Results of Treatment of Severe Carpal-Tunnel Syndrome without Internal Neurolysis of the Median Nerve

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ABSTRACT: Thirty-three hands (twenty-nine patients) had a release of the carpal tunnel without internal neurolysis for severe carpal-tunnel syndrome. All of the hands had increased values for two-point discrimination or thenar atrophy, or both. Twenty-three (89 per cent) of the twenty-six hands that had increased values for two-point discrimination and twenty-six (87 per cent) of the thirty hands that had an elevated result on Semmes-Weinstein testing had normal values at follow-up. Nine (90 per cent) of the ten hands that had weakness of the thenar muscles (grade-3 strength or less) regained grade-4 or 5 strength. Thirteen (65 per cent) of the twenty hands that had thenar atrophy regained normal muscle bulk. Eighteen (62 per cent) of the twenty-nine patients had complete resolution of symptoms and signs of compression of the median nerve.

No significant difference was found between the results in this series of patients and those in a previously reported similar group of patients who were treated by release of the carpal tunnel combined with internal neurolysis of the median nerve.

In 1973, Curtis and Eversmann reported on a series of patients with carpal tunnel syndrome who were treated by division of the transverse carpal ligament and internal (interfascicular) neurolysis of the palmar 50 per cent of the median nerve. They concluded that internal neurolysis was an effective adjunctive technique for the treatment of carpal tunnel syndrome associated with sensory loss or thenar atrophy, or both. Other authors, however, have questioned the value of neurolysis, suggesting that intraneural division may lead to increased interfascicular fibrosis.

The purpose of this prospective clinical study was to compare the results in a group of patients in whom severe carpal-tunnel syndrome was treated by release of the carpal tunnel alone with the results in a previously reported series of patients who were treated by release of the carpal tunnel combined with internal neurolysis of the median nerve.

Methods

Between July 1978 and September 1985, sixty hands (sixty-one patients) with severe carpal-tunnel syndrome that was associated with sensory loss or thenar atrophy, or both, were treated operatively at the University of California San Diego Medical Center and Veterans Administration Hospital and the University of California Hospital at Davis. The staff surgeons at all three hospitals had been trained by the senior one of us (R. H. G.) and used similar operative techniques. All of the patients exhibited the characteristic signs and symptoms of carpal-tunnel syndrome and had electrodiagnostic confirmation of compression of the median nerve. All patients had severe carpal-tunnel syndrome, demonstrating either thenar atrophy or increased values for two-point discrimination in the distribution of the median nerve, or both. Group I consisted of the first consecutively treated thirty-six hands and thirty-two patients, underwent release of the carpal tunnel and internal neurolysis of the median nerve. Group II consisted of the subsequently treated thirty-three hands and twenty-nine patients, underwent release of the carpal tunnel without neurolysis.

Preoperatively, there were no statistically significant differences between the two groups with regard to age, hand dominance, values for two-point discrimination,
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atrophy, Semmes-Weinstein monofilament values, muscle strength, and electrodiagnostic findings (p > 0.05 for each, as determined by the Student t and chi-square tests). Prospective data sheets were completed for all of the patients preoperatively and postoperatively until the study was completed. The results of the study of the Group-I patients have been reported previously.

The average age of the patients in Group II was fifty-five years (range, twenty-eight to eighty-four years). There were seventeen men and twelve women. Eighty right hands and fifteen left hands were operated on. The length of follow-up was a minimum of one year, or until symptoms and physical findings returned to normal. The average length of follow-up was sixteen months.

Preoperatively, all patients had complained of pain or numbness in the distribution of the median nerve. Sensibility of each digit that was innervated by the median nerve was tested with the Weber two-point discrimination test, using a dull-pointed eye caliper applied in the longitudinal axis while not blanching the skin. The radial and ulnar sides of the ring finger were tested separately. The classifications of the values for two-point discrimination were: normal (zero to six millimeters), fair (seven to ten millimeters), poor (eleven to fifteen millimeters), and protective (more than fifteen millimeters). Seven hands had normal, eleven had fair, and one had poor two-point discrimination. Fourteen had protective sensibility (Table I). Thirty-one hands also had Von Frey pressure testing using the Semmes-Weinstein pressure aesthesiometer. Preoperatively one hand was in the normal range of 2.44 to 2.83 (0.0276 to 0.068 force [gram]), fourteen were in the range of 3.22 to 3.84 (0.166 to 0.693 force [gram]), and sixteen were in the range of more than 3.84 (more than 0.693 force [gram]) (Table II).
The strength of the thenar muscles was tested in thirty hands. The strength of the abductor pollicis brevis and opponens pollicis muscles was manually graded on a scale of zero to 5 according to the classification of the American Orthopaedic Association. Preoperatively, the strength of the thenar muscles was grade 1 in one hand, grade 2 in two hands, grade 3 in seven hands, grade 4 in fourteen hands, and grade 5 in six hands (Table III). Thenar atrophy was measured in thirty-two hands. It was graded as none, mild to moderate, or severe based on the bulk and contour of the thenar eminence. Mild to moderate atrophy consisted of flattening of the thenar eminence, and severe atrophy consisted of excavation along the proximal radial border of the thenar eminence (Figs. 1-A and 1-B). Twenty hands had clinical atrophy preoperatively, seventeen being mild to moderate and three being severe (Table IV).

Electrodiagnostic studies were done on all hands. A distal motor latency of the median nerve that was longer than 4.5 milliseconds or a sensory latency that was longer than 3.5 milliseconds was considered to be abnormal. Preoperatively, the average distal motor latency of the median nerve was 6.5 milliseconds (range, 3.9 to 13.0 milliseconds), with two hands having no motor response to stimulation.

<p>| TABLE I |
|-----------------|-----------------|
| <strong>VALUES FOR TWO-POINT DISCRIMINATION</strong> | <strong>(THIRTY-THREE HANDS) (No. of Hands)</strong> |</p>
<table>
<thead>
<tr>
<th>Preoperative</th>
<th>Postoperative</th>
</tr>
</thead>
<tbody>
<tr>
<td>Normal (0-6 mm)</td>
<td>7</td>
</tr>
<tr>
<td>Fair (7-10 mm)</td>
<td>11</td>
</tr>
<tr>
<td>Poor (11-15 mm)</td>
<td>1</td>
</tr>
<tr>
<td>Protective (&gt;15 mm)</td>
<td>14</td>
</tr>
</tbody>
</table>

Three hands using two-point discrimination. These one hands were tested with the Semmes-Weinstein monofilaments. Strength and atrophy of the thenar muscles were determined in thirty and thirty-two hands, respectively.

**Results**

**General**

Eighteen patients (twenty-two hands) had complete resolution of the preoperative symptoms and abnormal physical findings. The average time from operation to complete resolution of the symptoms was three months (range, three weeks to eighteen months). Twenty-two of these patients (eighteen hands) had had preoperative nocturnal symptoms. Twenty-two of these hands (eighteen patients) had had preoperative values for two-point discrimination.

Twelve hands (ten patients) had had thenar atrophy. Twelve hands (ten patients) had had thenar atrophy. The presence of both abnormal two-point discrimination and thenar atrophy had no apparent effect on the length of time it took for these abnormal findings to resolve.

Seven patients (seven hands) had complete resolution of the symptoms but had persistent abnormal physical findings. Five (five hands) of the seven had had preoperative nocturnal symptoms. Three hands had persistent elevation of values for two-point discrimination. Two of these had improved from protective to fair two-point discrimination, but one remained unchanged. The thenar atrophy—in all these hands (six patients) had not improved, although in nine of these hands the motor strength had improved one grade.

Three patients (three hands) had complete resolution of the abnormal physical findings but had persistent symptoms. Two had relief of paresthesias and pain at night, but still complained of mild numbness. The third patient continued to complain of numbness and pain, although values for two-point discrimination had decreased from four to four millimeters, the values on Semmes-Weinstein monofilament testing had returned to normal from preoperative values of more than 3.84 (more than 0.693 force [g]) and motor strength had increased from grade 4 to 5.

One patient (one hand) had neither resolution of symptoms nor significant improvement of the abnormal physical findings. Paresthesias, mild-to-moderate atrophy, and increased two-point discrimination (eight millimeters) were still present seventeen months postoperatively.

**Assessment of the Thenar Muscles**

Seventeen hands had mild-to-moderate atrophy, three hands had had severe atrophy preoperatively. Two
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<table>
<thead>
<tr>
<th>TABLE IV</th>
</tr>
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<tbody>
<tr>
<td>THENAR MUSCLE ATROPHY (THIRTY-TWO HANDS) (No. of Hands)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Preoperative</th>
<th>Postoperative</th>
</tr>
</thead>
<tbody>
<tr>
<td>None</td>
<td>12</td>
</tr>
<tr>
<td>Mild to moderate</td>
<td>17</td>
</tr>
<tr>
<td>Severe</td>
<td>3</td>
</tr>
</tbody>
</table>

of the hands that had had mild-to-moderate atrophy and one that had had severe atrophy regained normal muscle bulk postoperatively. Nine hands (69 per cent) did so by one year and three hands (23 per cent), by two years (Table V). One hand with mild-to-moderate atrophy preoperatively regained normal muscle bulk by forty-one months postoperatively. This hand had been lost to follow-up for several months, however, and atrophy may have resolved earlier. The five hands with mild-to-moderate atrophy preoperatively that did not regain normal muscle bulk were followed for sixteen, seventeen, twenty-three, twenty-four, and twenty-eight months. The two hands with severe atrophy preoperatively that did not regain normal bulk of the thenar muscles were followed for seventeen and twenty-four months.

Postoperatively, strength of the thenar muscles was graded as 3 in one hand, 4 in eleven hands, and 5 in eighteen hands. No hand became weaker. Most hands improved by one grade in muscle strength, and six improved by two grades. Several hands regained muscle strength, although muscle bulk did not appear to improve. Nineteen of the twenty hands that had had atrophy preoperatively had postoperative evaluations of muscle strength. Eighteen of the nineteen hands had grade-4 or 5 strength, including two of the three hands that had severe atrophy.

Sensibility

All of the hands had either improved or unchanged sensibility postoperatively. Thirty hands had normal, two had fair, and one had poor two-point discrimination. None had protective sensibility (Table I). Twelve of the fourteen hands that had had only protective sensibility preoperatively had normal values postoperatively.

Twenty-six hands had elevated values for two-point discrimination preoperatively. Twenty-three of them had normal values postoperatively: twenty-two (96 per cent) by six months (Table VI) and one hand, which had had fair two-point discrimination preoperatively, by eighteen months. This hand had been lost to follow-up for seven months, however, and may have returned to normal early.

Excluding that hand, the mean times for the hands with poor, and protective sensibility to return to normal values for two-point discrimination were 1.6, 2.0, and 3.5 months, respectively. The three hands that did not regain normal two-point discrimination (two with protective and one with poor sensibility preoperatively) were followed for twelve, seventeen, and seventeen months.

Twenty-six hands had improved values on Semmes-Weinstein monofilament testing. Four hands remained normal postoperatively: two in the range of 3.22 to 3.34 (0.166 to 0.693 force [gram]) and two in the range of 3.34 to 3.84 (more than 0.693 force [gram]). Despite the presence of three of these four hands had normal and one had elevated values for two-point discrimination postoperatively.

Operative Findings

At operation most nerves demonstrated compressive changes beneath the transverse carpal ligament that consisted of thickening, loss of epineural vascularity, and fibrosis. There was no apparent correlation between the degree of venous compression and the severity of the patient's symptoms.

There were no operative or postoperative complications.

Discussion

Experimental studies have suggested that the early manifestation of low-grade peripheral nerve compression is reduced epineural blood flow. Continued compression causes stasis of capillary circulation due to impairment of venous occlusion, but the impairment of blood flow is rapidly reversible when the compression is released. When compression is prolonged, however, impairment of capillary circulation causes hypoxic injury to intraneural capillaries. Epineural edema develops, followed by perineural (infracapsular) edema. It has been suggested that perineural edema interferes with nerve function by altering the local ionic environment of axons and decreasing capillary flow as a result of elevated endoneurial fluid pressure. Since the diffusion barrier of the perineurium is resistant to ischemia, endoneural edema cannot travel through the perineural membrane. A vicious cycle...
established, which Lundborg et al. called an endoneural "compartment syndrome in miniature". Sunderland proposed that long-standing edema induces invasion by fibroblasts, breakdown of the perineurium, intraneuronal fibrosis (both interfascicular and intrafascicular), demyelination, and axonal degeneration.

The physiological effect of operative neurolysis of a severely compressed peripheral nerve is unknown. The goal is to release fascicles from investing epineural scar, thereby reducing fascicular constriction and allowing recovery of nerve function. In 1985, Rhoades et al. reported on the safety and effectiveness of internal neurolysis in the treatment of severe compression of the median nerve in the carpal tunnel. That study was based on a prospective series of thirty-six hands in thirty-two patients who had release of the carpal tunnel and internal neurolysis of the median nerve (Group I). After the results of that series were reported, we were encouraged to do a second prospective study. We established a control series of patients who had equal severity of carpal-tunnel syndrome. Accordingly, the present study compared the two groups (Group II) underwent release of the transverse ligament without internal neurolysis of the median nerve. We established a control group not because of dissatisfaction with the clinical outcome of Group I, but because of continued interest in determining the best possible treatment for patients who have severe carpal-tunnel syndrome.

A comparison of motor weakness of the thenar muscles preoperatively and postoperatively in the two groups.

A comparison of atrophy of the thenar muscles preoperatively and postoperatively in the two groups.
The characteristics of both groups were statistically similar preoperatively and had few significant differences postoperatively, as determined by the Student t and chi-square tests. The average time to complete resolution of symptoms was 4.7 months in the thirty-two patients (thirty-six hands) in Group I (treated with internal neurolysis) and 3.0 months in the twenty-nine patients (thirty-three hands) in Group II (treated without neurolysis) (p > 0.05). The majority of patients in both groups had improvement of sensory and motor abnormalities. Three (10 per cent) of twenty-nine hands in Group I and one (3 per cent) of thirty hands in Group II had thenar motor strength of grade 3 or less postoperatively (p > 0.05) (Fig. 2). Nine (25 per cent) of thirty-six hands in Group I and seven (22 per cent) of thirty-two hands in Group II had thenar atrophy postoperatively (p > 0.05) (Fig. 3). Seven (19 per cent) of thirty-six hands in Group I and three (9 per cent) of thirty-three hands in Group II had persistent elevation of values for two-point discrimination postoperatively (p > 0.05) (Fig. 4).

There were two areas of significant difference, however, between the two groups. Ten (31 per cent) of the patients in Group I had complete resolution of symptoms and objective signs as compared with eighteen (62 per cent) of the patients in Group II (p < 0.05) (Fig. 5). Six (55 per cent) of eleven hands in Group I and four (13 per cent) of thirty-one hands in Group II still had abnormal values on Semmes-Weinstein threshold testing postoperatively (p < 0.01) (Fig. 6).

Thirty-one per cent of Group-I patients had complete resolution of symptoms and signs, 71 per cent had return of normal values for two-point discrimination, and 50 per cent regained normal thenar-muscle bulk. Sixty-two per cent of Group-II patients had complete resolution of symptoms and signs, 89 per cent had return of normal values for two-point discrimination, and 65 per cent of the patients regained normal thenar-muscle bulk.

The similarity in the findings in Groups I and II indicates that internal neurolysis does not significantly affect the clinical function of the median nerve or improve surgical outcome. The favorable results reported in the study (Group I) may not have been due to internal neurolysis at all, but rather to the release of the transverse carpal ligament, with a consequent decrease in extraneural pressure. Secondary changes within the nerve, which have been precipitated by ischemia or mechanical deformation, resolved spontaneously in most patients over time. In the patients who did not recover full function, internal neurolysis made no significant difference. It is possible that changes once perineural breakdown and endoneural fibrosis have occurred.

A comparison of two-point discrimination preoperatively and postoperatively in the two groups.

A comparison of complete resolution of symptoms in the two groups.
occurred, operative techniques of this type are not effective in improving nerve function.

The indication for surgery in both groups of patients was carpal tunnel syndrome associated with either elevated values for two-point discrimination in the distribution of the median nerve or thenar atrophy, or both. The quantification of thenar atrophy was particularly difficult. We attempted to standardize its assessment by simplifying the classification and by using the same examiners whenever possible. A close look at Group II reveals that of the hands that had mild-to-moderate atrophy, 71 per cent (twelve of seventeen hands) regained normal muscle bulk at an average of 11.9 months postoperatively. Interestingly, of the hands that did not regain normal muscle bulk, 80 per cent (four of five hands) had grade-4 or 5 strength of the abductor pollicis brevis and opponens pollicis muscles postoperatively. In both Groups I and II, however, only one of the five hands with severe atrophy had regained normal muscle bulk at final follow-up. Over-all, nine (50 per cent) of the hands in Group I and thirteen (65 per cent) in Group II that had atrophy preoperatively regained normal thenar-muscle bulk.

A significant percentage of hands in both groups did not improve postoperatively. Seven (19 per cent) of the hands in Group I had continued elevation of values for two-point discrimination postoperatively, and nine (25 per cent) in Group II had persistent thenar atrophy. Three (9 per cent) patients in Group II had continued elevation of values for two-point discrimination, and seven (22 per cent) had persistent atrophy.

No correlation was found between the operative and age, duration of symptoms, preoperative physiognoms, or electrodiagnostic values that could be used to predict the final outcome. We had originally hoped that increased values for two-point discrimination or thenar atrophy would indicate which hands with carpal tunnel syndrome were most likely to do well with release of the carpal tunnel. Instead, we found that the majority of hands in both groups had satisfactory results, independent of the preoperative severity and motor function.

Previously, it was concluded that internal neurorrhaphy of the median nerve ‘‘should be performed when the severe muscle atrophy, and/or two-point discrimination values greater than 15 millimeters’’ 6. As a result of the comparative study, however, our opinion has changed. We no longer perform internal neurolysis as an adjunct to vision of the transverse carpal ligament since the results of this study failed to demonstrate a significant benefit to treatment of carpal tunnel syndrome.

References

4. GREEK, D. P.: Personal communication.