CAUSES OF FAILURE AFTER REPAIR OF THE MEDIAN NERVE

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In a recent review of the results of repair of the median nerve at the wrist we found that almost half were unsatisfactory. The present study was undertaken in order to find out the causes of failure, and to explore the possibilities of improving the results.

MATERIAL

The patients were operated upon at the Royal National Orthopaedic Hospital between January 1948 and December 1955. This gave a follow-up period of at least three years. There were forty patients in whom histological preparations of the resected nerve ends were available for study. Ten patients operated upon during the same period were excluded because histological preparations were not available.

METHODS OF EXAMINATION

Clinical—The results were analysed by the method recommended in Peripheral Nerve Injuries, the report by the Nerve Injuries Committee of the Medical Research Council (1954). This method was used by Nicholson and Seddon (1957) in their analysis of nerve repair in civil practice and we used their criteria of useful recovery to divide the cases into clinical failures and successes.

<table>
<thead>
<tr>
<th>Factors influencing result</th>
<th>Number of cases</th>
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</thead>
<tbody>
<tr>
<td>Level of lesion</td>
<td>—</td>
</tr>
<tr>
<td>Gap after resection</td>
<td>—</td>
</tr>
<tr>
<td>Extent of mobilisation</td>
<td>— (See Fig. 1)</td>
</tr>
<tr>
<td>Delay before repair</td>
<td>2</td>
</tr>
<tr>
<td>Separation of suture line</td>
<td>2</td>
</tr>
<tr>
<td>Unequal stump diameter</td>
<td>1</td>
</tr>
<tr>
<td>Incongruity of funicular pattern</td>
<td>—</td>
</tr>
<tr>
<td>Inadequate resection (distal)</td>
<td>4</td>
</tr>
<tr>
<td>Endoneurial fibrosis</td>
<td>4</td>
</tr>
<tr>
<td>Unexplained failures</td>
<td>5</td>
</tr>
<tr>
<td>Total</td>
<td>18</td>
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A useful degree of sensory recovery was defined as recovery of pain and touch sensibility throughout the autonomous area even if over-reaction to stimuli was present (Grade 2+). A useful degree of motor recovery was taken to be that in which the thenar muscles contracted against gravity (Grade 3).
Histological—Cross-sections of the nerve were made at the proximal and distal levels of resection: these were stained by the lissamine-fast-red tartrazine modification of the Masson trichrome technique (L.F.R.) (Lendrum 1947) and were examined to assess the amount of endoneurial fibrosis. This assessment was made by examination of the sections in the usual way and by a further examination with the sections between crossed polaroid sheets.

ANALYSIS OF RESULTS

Of the forty patients twenty-two had useful recovery and in eighteen the operations were regarded as failures.

POSSIBLE CAUSES OF FAILURE

The factors responsible for failure have been discussed by Seddon (1949). Those thought to be responsible in this series are shown in Table I.

Level of lesion—The level of the lesion is important but it was not relevant in this series, in which all the lesions were at the level of the wrist.

Gap—The gap that remains after resection of the nerve ends is also important and can prejudice recovery if it is greater than seven centimetres (Zachary 1954a). There was no gap of such an extent in this series.

Extent of mobilisation—Nicholson and Seddon (1957) have shown that local mobilisation of the nerve and flexion of both elbow and wrist gives a higher proportion of good results than full mobilisation to the elbow which allows suture to be carried out with the elbow flexed and the wrist neutral. A possible reason for this is that extensive mobilisation interferes with the blood supply of the nerve. Their conclusion is borne out by this series (Fig. 1).

Interval between injury and repair—The longest interval between injury and operation following which useful recovery may be expected in this type of case is said to be thirty-two months (Zachary 1954b). Two patients in this series were operated upon after longer intervals, and in both the operation was a clinical failure. In each of these cases, however, the resection of the distal stump was not clear of glioma. In this series the longest interval followed by a satisfactory result was fifteen months.

Post-operative separation of the suture line—Two patients who did not make the anticipated recovery agreed to re-exploration about nine months later and were found to have large neuromata at the site of the previous suture, possibly indicating that separation had occurred. Such separation can be detected if radio-opaque markers are attached to the nerve sheath near the suture line (Fig. 2) and observed radiographically. Too rapid extension of the elbow and wrist after the operation is a possible cause of rupture at the suture line. However, the rate of extension was no greater in the cases of failure than in patients with successful results.

Condition of the nerve stumps—The gross condition of the nerve stumps is also important. In one failure the diameter of the distal stump was noted at operation to be much smaller than that of the proximal stump.
Other factors—Incongruity of the funicular pattern is a cause of failure in proximal lesions, and one over which the surgeon has no control (Sunderland 1945). At the level of the wrist, however, motor and sensory divisions of the nerve are well defined.

In every case the level of resection was judged to be adequate at the time of operation. That is, there was no palpable thickening of the nerve, the epineurium was mobile, and there appeared to be intact nerve bundles at both proximal and distal levels of resection. In eight cases this clinical judgment was not supported by the histological findings. In three cases the proximal level of resection had passed through neuromatous tissue. In two of these the clinical result was satisfactory, and in the remaining case, which was a failure, the distal section was through glioma. In three other cases the distal section passed entirely through glioma and these were clinical failures. It appears that the presence of neuromatous tissue in the proximal stump does not preclude useful recovery, but that the presence of gliomatous tissue in the distal stump is more sinister.

The degree of fibrosis of the endoneurium can also be a limiting factor in recovery after suture (Holmes and Young 1942). All degrees of increase in the endoneurial collagen were seen up to a stage where it was as thick inside the nerve bundle as around it (Figs. 3 to 6). There was, of course, variation between individual nerve bundles in any given case although they usually showed the same degree of fibrosis. In all cases empty Schwann tubes were found in the distal nerve bundles, although they were smaller and less numerous in those bundles showing the most fibrosis. In four cases there were bundles of collagen in the endoneurium as thick as those in the epineurium (Fig. 6) (three in the distal end only, and one in both proximal and distal ends). All the four patients had poor clinical results and it is suggested that this degree of collagenisation may have affected the result.

DISCUSSION

Two major points have emerged from this study. The first concerns the use of radio-opaque markers. In two cases in which re-exploration was agreed to, the finding of a large neuroma suggested that the suture line might have parted. If radio-opaque markers had been used this could have been determined at an early stage, and re-exploration carried out immediately. Separation of the suture line may have been the critical factor in the five unexplained failures in this series. The use of markers adds little time to the operation and removes doubts about failure from this cause.

The second point concerns the adequacy of resection of the nerve ends. In four patients with a poor result the distal face was found to be composed of gliomatous tissue, and in four other cases of clinical failure there was considerable endoneurial collagenisation. The evidence that we have indicates that endoneurial fibrosis up to the degree depicted in Figure 5 is compatible with a satisfactory clinical result, and the aim should be to resect the end-bulbs so that this, or a more favourable result, is achieved.
Provided that the final gap does not exceed seven centimetres the nerve ends may be resected repeatedly until the best condition is achieved. Since the degree of endoneurial fibrosis often decreases considerably over quite short distances, especially in the distal stump (Figs. 7 and 8), there is considerable encouragement to perform "trial sections." Histological control of this procedure would be required and this means the preparation and examination of frozen sections.

Examples of the degree of fibrosis found in nerve bundles in this series of cases, from the minimal increase depicted in Figure 3 to the condition in Figure 6 where condensation of collagen in the endoneurium has produced birefringent bundles as thick as those found in the surrounding connective tissue. (Paraffin sections Lissamine-fast red. Polarised light, × 100.)

The material from a few patients has been examined as frozen sections, both as unstained preparations examined between crossed polaroid sheets and after staining with L.F.R. Provided that no fat solvents make contact with the unstained section, both the degree of fibrosis and the density and size of myelin sheaths may be assessed in such sections, which can be prepared in a few minutes (Figs. 9 and 10). These sections have been preserved in water mountant
and do not appear to have deteriorated. The stained preparations, although different in some respects from paraffin-embedded material, give as much information and appear to be as permanent as paraffin sections (Figs. 11 to 14). We hope, therefore, to give this technique a fuller trial, although Blackwood and Holmes (1954) concluded that the disadvantages attached to the use of frozen sections outweigh their usefulness as applied to the particular problem of nerve repair.
One large and two smaller bundles of nerve fibres occupy the centre of the photomicrograph. The brightly birefringent circles, some of which have a "hot cross bun" appearance, are myelin sheaths. (Frozen section, unstained in water: proximal stump. Polarised light, ×80.)

The nerve bundles do not contain any large myelinated fibres. There is an increase in the collagenisation of the neurium. (Frozen section, unstained in water: distal stump. Polarised light, ×80.)
The striking feature of peripheral nerve frozen sections is the larger size of the myelinated sheaths as compared with similar material embedded in paraffin. (Proximal level of resection. Frozen section Lissamine-fast red. 80.)

Proximal level of resection. A "conventional" section for comparison with Figure 11. (Paraffin section Lissamine-fast red. 80.)
Distal level of resection. One of the disadvantages of unembedded sections, the tendency for the section to break up, is obvious. This section gives essential information about adequacy of resection: it is clear of glioma and not severely collagenised. (Frozen section Lissamine-fast red, × 80.)

Distal level of resection. A "conventional" histological section for comparison with Figure 13. Although this section is aesthetically more pleasing it does not provide any information that cannot be found in a stained frozen section. (Paraffin section Lissamine-fast red, × 80.)
SUMMARY

1. The clinical results in forty cases of repair of the median nerve at the wrist have been examined. Almost half were unsatisfactory.

2. The factors that may have predisposed to failure of adequate re-innervation are discussed.

3. The results might be improved by the use of radio-opaque markers for early detection of separation at the suture line, and by the use of frozen sections to determine the adequacy of resection.

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REFERENCES


