method as in case 1. The only difference in the rehabilitation programme between the two cases was that in case 2 the graft tension was somewhat greater than in case 1, and full weight-bearing was delayed by a week.

One week after the surgery, the pricking pain in the inguinal area disappeared. The thigh was hyperaesthetic for approximately one month. Two and a half years later, the muscle strength had recovered to MRC grade 4 and femoral nerve sensation had improved to 7/10.

Discussion
Iatrogenic femoral nerve injuries occur most frequently during hernia operations, appendectomies, total hip replacements, gynecological procedures, and arterial bypass operations and are occasionally observed after laparoscopy, sympathectomy, or retroperitoneal tumour resection.\(^1,2,5,6\)

The appropriate operation to remove a schwannoma is enucleation of the tumour from the nerve without damage to the normal fascicle.\(^7\) In this way, the lesion can be removed without significant loss of nerve function.\(^8,9\) Intra-operative, electrical stimulation of the nerve and measurements of nerve action potentials can be very helpful.\(^7,9,10\)

However, retroperitoneal tumours are often diagnosed by surgeons who are not entirely familiar with peripheral nerves. Indeed, the general surgical oncology literature suggests that tumours in the retroperitoneum should be
resected without biopsy. Unfortunately, the femoral nerve trunk is sometimes included in the resection. In the two cases we describe, the femoral nerve was unfortunately removed without the assistance of monitoring of the nerve action potential. We feel that this should be brought to the attention of those surgeons who are not entirely familiar with peripheral nerves, to alert them to the potential hazards of this type of surgery.

If the nerve defect is too long for direct suturing, the nerve should be repaired using a cable graft. In our cases, we created long grafts, and obtained good results in each case. It is accepted that up to 6 cm, the length of the graft does not affect the quality of the result. Even when the length of the graft is more than 6 cm, good function may be recovered (Table I). Gousheh and Razian reported four cases (three with a 10 cm nerve graft and one with a 14 cm nerve graft) of femoral nerve damage in the pelvic region due to gunshot injuries sustained during the Iran-Iraq War. They performed long nerve grafting and obtained good results in the three cases with 10 cm nerve grafts, the muscle power of the quadriiceps femoris post-operatively. Although the muscle atrophy seen after nerve injury is a combination of denervation and disuse atrophy, it has been reported that electrical stimulation is a useful means of preventing denervation atrophy after nerve injury. In our patients, we used two additional techniques in an attempt to achieve good function. Fibrin glue was used both to hold the nerve bundles together longitudinally and then to reinforce the suture lines. Nerve repairs using fibrin glue are associated with less inflammatory response and less fibrosis and granuloma formation. We also administered low-frequency electrical stimulation to the quadriceps femoris post-operatively. Although the muscle atrophy seen after nerve injury is a combination of denervation and disuse atrophy, it has been reported that electrical stimulation of the denervated muscle is a useful means of preventing denervation atrophy after nerve injury.

We usually use this technique after operations for injury to the brachial plexus and its derivatives for about one year, on the recommendation of Williams and Nemoto and Williams.

We obtained good results in these two cases with sural nerve grafts of 10 cm or more. The probable reasons for this are that we performed the sural nerve grafting soon after the injury, the patients were not too old, the nerve repairs were reinforced with fibrin glue, and electrical stimulation was applied to prevent muscle atrophy. Good functional results may be obtained even if the nerve graft is more than 10 cm long.

No benefits in any form have been received or will be received from a commercial party related directly or indirectly to the subject of this article.

References

### Table I. Reports of sural nerve grafts of 10 cm or more

<table>
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<tr>
<th>Authors</th>
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<th>MRC grade</th>
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* MRC, Medical Research Council
† iatrogenic case
‡ retroperitoneal lesion
§ retroperitoneal lesion


