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Case Report

Unaffected contralateral S1 transfer for the treatment of lumbosacral plexus avulsion

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ABSTRACT

Introduction: This study describes a new surgical strategy for lumbosacral plexus avulsion by transfer of the unaffected contralateral S1 nerve root.
Methods: A surgical reconstruction of the sacral nerve was performed on a 10-year-old boy with left lumbosacral plexus avulsion. The unaffected S1 nerve root (right side) is severed extradurally for transfer. A 25-cm long nerve graft from the common peroneal nerve of the affected side was used as donor nerve. One end of the nerve graft was anastomosed to the proximal stump of the right-sided extradural S1 nerve. The distal end of the nerve graft was divided into two fascicles and anastomosed to the left-sided inferior gluteal nerve and the branch of the sciatic nerve innervating the left-sided hamstrings.
Results: According to motor score of the British Medical Research Council (MRC) system, the strength of glutei and hamstrings improved to the level of M3 1.5 years after surgery.
Conclusions: The extradural S1 nerve root in the unaffected side can be considered as a suitable donor nerve for transfer in patients with root avulsion of the lumbar or sacral nerve plexus.
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Nerve transfer is a validated surgical procedure for the functional restoration of nerve tissue after damage. To date, various nerve transfer procedures have been used for management of brachial plexus avulsion injuries in the upper extremity [1–3]. In cases of lumbosacral plexus avulsion where the donor nerve is limited, intercostal nerves often serve as the donor nerves [4,5]. However, the limited numbers of axons in the intercostal nerves are insufficient to reconstruct lower limb function effectively [6,7]. Therefore, it is imperative that the suitable donor nerves are identified.

In 1986, Gu et al. [8] introduced the use of contralateral C7 nerve root transfer to repair a brachial plexus injury. The key factor required for this procedure is to ensure that severance of C7 nerve root does not affect function on the healthy side. The brachial plexus is made up of the ventral rami of C5, C6, C7, C8 and T1 [9]. The sacral plexus originates from L4, L5, S1, S2 and S3 nerve roots [10]. The formation of both plexuses is in a similar manner. C7 and S1 roots are the central root of each plexus. Although it is unknown whether severance of S1 nerve would affect the function of the lower extremity, the unaffected contralateral S1 nerve may be a suitable novel donor nerve for the repair of lumbosacral plexus avulsion.

Our previous experimental studies in monkeys have confirmed that the severing of lumbosacral plexus L6 nerve root, which is the counterparts of S1 in humans, did not affect lower limb function [11]. Based on the preclinical results, we attempt to treat lumbosacral plexus avulsion by transfer of the contralateral unaffected S1 nerve root. To the best of our knowledge, it was the first study that the functions of the healthy limb were evaluated after extradural S1 nerve transection and the contralateral unaffected S1 as the donor nerve to repair the lumbosacral plexus avulsion.

Case report

A 10-year-old boy suffered from a complex pelvic fracture with dissociation of the left-sided sacroiliac joint (Fig. 1). The patient was referred to our care 3 months after injury. No active movement was noted in his left-sided glutei and hamstrings. No active movement was present below the left-sided knee. The strength of the quadriceps and adductor muscles was MRC grades M4–M5. There was no sensation through the posterior thigh and below the left-sided knee. The patient was difficult to stand and walk without support. His right-sided lower limb was normal in strength and sensation.

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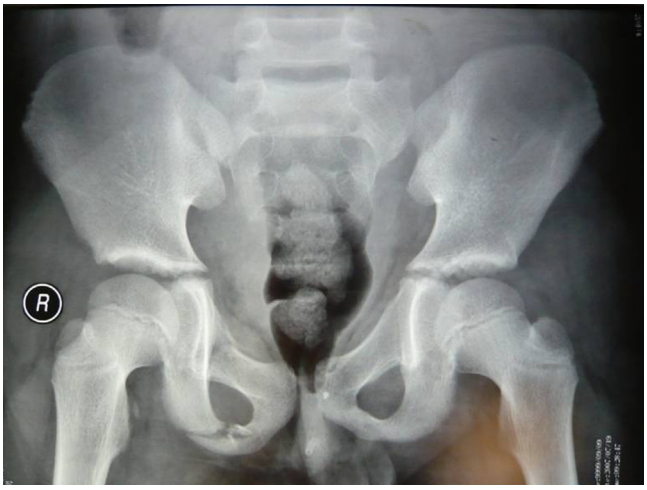

Fig. 1. A 10-year-old boy suffering from a complex pelvic fracture with dissociation of the left-sided sacroiliac joint.

Electrophysiological assessment showed no activity of the peroneus, tibialis anterior and biceps femoris muscles in left lower limb. A lumbar myelogram showed multiple pseudomeningoceles that involved in left-sided L4 to S1 nerve roots, which indicated lumbosacral root avulsion. The right-sided nerve roots were normal.

A surgical reconstruction of the sacral nerve was performed 3 months after injury. Informed consent was obtained from the patient's parents before surgery. All institutional and governmental regulations concerning the ethical use of human volunteers were followed during the course of this research.

The operation was performed under general anaesthesia in the prone positioning. The lumbar and sacral roots were exposed through a standard posterior lumbosacral laminectomy and the sciatic and the gluteal nerves were reached by detaching the gluteus maximus medially. A laminectomy was carried out from L4 to S4. The left-sided L4 to S4 nerve roots were absent outside the dura (Fig. 2). The dura was then opened in the midline, and an intradural exploration was performed. It clearly demonstrated the lacerations to the left-sided L4 to S4 ventral and dorsal nerve roots. Proximal root stumps could not be found. The distal root stumps were pulled out from the spinal canal into the pelvis and were

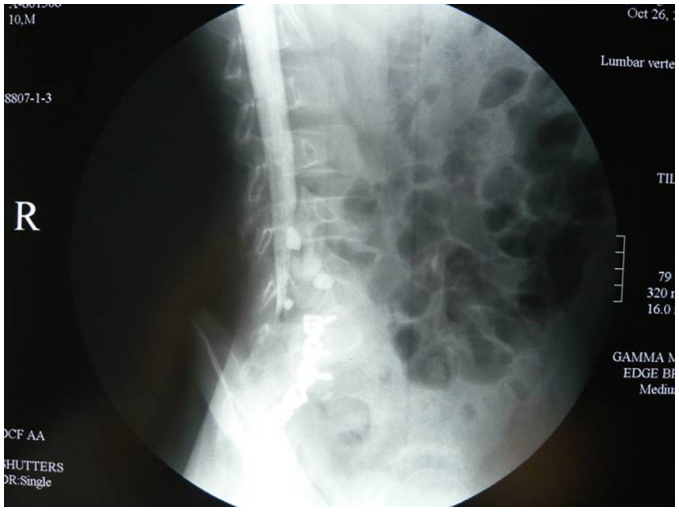

Fig. 2. A lumbar myelogram shows multiple pseudomeningoceles that involved in left-sided L4 to S1 nerve roots, which indicates lumbosacral root avulsion.

therefore difficult to explore properly. The sciatic and the gluteal nerves were reached by detaching the gluteus maximus medially. The superior gluteal nerve developed scar tissue. The inferior gluteal nerve and the branch of the sciatic nerve innervating the hamstrings were normal. As the stumps of the proximal root could not be retrieved. Nerve transfers were performed with the use of the unaffected contralateral S1 root (right side). After the location was confirmed, the right S1 nerve root was transected extradurally as distally as possible. A nerve graft of the common peroneal nerve that was approximately 25 cm in length was taken from the injured left leg. One end of the nerve graft was anastomosed to the proximal stump of the right S1 nerve root using a 10-0 absorbable suture. The distal end of the nerve graft was divided into two fascicles. One fascicle was anastomosed to the inferior gluteal nerve and the other was anastomosed to the branch of the sciatic nerve that innervated the hamstrings (Fig. 3). The wound was closed with three layers of sutures and an external drain was placed. After surgery, broad-spectrum antibiotics were given for 3 d. The patient was moved to a rehabilitation clinic 2 weeks postoperatively.

The patient was followed-up for 38 months. Clinical assessment and electrophysiological evaluation were performed at every follow-up time. Electrophysiological studies included the motor nerve conduction velocity, sensory nerve conduction velocity and the sensory evoked potential of the sciatic nerve.

The electrophysiological studies showed the functions of the donor limb were generally normal except that the amplitude of sensory evoked potentials of the sciatic nerve was slightly reduced. Electrophysiological examination revealed "nascent" motor unit potentials in the gluteus major approximately 6 months postoperatively, and in the hamstrings approximately 10 months after surgery. It indicated that the contralateral S1 nerve supplying the gluteus major and hamstring muscles had regenerated successfully. At 16 months postoperatively, the strength of the gluteus maximus and hamstring muscles improved to the level of M3 (Fig. 4), which meant that the patient could stand and walk without support. We noticed that the patient had to bend his knee of the uninvolved side first to initiate knee flexion on the affected side. However, the patient could move the affected side independently 2 years after surgery. At the final follow-up, the patient did not need any orthosis to stabilise the leg. The patient had numbness in the lateral plantar region of the right limb after surgery, but the symptom recovered within 6 months (Fig. 5). The strength of peroneus longus recovered to M4 1.5 year post-operation. No other adverse effects on the donor limb were detected. The right-sided plantar flexion and toe flexion is normal and he can stand with toes.

Discussion

Injuries to the brachial plexus have been treated surgically. Considerable developments in surgical strategies lead to functional improvements of the upper limbs. Similar improvements have not yet occurred for the treatment of lumbosacral plexus injuries. Despite technical advancement, the functional outcomes after the surgical treatment of lumbar nerve root injuries is considered to be hopeless; therefore, conservative treatment has been advocated [12,13]. Ventral root lesions can be repaired when proximal root stumps are in continuity with the spinal cord. These can be reconnected to the periphery with nerve grafts [14]. In cases which the proximal stump of the root is difficult or impossible to retrieve, only palliative procedures can be performed. In the upper extremities, nerve transfers have changed the poor prognosis of extensive nerve root injuries [15]. We hypothesised that the current surgical strategies for brachial plexus repairs could be

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