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Background: Compared with the open technique, endoscopic carpal tunnel release has a shorter postoperative recovery period but has been associated with an increased risk of iatrogenic injury. Because of morbidity of the open method, including painful scars, pillar pain, tendon adhesions, scar entrapment of the median nerve, chronic regional pain syndrome, and a longer postoperative recovery period, many patients have been treated nonoperatively to circumvent or forestall surgery, resulting in unrelieved median nerve compression and an increased risk of permanent nerve injury.

Methods: Inclusion criteria included a diagnosis of carpal tunnel syndrome based on history and physical examination and electrodiagnostic studies; failure of a short trial of conservative therapy; and advanced disease as evidenced by sensory, motor, or atrophic changes in the median nerve distribution. Exclusion criteria included prior surgery, wrist extension of less than 40 degrees, mass within the carpal tunnel, Guyon’s syndrome, and bony carpal tunnel abnormalities. Patients meeting these criteria were treated by the Brown two-portal endoscopic technique.

Results: A total of 14,722 patients were treated with the Brown endoscopic procedure. Eleven patients (0.07 percent) required conversion to an open procedure. There was one iatrogenic injury. Postoperative results were inversely related to the severity of the preoperative electrodiagnostic studies and the duration of symptoms regardless of the method of nonoperative treatment given.

Conclusions: Operative decompression should be carried out promptly if symptoms have been present for 2 months or longer, as the occurrence of permanent nerve damage has been noted within this time frame. The authors advocate use of the two-portal endoscopic technique as previously described by Brown et al. for this purpose. (Plast. Reconstr. Surg. 120: 1911, 2007.)

For nearly two decades, there has been a lack of consensus regarding the operative intervention for the treatment of carpal tunnel syndrome (i.e., open versus endoscopic release of the transverse carpal ligament). The aim of this article is to present our experience in 14,722 patients using the two-portal endoscopic procedure as described by Brown et al. over a 12-year period and to discuss the evolution of the standard of care of those afflicted with this syndrome in the context of the findings of this study.

PATIENTS AND METHODS

This is a retrospective study of all consecutive patients treated at a tertiary hand surgery referral center staffed by four hand surgeons, with a large referral base both nationally and internationally, over a 12-year period from 1993 to 2005 inclusive. All patients with a definitive diagnosis of carpal tunnel syndrome based on history and physical examination, confirmed by electrodiagnostic studies and treated by endoscopic carpal tunnel release as described by Brown et al. were included.
in the study. Those patients having had prior carpal tunnel surgery (either open or endoscopic), less than 40 degrees of passive extension of the wrist, a mass within the carpal tunnel, ulnar entrapment at Guyon’s canal, or bony abnormalities noted on a carpal tunnel view of the wrist were excluded.

The duration of the patient’s symptoms and nonoperative management, if any, was noted. A clinical diagnosis of carpal tunnel syndrome was established by the presence of three or more of the following findings: a history of recurrent or persistent paresthesias in the median nerve distribution, worsening of symptoms with hand activity, nocturnal awakening with paresthesias, and the presence of a positive Tinel’s and/or Phalen’s sign on physical examination. Baseline anteroposterior, lateral, and carpal tunnel view radiographs were obtained on the involved hands in all patients to exclude the presence of a space-occupying bony lesion of the carpal tunnel or the presence of concomitant disease. All patients diagnosed with carpal tunnel syndrome on a clinical basis were referred for confirmatory electrodiagnostic tests (i.e., nerve conduction studies and electromyography). These were administered within 2 weeks of the patient’s initial visit. β Nerve conduction studies were considered positive if they met any of the following criteria: (1) a median motor latency of greater than or equal to 4.1 msec; (2) a median sensory latency of greater than 3.6 msec; (3) a median mid-palmar sensory latency of greater than or equal to 2.1 msec; (4) a transcarpal orthodromic median to ulnar latency comparison study of greater than or equal to 0.3 msec; and/or (5) a transcarpal orthodromic median to radial sensory latency of greater than or equal to 0.9 msec.

For this study, patients were segregated into four grades of severity of median nerve compression in the carpal tunnel on the basis of delayed sensory latency determined by electromyography: grade I, 3.7 to 4.19 msec; grade II, 4.2 to 4.9 msec; grade III, 5.0 to 7.0 msec; and grade IV, greater than 7.0 msec.

Those patients with a definitive diagnosis of carpal tunnel syndrome with a short duration of symptoms (i.e., <2 months), intermittent in occurrence, and no findings of muscle weakness or atrophy were given a short course of nonoperative treatment consisting of oral nonsteroidal antiinflammatory agents and on occasion a short course of oral steroids. No steroids were given by injection, to minimize the risk of iatrogenic injury. All patients treated nonoperatively were given a volar wrist splint to wear at night and advised to modify any activity that aggravated their symptoms. Nonoperative therapy was abandoned in favor of surgical intervention if complete resolution of symptoms was not obtained within a 3-week period.

For those patients with a history of long-standing symptoms; a prior history of failed nonoperative therapy; or findings of sensory deficit in the median nerve distribution, thenar muscle weakness, or atrophy, surgery was carried out without delay. Surgical decompression of the carpal tunnel was performed using the two-portal endoscopic technique as described by Brown et al.1–3 For those patients with bilateral involvement with failed conservative therapy, decompression of the contralateral side was offered within 1 week of the initial surgery, provided that there were no medical contraindications. Conversion to an open procedure was performed in the case that any difficulties were encountered.

Postoperatively, patients were followed up at 1 week, at 4 to 6 weeks, and at 3 months. Those with resolution of symptoms were then given an open appointment. In those patients whose symptoms were unresponsive to surgery after a 6-week period, repeat electrodiagnostic studies were performed. Those with lack of improvement from preoperative studies were then offered an open carpal tunnel release and an external neurolysis if indicated by intraoperative findings.

The success of the surgery was determined on the basis of resolution of the patient’s symptoms. Patients whose symptoms failed to resolve 12 months after either an endoscopic or a secondary open carpal tunnel release with neurolysis were assessed as having permanent nerve damage.

There were two subgroups in the study, a group of 2163 patients who were followed over a 10-year period and a smaller group of 591 patients who had undergone an open carpal tunnel release elsewhere before having an endoscopic release on the contralateral side at our facility. The latter group was given a questionnaire to elicit their assessment of both surgical procedures from the patient’s point of view.

The Spearman rank correlation test was used to determine the correlation of the preoperative electrodiagnostic severity grade of median nerve compression with the following parameters:

1. The average duration of symptoms in nonworkers’ compensation patients in which the method of preoperative treatment was known.
2. The incidence of permanent nerve injury (e.g., those patients who were improved or
with no change following endoscopic carpal tunnel release in both the non–workers’ and workers’ compensation patients.

3. Incidence of severe permanent nerve damage (e.g., in those patients with no change following open revision surgery in both the non–workers’ and workers’ compensation groups.

Brown Two-Portal Endoscopic Procedure

We prefer a short general anesthetic or regional intravenous anesthesia if there are medical contraindications to a general anesthetic. Two surgeons working together ensure a smooth and flawless execution of the procedure. Each surgeon has a dedicated video monitor. The technique of the Brown two-portal endoscopic procedure is illustrated in Figures 1 through 10.

RESULTS

Over the duration of the study, a total of 14,722 patients underwent endoscopic carpal tunnel release, using the technique described by Brown et al.1–3 Of this population, a total of 12,494 were non–worker’s compensation patients and 2228 were worker’s compensation patients.

The preoperative electrodiagnostic severity grade was positively correlated with the average duration of symptoms, regardless of the method of nonoperative treatment given, the incidence of permanent nerve injury following endoscopic release in both workers’ and non–workers’ compensation patients, and the incidence of severe permanent nerve damage following open revision in both groups. In each case, the Spearman rank correlation coefficient \( r_s \) was 1 (i.e., \( p < 0.001 \)) (Table 1).

Of the 12,494 non–workers’ compensation patients in the study, data regarding the method of nonoperative treatment was available for a total of

Fig. 1. Instruments used in the Brown two-portal endoscopic procedure are manufactured by Instratek, Inc. (Houston, Texas). Pictured from the top downward are the synovial elevator, the obturator fitted with the slotted cannula, the probe, and the hook knife.

Fig. 2. Preoperative markings. The dotted lines denote the position of the palmaris longus tendon. The incision for the proximal portal is located 1 to 2 cm proximal to the distal wrist crease, is 1 cm in length, and is concealed within the proximal wrist crease when possible. The position of the distal edge of the transverse carpal ligament is estimated by the drawing of two points 3 to 3.5 cm and 4 to 4.5 cm distal to the distal wrist crease along a line from the palmaris longus tendon (or mid-palmar point if the tendon is absent) to the third web space. A 1-cm circle drawn around the distal portal denotes the position of the exit zone for the obturator.

Fig. 3. The synovial elevator is introduced into the proximal portal and used to separate the ulnar bursa and synovium from the undersurface of the transverse carpal ligament. The transverse fibers should be palpable at the end of this phase of the operation.
12,171 patients. The duration of symptoms directly correlated with the grade of severity of the patient’s preoperative electrodiagnostic tests irrespective of the manner of nonoperative treatment given (Fig. 11). Of these patients, 6824 received no preoperative treatment (i.e., surgery only), 3419 received nonsteroidal antiinflammatory drugs orally, 1182 received nonsteroidal antiinflammatory drugs and steroids orally, and 746 patients received steroid injections to the carpal tunnel.

The numbers of patients receiving each method of nonoperative treatment given are listed in Table 2. (Please note that patients treated with steroid injections of the carpal tunnel had these administered elsewhere before evaluation and treatment at our facility.)

Of the entire group of non-workers’ compensation patients, total of 2624 patients were assessed as grade I, 6997 patients were assessed as grade II, 2374 patients were assessed as grade III, and 499 patients were assessed as grade IV (Table 3). A total of 10 patients (0.08 percent) required conversion to an open procedure. After surgery, the percentage of patients having complete resolution of symptoms in each grade was inversely related to the grade of severity, whereas those patients with
some component of permanent nerve injury (i.e., those improved and with no change) was positively related to increasing grade of severity Figure 12. Of the group as a whole, symptoms completely resolved in 10,326 patients (82.6 percent). A total of 1836 patients (14.7 percent) had marked improvement with incomplete resolution of their symptoms and 322 patients (2.6 percent) had no improvement, requiring an open revision and external neurolysis.

Similarly, improvement of symptoms in those undergoing an open revision in the non–worker’s compensation group was also inversely related to increasing grade of severity, although all patients in the revision group had some component of permanent nerve damage (Table 4 and Fig. 13). Of the 2163 patients in the non–worker’s compensation group who were followed for a 10-year period, 81 (3.7 percent) had recurrence of their symptoms and subsequently required an open revision.

A total of 591 patients in this group had undergone an open procedure of the carpal tunnel...
The grade of preoperative electrodiagnostic grade of severity versus average duration of symptoms. The grade of preoperative electrodiagnostic grade of severity is directly proportional to the duration of symptoms, regardless of the method of nonoperative treatment given.

### Table 2. Method of Nonoperative Therapy in 12,171 Non–Workers’ Compensation Patients

<table>
<thead>
<tr>
<th>Electrodiagnostic Degree of Severity</th>
<th>Surgery</th>
<th>NSAIDs</th>
<th>NSAIDs and Oral Steroids</th>
<th>Steroid Injections</th>
</tr>
</thead>
<tbody>
<tr>
<td>Grade I</td>
<td>1501</td>
<td>821</td>
<td>236</td>
<td>149</td>
</tr>
<tr>
<td>Grade II</td>
<td>3753</td>
<td>1949</td>
<td>686</td>
<td>418</td>
</tr>
<tr>
<td>Grade III</td>
<td>1365</td>
<td>581</td>
<td>236</td>
<td>134</td>
</tr>
<tr>
<td>Grade IV</td>
<td>205</td>
<td>68</td>
<td>24</td>
<td>45</td>
</tr>
<tr>
<td>Totals</td>
<td>6824</td>
<td>3419</td>
<td>1182</td>
<td>746</td>
</tr>
</tbody>
</table>

NSAIDs, nonsteroidal antiinflammatory drugs.

### Table 3. Results of Endoscopic Carpal Tunnel Release in Non–Workers’ Compensation Patients

<table>
<thead>
<tr>
<th>Grade</th>
<th>No. of Patients</th>
<th>Asymptomatic</th>
<th>Improved</th>
<th>No Change</th>
<th>Open Conversion</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>2624</td>
<td>2495</td>
<td>100</td>
<td>27</td>
<td>2</td>
</tr>
<tr>
<td>II</td>
<td>6997</td>
<td>6178</td>
<td>623</td>
<td>190</td>
<td>6</td>
</tr>
<tr>
<td>III</td>
<td>2874</td>
<td>1571</td>
<td>724</td>
<td>77</td>
<td>2</td>
</tr>
<tr>
<td>IV</td>
<td>499</td>
<td>82</td>
<td>389</td>
<td>28</td>
<td>0</td>
</tr>
<tr>
<td>Totals</td>
<td>12,494</td>
<td>10,326</td>
<td>1836</td>
<td>322</td>
<td>10</td>
</tr>
</tbody>
</table>

Fig. 11. Postoperative results of endoscopic carpal tunnel release in non–workers’ compensation patients. Note that the percentage of patients with permanent nerve injury is directly related to an increasing preoperative electrodiagnostic grade of severity.
elsewhere before having an endoscopic release of the contralateral hand at our center. Of these, a total of 588 patients (99.5 percent) recommended the endoscopic over the open procedure on a follow-up questionnaire.

Of the 2228 patients in the workers’ compensation group, a total of 512 were assessed to be grade I; 1315 patients, grade II; 334 patients, grade III; and 67 patients, grade IV. One patient required conversion to an open carpal tunnel release (Table 5). As in the non–workers’ compensation group, complete resolution of symptoms in the workers’ compensation group was inversely related to increasing grade of severity of preoperative electrodiagnostic test results, in a parallel but downwardly shifted distribution relative to the non–workers’ compensation group (Table 6 and Fig. 15).

We have noted no cases of infection postoperatively. In some patients, the proximal portal may take a few extra days to heal but has not been considered a complication per se, as only Steri-Strips (3M, St. Paul, Minn.) are used for closure of the portals. The primary complication of this procedure is failure of the procedure to relieve the patient’s symptoms of median nerve compression as noted above.

**DISCUSSION**

For nearly two decades, there has been a lack of consensus regarding the operative intervention for the treatment of carpal tunnel syndrome (i.e., open versus endoscopic release of the transverse carpal ligament). Successful treatment of carpal tunnel syndrome results in the elimination or improvement of the patient’s symptoms in addition to halting the progression of nerve injury caused by extrinsic compression.3

Open carpal tunnel release was originally described by Cannon and Love in 1946.6 The following year, Brain, a British neurologist, popularized the concept of carpal tunnel syndrome in a classic article detailing the pathophysiology of median nerve compression and the treatment of six patients with release of the transverse carpal ligament.7 Phalen, however, is credited with popularizing the technique of open carpal tunnel release because of his reports of treatment of carpal tunnel syndrome with this technique.8,9 Open carpal tunnel release has since been considered the standard of care in the operative treatment of carpal tunnel syndrome.
Because of concern over the possibility of postoperative morbidity with the open technique, painful scars, pillar pain, tendon adhesions, scar entrapment of the median nerve, chronic regional pain syndrome, and a prolonged postoperative recovery period, surgery is often delayed in favor of nonoperative treatment, resulting in prolongation of extrinsic median nerve compression in the carpal tunnel and an increased risk of permanent nerve damage.

To address these concerns, Okutsu et al. initially described endoscopic carpal tunnel release in 1987 and in later a modification in 1989 using a uniportal technique that was never commercialized. Endoscopic carpal tunnel release from that point evolved with subsequent variations of the uniportal technique as described by Agee et al., Menon, and Worseq et al. A high incidence of iatrogenic complications with Agee’s original instrumentation, marketed by 3M, resulted in it being withdrawn from the market before a revised version was reintroduced 2 years later. This was attributable to a design flaw in which the blade assembly was not visible to the surgeon.

The advent of the biportal approach as described by Chow in 1989 and later by Brown et al. in 1992 marked a further evolution of endoscopic carpal tunnel release. The chief advantage of the biportal over the uniportal technique is that the transverse carpal ligament is isolated from the neurovascular structures (i.e., the ulnar artery and palmar arch, and the median nerve and its branches). In the uniportal technique, the position of the tip of the instrument has to be determined by endoscopic visualization alone.

Table 5. Results of Endoscopic Carpal Tunnel Release in Workers’ Compensation Patients

<table>
<thead>
<tr>
<th>Grade</th>
<th>No. of Patients</th>
<th>Asymptomatic</th>
<th>Improved</th>
<th>No Change</th>
<th>Open Conversion</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>512</td>
<td>431</td>
<td>37</td>
<td>44</td>
<td>0</td>
</tr>
<tr>
<td>II</td>
<td>1315</td>
<td>936</td>
<td>251</td>
<td>127</td>
<td>1</td>
</tr>
<tr>
<td>III</td>
<td>334</td>
<td>169</td>
<td>127</td>
<td>38</td>
<td>0</td>
</tr>
<tr>
<td>IV</td>
<td>67</td>
<td>3</td>
<td>55</td>
<td>9</td>
<td>0</td>
</tr>
<tr>
<td>Totals</td>
<td>2228</td>
<td>1539</td>
<td>470</td>
<td>218</td>
<td>1</td>
</tr>
</tbody>
</table>

Fig. 14. Postoperative results of endoscopic carpal tunnel release in workers’ compensation patients. As in the non–worker’s compensation group, the incidence of permanent nerve injury is directly related to increasing grade of preoperative electrodiagnostic grade of severity. Note that the postoperative results are inferior to those in the non–workers’ compensation group.
ament (i.e., 22 percent\textsuperscript{19} and 50 percent\textsuperscript{18}). One study noted that the midsection of the transverse carpal ligament was thicker than the cutting length of the triangular blade and in 50 percent of the specimens examined was thicker than the cutting length of the probe and the hook blades.\textsuperscript{19} Another concern cited in the study by Seiler et al. was a focal point of compression of the ulnar nerve at the level of the pisiform and the pisohamate ligament when the wrist was fully dorsiflexed in the hand platform.\textsuperscript{19} This may account for the two cases of ulnar nerve neurapraxia reported in conjunction with this technique.\textsuperscript{17} In a meta-analysis of all reported endoscopic techniques for carpal tunnel release, Jimenez et al. concluded that the technique described by Brown et al.\textsuperscript{1,2} was the procedure of choice for endoscopic carpal tunnel release.\textsuperscript{10}

Benson et al.,\textsuperscript{20} in a review of reported complications of 22,237 cases of endoscopic and 5669 cases of open carpal tunnel release, noted that the incidence of operative complications was lower in the endoscopic group and concluded that the selection of an open versus an endoscopic approach was not supported by a review of the literature.

There is no consensus in the grading of the severity of carpal tunnel syndrome. We designed a grading scale based on the severity of preoperative electrodiagnostic studies, as this is both reproducible and objective, whereas a scale based solely on clinical findings would have introduced subjectivity and interobserver variability. Although Bland et al.\textsuperscript{21} had drafted a similar six-tier scale, we felt that there was no benefit to having more than four tiers in a clinical grading system.

Nerve conduction studies have been cited as not being predictive of the results of surgery.\textsuperscript{22} However, there was a high correlation between the severity of the latency of nerve conduction and the results of surgery in our study. In addition, although there was a parallel association in workers’ compensation patients to the results of preoperative nerve conduction studies, the results of surgery were not as good as the non–workers’ compensation group. This finding agrees with that of Bland et al. (i.e., workers’ compensation claims are consistently associated with a poorer outcome).\textsuperscript{21} The explanation for this finding may be attributable to factors that are nonphysiologic and are beyond the scope of this article.

As the results of surgery were inversely related to the duration of symptoms, we strongly recommend surgical intervention for those patients with early onset or mild carpal tunnel syndrome that does not respond to a short course of nonoperative therapy and for prompt endoscopic surgical intervention in all patients with more advanced disease, excluding

<table>
<thead>
<tr>
<th>Grade</th>
<th>No. of Patients</th>
<th>Asymptomatic</th>
<th>Improved</th>
<th>No Change</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>44</td>
<td>0</td>
<td>27</td>
<td>17</td>
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<td>II</td>
<td>127</td>
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<td>62</td>
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<td>III</td>
<td>38</td>
<td>0</td>
<td>15</td>
<td>23</td>
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<tr>
<td>IV</td>
<td>9</td>
<td>0</td>
<td>2</td>
<td>7</td>
</tr>
<tr>
<td>Totals</td>
<td>218</td>
<td>0</td>
<td>106</td>
<td>112</td>
</tr>
</tbody>
</table>

Table 6. Results of Open Revision in Workers’ Compensation Patients

![Fig. 15. Results of open revision in workers’ compensation patients. As in the non–workers’ compensation group, postoperative results for workers’ compensation patients show that the degree of permanent nerve injury is directly related to an increasing grade of preoperative electrodiagnostic grade of severity. Note that the postoperative results are inferior to those in the non–workers’ compensation group.](image-url)
those with specific contraindications. Because we have observed a small incidence of permanent nerve injury (i.e., symptoms of paresthesias in the median nerve distribution that do not completely resolve postoperatively) in patients with symptoms as short as 2 months’ duration, we do not treat patients nonoperatively who have had symptoms for this length of time.

Three recently published prospective studies advocated the use of steroid injections or nonsteroidal antiinflammatory drugs for the treatment of carpal tunnel syndrome with or without splinting. These studies, however, were restricted to those patients with idiopathic carpal tunnel syndrome without predisposing medical conditions and had relatively small numbers of patients, with two studies having a limited duration of follow-up (i.e., 8 weeks and 6 months). Although the patients in the study by Graham et al. were followed for at least 1 year, only 10 percent of patients were asymptomatic at 1 year after treatment with wrist splinting and steroid injection. In the study by Hagebeuk and De Weerd, only 15 percent had a durable response by the third month after injection, with a number of patients requiring a second or even a third injection to keep their symptoms under control over a 6-month period.

In aggregate, these studies demonstrate that although conservative therapy may be helpful in those patients who present early with mild symptoms, the long-term outcome for the vast majority of patients is poor. Thus, these publications do not make a compelling case for more than a short trial of conservative therapy in the treatment of carpal tunnel syndrome.

The results of this study, in the opinion of the authors, define a new paradigm for the treatment of carpal tunnel syndrome: (1) decompression of the median nerve should be carried out without undue delay, in the case of failure of a short course of conservative therapy; and (2) in the absence of specific contraindications and with properly trained surgeons, endoscopic is preferable to open release. In light of our experience, we advocate the use of the two-portal endoscopic technique as described by Brown et al. for this purpose.

CONCLUSIONS

The results of a 12-year experience using the two-portal endoscopic technique as described by Brown et al. for the treatment of carpal tunnel syndrome are presented. We have noted that the results of surgery negatively correlate with the severity of preoperative electrodiagnostic studies, duration of symptoms, and delay of surgery in favor of nonoperative treatment. For these reasons, we advocate endoscopic surgical intervention for those patients who had symptoms for 2 months or longer and/or in those patients who do not obtain complete relief of symptoms with 3 weeks of conservative therapy to minimize both patient morbidity and the risk of incremental nerve injury.

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DISCLOSURE

Dr. Brown is the founder and owner of Instratek, Inc., located in Houston, Texas, which manufactures the instrumentation used in the two-portal endoscopic carpal tunnel procedure described in this article.

REFERENCES


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