The radial and posterior interosseous nerves

RESULTS OF 260 REPAIRS
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The outcome of 260 repairs of the radial and posterior interosseous nerves, graded by Seddon’s modification of the Medical Research Council Special Committee’s system, was analysed according to four patterns of injury; open ‘tidy’, open ‘untidy’, closed traction, and those associated with injury to the axillary or brachial artery. We studied the effect on the outcome of delay in effecting repair and of the length of the defect in the nerve trunk.

Of the 242 repairs of the radial nerve we found that 30% had good results and 28% fair; 42% of the repairs had failed. The violence of injury was the most important factor in determining the outcome. Of the open ‘tidy’ repairs, 79% achieved a good or fair result, and 36% of cases with arterial injury also reached this level. Most repairs failed when the defect in the nerve trunk exceeded 10 cm. When the repairs were carried out within 14 days of injury, 49% achieved a good result; only 28% of later repairs did so. All repairs undertaken after 12 months failed. Of the 18 repairs of the posterior interosseous nerve, 16 achieved a good result.

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The radial nerve is the largest terminal branch of the brachial plexus. It was the most commonly injured nerve reported in 16 500 cases of war wounds1 and the incidence of lesions of the radial nerve came third after that of injury to the median and ulnar nerves in British casualties in World War II.2 In civilian practice, the radial nerve is injured less commonly than the median or ulnar nerves.3
Zachary4 studied 113 cases of repair by direct suture within six months of injury, the maximum amount of nerve resected being 5 cm. There was a good or fair outcome in 61.5% of cases. In Seddon’s5 series of 63 nerve sutures, 77.8% of results were graded good or fair.
Kline and Hudson6 reported 171 cases of injury to the radial nerve. The results of surgery were better in the more distal lesions and the outcome after repair of ‘lacerated’ nerves was better than that of nerves damaged by fractures or gunshot wounds. The best results were obtained after primary repair, followed by secondary repair; the worst were in cases which required grafting.

Patients and Methods
Between 1975 and 1994, we repaired the radial and posterior interosseous nerves in 291 patients. The injuries had been graded according to Seddon’s modification7 of the MRC system.8 Of these, 260 patients were followed for a minimum of two years, with 31 being lost to follow-up. The mean age of the patients was 28 years (12 to 68). The injuries to the radial nerve were classified into four groups as follows:
1) open ‘tidy’ wounds from glass, knife or scissors (73);
2) open ‘untidy’ wounds, from penetrating missile injury, open fracture or fracture dislocation and/or contaminated wounds (52);
3) closed traction injuries, usually associated with fractures of the humerus (62); and
4) injuries which included an associated lesion of the axillary or brachial artery (55).

The 18 cases of injury to the posterior interosseous nerve are described separately.

At first attendance the information obtained included the hospital identification number, age, limb dominance, occupation, mode of injury, injuries within the damaged limb to other nerve trunks, the skeleton, the vessels and skin, and associated injuries elsewhere. The findings recorded at operation included the level of injury, the gap after resection between the proximal and distal nerve stumps, the source of the graft, the number and length of grafts, details regarding suture material, the use of fibrin clot glue, and the method and duration of splinting. Patients were reviewed at
intervals of three months for the first year and at six-monthly intervals thereafter. The recovery of the nerve was mapped by recording an advancing Tinel’s sign, and by charting the recovery of individual muscles. EMG examination was carried out sparingly either to confirm recovery or lack of it as a prelude to the appropriate musculotendinous transfers. Recovery of sensation to the skin innervated by the superficial radial nerve was not recorded.

Table I. The MRC grading of motor recovery in a mixed trunk peripheral nerve

<table>
<thead>
<tr>
<th>Grade</th>
<th>Motor recovery</th>
</tr>
</thead>
<tbody>
<tr>
<td>M0</td>
<td>No contraction</td>
</tr>
<tr>
<td>M1</td>
<td>Return of perceptible contraction in the proximal muscles</td>
</tr>
<tr>
<td>M2</td>
<td>Return of perceptible contraction in both proximal and distal muscles</td>
</tr>
<tr>
<td>M3</td>
<td>Return of perceptible contraction in both proximal and distal muscles of such degree that all important muscles are sufficiently powerful to act against resistance</td>
</tr>
<tr>
<td>M4</td>
<td>Return of function as in stage 3 with the addition that all synergic and independent movements are possible</td>
</tr>
<tr>
<td>M5</td>
<td>Complete recovery</td>
</tr>
</tbody>
</table>

Table II. Our simplified version of the MRC grading of motor recovery in a mixed-trunk peripheral nerve

<table>
<thead>
<tr>
<th>Grade of result</th>
<th>Proximal muscles</th>
<th>Distal muscles</th>
</tr>
</thead>
<tbody>
<tr>
<td>Good</td>
<td>M5 or M4 (powerful elbow extension)</td>
<td>M3 (wrist extension against gravity)</td>
</tr>
<tr>
<td>Fair</td>
<td>M3 (wrist extension against gravity)</td>
<td>M2 (extension of thumb and fingers with gravity eliminated)</td>
</tr>
<tr>
<td>Poor</td>
<td>M2 or M1</td>
<td>M1, 0</td>
</tr>
</tbody>
</table>

Table III. Levels of injury that can occur in the proximal and distal muscles

<table>
<thead>
<tr>
<th>Level of injury</th>
<th>Proximal muscles*</th>
<th>Distal muscles*</th>
</tr>
</thead>
<tbody>
<tr>
<td>High; above branches to triceps</td>
<td>Triceps</td>
<td>BR/ECRL/ECRB</td>
</tr>
<tr>
<td>Intermediate; to posterior interosseous nerve</td>
<td>BR/ECRB and ECRL</td>
<td>EPL/EDC/APL</td>
</tr>
<tr>
<td>Low; to posterior interosseous nerve</td>
<td>EDC ECU</td>
<td>EPB/EPL EI</td>
</tr>
</tbody>
</table>

* BR, brachioradialis; ECRB, extensor carpi radialis brevis; ECRL, extensor carpi radialis longus; EDC, extensor digitorum communis; EI, extensor indicis; ECU, extensor carpi ulnaris; EPL, extensor pollicis longus; APL, abductor pollicis longus; EPB, extensor pollicis brevis

Table IV. Results of repair of 242 radial nerves by wound type, by number and percentage

<table>
<thead>
<tr>
<th>Wound</th>
<th>Number of nerves repaired</th>
<th>Results</th>
<th>Good</th>
<th>Fair</th>
<th>Poor</th>
</tr>
</thead>
<tbody>
<tr>
<td>Open ‘tidy’</td>
<td>73</td>
<td>28</td>
<td>38</td>
<td>30</td>
<td>41</td>
</tr>
<tr>
<td>Closed traction</td>
<td>62</td>
<td>19</td>
<td>31</td>
<td>17</td>
<td>27</td>
</tr>
<tr>
<td>Open ‘untidy’</td>
<td>52</td>
<td>13</td>
<td>25</td>
<td>13</td>
<td>25</td>
</tr>
<tr>
<td>Associated vascular injury</td>
<td>55</td>
<td>12</td>
<td>22</td>
<td>8</td>
<td>14</td>
</tr>
<tr>
<td>Total</td>
<td>242</td>
<td>72</td>
<td>30</td>
<td>68</td>
<td>28</td>
</tr>
</tbody>
</table>

Results

Radial nerve. Only 22 (9%) of the 242 radial nerves were sutured; the remainder were grafted. The mean length of the graft was 5.3 cm (1 to 16) and the mean number of
grafts 4.6 (2 to 8). The mean delay between injury and repair was 90 days (0 to 440); 77 ‘early’ repairs (32%) were carried out within 14 days of injury. In four patients, with some recovery of muscle function, the outcome was marred by persistent significant neuropathic pain. These results were graded as poor.

**Effects of types of injury.** The chi-squared test showed significant differences in the outcome in repair between the different groups. Comparison of the open ‘tidy’ and closed traction groups suggested that the former gives a better result (p = 0.024). The differences between the open ‘tidy’ and the open ‘untidy’ groups were highly significant (p = 0.0025). The most extreme difference was seen between the open ‘tidy’ group and the group with associated vascular injuries (p = 0.0000035). Differences in outcome between the open ‘tidy’ group and the group with associated vascular injuries, and between the closed traction and vascular injury groups did not reach statistical significance (Table IV). These results show the effect of severity of injury, and in particular of arterial injury, on the results. In 22 (9%) patients, grafts exceeded 10 cm in length, and none of these achieved a good result.

**Effect of delay.** Of 77 nerves repaired within 14 days, 49% achieved a good result. Only 28% of the 169 ‘late’ repairs achieved this grade; the mean delay was 190 days (15 to 440). There were no good results in the repairs when the interval exceeded 12 months.

**Level of injury.** Four of the 21 high repairs (19%) were graded as good and of the 221 intermediate lesions 31% achieved good results.

**Posterior interosseous nerve.** Of the 18 lesions, 17 were grafted. The mean defect was 4 cm (0 to 7) in length. The mean interval from injury to repair was 76 days (0 to 220). There were 16 good results, one fair and one poor. In none of the 18 nerves was there an arterial injury and no repair was carried out after a delay of more than eight months.

**Arterial group.** Urgent vascular repair was undertaken in 22 of the 55 patients. Delayed arterial reconstruction was carried out in 16 further patients because the vessel had not been repaired primarily (6), or because repair had failed (8) or had been complicated by a false aneurysm (2). Successful arterial reconstructions had been carried out in 12 patients in the admitting hospital. In five the artery was not repaired.

**Discussion**

Several factors determine the outcome of repair of peripheral nerves in general, and of the radial nerve in particular.

The most important influence on the prognosis is the violence of the injury. The length of the graft, arterial injury and an open ‘untidy’ wound are reflections of this. Delay is a significant factor. In our series, 77 repairs were carried out within 14 days, representing a higher proportion than that seen in others. The proportion of severe injuries with combined arterial and multiple nerve rupture was also higher. We strongly recommend early repair of this nerve, in tidy wounds and in the closed-traction rupture. The radial nerve is not easy to mobilise and direct suture is possible only in the fresh ‘tidy’ wound. Repair by graft is usually required in delayed cases because of the gap after resection of the proximal and distal stumps. In iatrogenic injury “it is indeed hard for the operating surgeon to credit that he or she has been responsible for the production of a serious nerve lesion, a feeling which may cloud vision and inhibit action”. Diagnosis was delayed for more than six months in nearly one half of patients suffering transection of major nerves during operation. Repairs to the posterior interosseous nerve were probably more successful because the lesion is more distal and thus nearer to the target organ, and there is no cutaneous component to the nerve. There is, it seems, a clear relationship between the level of the lesion and the outcome after repair.

The anatomical studies of Sunderland and Bradley reveal potentially significant features. Data obtained from 20 dissections in cadavers showed that the long head of triceps is innervated by branches arising in the axilla or brachio-axillary angle, the medial head of the muscle by branches in the brachio-axillary angle, and the lateral head by branches arising in the spiral groove. The branches to brachioradialis and extensor carpi radialis consistently arise proximal to the lateral epicondylo. Bundles passing to the superficial radial nerve can be distinguished from those destined for the posterior interosseous nerve at about 8 cm proximal to the lateral epicondylo. The most distal of all branches is that to extensor indicis proprius. The number of nerve bundles at different levels within the trunk, and the relative proportions of connective tissue and neural elements, were analysed in 20 dissections. The number of nerve bundles were, on average, 22 at the axilla, five in the spiral groove and nine at the lateral epicondylo. Bundles occupied about 33% of the cross-sectional area of the trunk of the nerve in the axilla, about 50% in the spiral groove and just below 40% at the lateral epicondylo. These findings suggest that nerve repair is more difficult proximally, where the nerve fibres are more dispersed and where the proportion of connective tissue is relatively high.

The profoundly depressing effect of associated injuries to the axillary or brachial arteries (64% poor results in 65 cases) requires further examination. Mild fibrosis was evident in 18 of these cases, and compression and fibrosis of the distal trunk were common findings. Postschaemic fibrosis of muscle and ischaemic compression of the nerve are factors which contribute to the particularly poor results in this group. The blood supply of the nerve itself may be relevant. Between its origin and its entrance into the spiral groove the nerve receives fewer arteries than elsewhere along its course. The first 8 to 10 cm of the nerve may not have a nutrient artery. This segment may therefore be wholly supplied by descending intraneural channels which reach it from the posterior cord, and consequently it
will be relatively avascular if transected at its origin. The profunda brachii artery accompanies and supplies the nerve in the spiral groove and damage to this vessel compromises circulation to the nerve. Tinel first remarked on the close relationship of the nerve to the shaft of the humerus: “In its spiral tract around the humerus it is very often affected by fractures of this bone or surrounded by callus formation”.

Our results suggest that outcomes for the repair of the radial nerve have not improved during the last 50 years. One possible explanation is the higher incidence of closed-traumatic injury and associated arterial damage in this series. As reported, however, by Seddon in 1975: “Fortunately, there is a most satisfactory tendon transplantation if suture is impossible or should fail”. Dunnet, Housden and Birch reviewed 49 cases of flexor-to-extensor transfer for palsy of the radial nerve. More than two-thirds of the patients reported impaired co-ordination and dexterity, and over four-fifths loss of endurance. The mean power of wrist extension was 22% of the uninjured side and that of digital extension was 31%. The power of grip was 40% of normal. A good result from repair of the radial nerve achieves better than this. Early flexor-to-extensor transfer is indicated when the prognosis for recovery is poor. A high traction rupture of the radial nerve, with a defect between the prepared stumps exceeding 10 cm, is best treated by musculotendinous transfer. If the interval from injury exceeds 12 months, transfer is more likely to improve function.

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References