Neurological deficit after surgical enucleation of schwannomas of the upper limb

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We evaluated 56 patients for neurological deficit after enucleation of a histopathologically confirmed schwannoma of the upper limb. Immediately after the operation, 41 patients (73.2%) had developed a new neurological deficit: ten of these had a major deficit such as severe motor or sensory loss, or intolerable neuropathic pain. The mean tumour size had been significantly larger in patients with a major neurological deficit than in those with a minor or no deficit. After a mean 25.4 months (12 to 85), 39 patients (70%) had no residual neurological deficit, and the other 17 (30%) had only hypoaesthesia, paraesthesiae or mild motor weakness.

This study suggests that a schwannoma in the upper limb can be removed with an acceptable risk of injury to the nerve, although a transient neurological deficit occurs regularly after the operation. Biopsy is not advised. Patients should be informed pre-operatively about the possibility of damage to the nerve: meticulous dissection is required to minimise this.

A schwannoma is a benign peripheral nerve sheath tumour consisting of Schwann cells. It is usually solitary but multiple tumours in a limb have been reported. Overall, 19% of schwannomas are found in the upper limb, where they comprise 5% of all soft-tissue tumours. They usually grow slowly and present as a painless swelling for several years without specific symptoms. They are frequently misdiagnosed as a benign solitary mass such as a ganglion, fibroma or myxoma.

A schwannoma is well encapsulated and eventually displaces the fascicles of the nerve, whereas a neurofibroma envelops them. For this reason, it is generally believed that a schwannoma can easily be enucleated from the nerve without producing a neurological deficit. However, even with meticulous dissection, removal of a tumour without damaging any fascicles can be technically difficult, and increases the risk of transient or permanent neurological damage. The threshold for iatrogenic injury during surgical dissection of a peripheral nerve tends to be lower in the upper limb than in the trunk or lower limbs. Even a minor neurological deficit in the upper limb is rapidly identified by the patient. The purpose of this study was to evaluate any temporary or permanent neurological deficit after enucleation of a histopathologically confirmed schwannoma of the upper limb.

Patients and Methods
We identified 56 patients who had undergone enucleation of a schwannoma of the upper limb between June 1996 and December 2007. There were 30 males and 26 females, with a mean age of 43.9 years (17 to 72). We included only histopathologically confirmed schwannomas of the brachial plexus and peripheral nerves of the upper limb. Those that originated from cutaneous nerves or unidentified branches were excluded, but we included schwannomas of the digital nerve in the hand. Patients who had undergone previous surgery or open biopsy were excluded. Multiple schwannomas present in the brachial plexus or one peripheral nerve were included, but patients who had schwannomas in multiple nerve sites were not included because of difficulty in interpreting the source of the neurological deficit. There was no case of plexiform schwannoma.

There were 14 schwannomas of the brachial plexus, 13 of the ulnar nerve, 24 of the median nerve, and five of the radial nerve. The locations and distributions of these tumours are summarised in Table I. The interval between detection and excision was a mean of 6.1 years (0.3 to 20). Spontaneous pain occurred in three patients. Paraesthesiae or hypoesthesia of the skin innervated by the affected nerve was present in 38 patients, and motor weakness in three.
At their initial presentation, each patient had a palpable mass with a positive Tinel’s sign. A peripheral nerve sheath tumour was diagnosed clinically when a mass in the line of a nerve was accompanied by a positive Tinel’s sign and motor or sensory loss in the distribution of that nerve. An MRI was performed in 22 patients, and an ultrasound in 20. Each MRI correctly diagnosed a peripheral nerve sheath tumour, but ultrasound suggested a ganglion or giant cell tumour of tendon sheath on four occasions.

Although we did not perform a biopsy because of the risk of iatrogenic injury and its adverse effect on subsequent enucleation, 13 patients had undergone a fine needle aspiration biopsy in other departments of our hospital or in other hospitals. The diagnosis was confirmed in only six patients and was inconclusive in the rest.

**Surgical technique.** Each operation was performed by a hand surgeon under loupe magnification using a microsurgical technique. Skin incisions were longitudinal except for tumours of the brachial plexus, which were approached through a transverse supracavicular incision. First, we exposed the tumour and the nerve above and below it. The usual finding was that of a tumour arising within the substance of the nerve, with uninvolved fascicles splayed over its surface (Fig. 1a). We carefully made a longitudinal incision in the epineurium between the fascicles and dissected the onion-skin-like epineurial layers until the shiny surface of the tumour was exposed (Fig. 1b). Gentle dissection along the plane of the tumour capsule from the epineurial layers usually allowed the tumour to be shelled out in one piece without disturbing the nerve fascicles (Fig. 1c). However, small fascicles entering either the capsule or the substance of the tumour were sometimes found as we approached the proximal and distal poles. We tried to isolate these fascicles to minimise the risk of damage to the nerve, but it was frequently impossible and on occasion we had to divide some of the fascicles, particularly when they entered the substance of the tumour. We did not carry out intra-operative nerve conduction studies to identify non-functioning fascicles.

The mean maximum diameter of the tumours was 2.4 cm (0.7 to 7).

**Evaluation of neurological deficit.** The ‘immediate’ post-operative neurological status of each patient was evaluated within five days when they were discharged from hospital or attended their first outpatient appointment. They were asked if they had any neurological symptoms such as pain, paraesthesiae or weakness, and were examined.

<table>
<thead>
<tr>
<th>Nerve</th>
<th>Arm</th>
<th>Forearm</th>
<th>Hand</th>
<th>Number</th>
</tr>
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<td>4</td>
<td>5</td>
<td>14</td>
</tr>
<tr>
<td>Ulnar nerve</td>
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<td>5</td>
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<tr>
<td>Median nerve</td>
<td>6</td>
<td>4</td>
<td>14</td>
<td>24</td>
</tr>
<tr>
<td>Radial nerve</td>
<td>4</td>
<td>1</td>
<td>5</td>
<td>5</td>
</tr>
</tbody>
</table>

Any new symptom was recorded and classified as a major or minor neurological deficit. Major deficits included anaesthesia or marked hypoesthesia, motor weakness of grade 3 or less according to the Medical Research Council muscle strength grading system and neuropathic pain. Patients with neuropathic pain were treated with nerve blocks as well analgesics, including opiates. Minor deficits indicated tolerable symptoms such as mild hypoesthesia, paraesthesiae, and mild motor weakness (grade 4).

All patients who had major deficits after the operation were subsequently re-examined to assess their final neurological status. Those with minor subjective changes were usually contacted by telephone and asked if they had any remaining deficit. The mean follow-up was 25.4 months (12 to 85).

We used Student’s t-test to identify significant factors related to the development of an ‘immediate’ major post-operative neurological deficit. The patient’s age, duration of symptoms and maximum diameter of the tumour were compared between patients with major deficits and those who had minor or no deficits. The level of significance was set at p < 0.05.

**Results**

Ten patients had a major neurological deficit immediately after surgery. There were seven with a motor palsy or severe weakness, one with marked sensory loss, and two with severe neuropathic pain. Three patients with a schwannoma of the brachial plexus developed an incomplete nerve palsy, and one with a schwannoma of the deep branch of the ulnar nerve had increased weakness and definite clawing. Three patients developed a radial nerve palsy that limited finger extension. One patient developed sensory impairment of the thumb, index and middle fingers after excision of a schwannoma of the median nerve in the forearm. Two patients developed neuropathic pain with hypoesthesia and weakness after excision of a schwannoma from the brachial plexus.

Of the seven patients with severe motor weakness, six recovered to some extent between three weeks and six months post-operatively, with restoration of muscle power to grade 4 or more at final follow-up. However, a 27-year-old woman with a schwannoma of the deep radial nerve in the radial tunnel developed a complete palsy and showed no evidence of recovery one year later. A sural nerve graft was performed, which resulted in motor recovery to grade 4 at final follow-up. One patient with a sensory deficit recovered gradually but had some persistent paraesthesiae at final follow-up. Two patients who had neuropathic pain recovered after analgesics and a nerve block within four weeks of their operation, but some tingling persisted.

Of those with minor defects, 31 patients, who had no subjective symptoms or mild paraesthesiae pre-operatively, developed hypoesthesia or paraesthesiae, post-operatively. Mild motor weakness with sensory impairment was noted.
in three patients with schwannomas of the ulnar nerve in the forearm, the median nerve in the palm, and the median nerve at the wrist, respectively. Although the sensory or motor change was recognised immediately after surgery, their symptoms were tolerable and further treatment was not required. Of these, 24 recovered completely within three months, but seven had persistent paraesthesiae at final follow-up. Nine patients who had pain or paraesthesiae pre-operatively improved after their operation.

Overall, 41 patients (73.2%) developed a new major or minor neurological deficit or an exacerbation of their pre-operative neurological symptoms immediately after the operation. At the final follow-up, 39 patients (70.0%) showed no residual neurological deficit, and the remaining 17, including one who required a nerve graft, had hypoesthesia, paraesthesiae, or mild motor weakness. None of these complications limited the daily activities of these patients. No recurrence of tumour was seen during the follow-up period.

When the age, duration of symptoms and maximum diameter of the tumour were considered, the mean diameter of the tumour was significantly greater in those with a major neurological defect than in those without (p = 0.01). Age and duration of symptoms did not appear to affect the outcome significantly.

**Discussion**

Schwannomas are rare tumours. In contrast to a neurofibroma, in which intraneural dissection with maintenance of nerve continuity is impossible because the fascicles are embedded in the tumour, the schwannoma is well encapsulated, with
the fascicles of the nerve spread over its surface. This would suggest that a schwannoma can be removed without damage to the underlying nerve fascicles. However, our study shows that an immediate neurological deficit was seen in 75% of patients, which suggests a high incidence of iatrogenic nerve injury during dissection. Although only ten patients developed a major neurological deficit, even a minor sensory or motor deficit was easily perceived by the patient.

It is essential to make the correct clinical diagnosis of schwannoma pre-operatively. Although pre-operative neurological impairment is rare, we found that Tinel's sign had been elicited in all patients, suggesting that it is the single most useful sign in making the correct diagnosis. Although the diagnosis of a soft-tissue tumour is usually confirmed by open biopsy, we do not recommend this when a peripheral nerve sheath tumour is suspected. It should be remembered that open biopsy risks iatrogenic nerve injury, sometimes resulting in a permanent neurological deficit, and leaves a scar that may interfere with the meticulous dissection required for enucleation. If necessary, instead of open biopsy, fine needle biopsy can be performed with a lesser risk of nerve injury. Our study included 13 patients who had undergone needle biopsy before operation. Only six of these confirmed the diagnosis, which demonstrates its limitation as a diagnostic tool. After definitive enucleation of the schwannoma in these 13 patients, four had a major deficit, seven had paraesthesiae and only two showed an improvement on pre-operative symptoms. Although a needle biopsy seems less invasive, we are concerned that it might increase the risk of nerve injury during surgical enucleation. Consequently, we no longer perform needle biopsy. MRI is most helpful in confirming the diagnosis pre-operatively, and ultrasound may be of use.6

The technique of removal or enucleation of the schwannoma has been described by several authors.7-10 Some recommend extracapsular excision and have reported good results,11,12 but it would seem possible to damage the fascicles in the capsular layer during dissection. We advocate intra-capsular enucleation to minimise the risk of injury. We believe that gentle dissection of the epineurial layer down to the shiny surface of the tumour is essential to allow the tumour mass to be shelled out safely while preserving the fascicles within the layers. Great attention must be paid when the dissection approaches the proximal and distal poles of the tumour, because small fascicles that cannot be separated from the tumour are frequently present. It is necessary to check whether there is a further layer beneath the plane of dissection. If so, this should be peeled off before shelling out the tumour. In some cases, despite meticulous dissection, we found one or more fascicles entering and leaving the substance of the tumour at its pole. We tried to isolate these small fascicles, but this was almost always unsuccessful because the fascicles became attenuated as we traced them into the tumour. Donner et al12 stimulated the fascicles entering the tumour substance and reported that their division did not usually lead to an increased neurological deficit because they were usually non-functional. However, the high incidence of immediate neurological deficit in this study suggests that their conclusion is incorrect. We believe that the transection of fascicles that run through the tumour is the cause of major post-operative neurological deficit. Oberle et al9 reported that post-operative neurological deficits occur mostly in patients with large tumours or long-standing symptoms. We observed that larger tumours tended to have more fascicles entering the tumour substance and were at greater risk of major neurological deficit after surgery. On the basis that a larger schwannoma is associated with a higher risk of fascicular injury during dissection, we strongly recommend early surgical enucleation when a schwannoma is found in the upper limb. Sawada et al13 has suggested that a schwannoma arising in the brachial plexus or in the proximal part of the upper arm may be at a higher risk of injury during surgery. We found no association between tumour location and post-operative neurological deficit.

Despite the high incidence of immediate neurological deficits, most tended to resolve with time. About one-third of the patients still had hypoesthesia, paraesthesiae, or mild motor weakness, but most were not really troublesome and did not affect activities of daily living. Our final results are comparable with those reported by other authors.10,12 Knight, Birch and Pringle14 reported that significant complications occurred in only five of 198 patients with a schwannoma. Artico et al11 reported that motor strength was reduced in five of 73 patients, including 16 who needed a nerve graft, mainly due to damage from previous operations.

Our study shows that a schwannoma in the upper limb can be removed with an acceptable risk of injury to the nerve, but with a high incidence of immediate neurological deficit. The correct clinical diagnosis of a schwannoma should be made pre-operatively so that the patient may be informed of potential neurological problems. Biopsy of the nerve should be avoided.

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


