PERIPHERAL NERVE COMPRESSIONS OF THE UPPER EXTREMITY

PITFALLS OF ENDOSCOPIC CARPAL TUNNEL RELEASE

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Carpal tunnel syndrome may be defined as an entrapment neuropathy of the median nerve at the wrist, producing a characteristic symptom complex. The typical patient experiences nocturnal paresthesias, numbness, and proximal radiation of pain to the forearm and arm. If the condition worsens, numbness in the median nerve distribution, together with weakness of the thenar muscles, can occur. It is the most common entrapment neuropathy of the upper extremity.

Carpal tunnel syndrome was described by Paget in 1854, and Marie and Foix, in 1913, first suggested sectioning the transverse carpal ligament to prevent progression of thenar atrophy caused by the nerve compression. The first surgical release of the transverse carpal ligament was performed by Learmonth in 1933. Phalen drew attention to the condition in a classic article in the Journal of Bone and Joint Surgery. Since then, open carpal tunnel release (OCTR) has been the standard procedure for patients with the carpal tunnel syndrome who did not respond to conservative treatment and whose neurologic symptoms were progressive.

In 1989, Chow presented his original endoscopic technique to release the transverse carpal ligament from within the carpal canal with the use of an endoscope. The original intrabursal placement of the cannula later was modified to the subligamentous or extrabursal position, which allegedly improved the visualization and safety of the procedure. Okutsu, in 1989, and Agee, in 1990, presented their own single-portal versions of the endoscopic carpal tunnel release (ECTR). Others have described a two-incision open technique and a minipalm incision open technique as a compromise between the "blind" endoscopic release and the large incision required in the open method. These modifications allow direct visualization of the carpal canal and its contents while maintaining the integrity of the glabrous skin of the palm.

Carpal tunnel syndrome affects up to 1% of the general population and 5% or more of workers in certain industries requiring repetitive use of the hands and wrists. Surgery for carpal tunnel syndrome is the surgery of the hand and wrist most frequently performed, with approximately 463,673 carpal tunnel releases performed annually in the United States. The economic costs are estimated nationally at almost $2 billion per year. Indirect indemnity costs account for an estimated two thirds of these total costs. It is not surprising, therefore, that the introduction of a new technique that claims to have less postoperative pain, earlier return to activities of daily living (ADL), and earlier return to work has generated a tremendous amount of interest in the medical community, the insurance industry, and the workers' compensation group.

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ANATOMIC CONSIDERATIONS

It is not within the scope of this article to describe the entire anatomy of the carpal canal and its contents. A description of some of the pertinent anatomy and the congenital abnormalities relevant to this discussion is presented, however. The carpal canal is a structure in the wrist bordered on three sides by bone and on the top by the unyielding, tough, deep transverse carpal ligament. The limits of the transverse carpal ligament correspond to bony attachments to the pisiform and the hook of the hamate on the ulnar side and to the tuberosity of the scaphoid and ridge of the trapezium on the radial side. The tunnel itself is approximately 5-cm long and its narrowest portion is at the level of the hook of the hamate. The terms transverse carpal ligament and flexor retinaculum are not synonymous. The flexor retinaculum is composed of the aponeurosis of the thenar and hypothenar muscles distally, the transverse carpal ligament, and the investing fascia of the distal forearm proximally.

Anything that causes a decrease in the volume of the carpal canal or an increase in the volume of its contents can cause pressure on the median nerve and produce a carpal tunnel syndrome. After surgical release of the transverse carpal ligament, definite morphologic changes take place. There is an increase in volume and cross-sectional area of the carpal canal because of anterior displacement of the contents of the carpal canal.

Numerous congenital variances occur at the level of the carpal canal. These include variations in the location and development of the superficial palmar arch (SPA), the motor branch of the median nerve, the median nerve, and in the ulnar–median palmar communicating branch, which can be at great risk during ECTR. There may be aberrant muscles and tendons within the carpal canal and, occasionally, a persistent enlarged median artery. The motor branch of the median nerve is extraligamentous in approximately 46% of cases, subligamentous in 31%, and transligamentous in 23%. There is no way of knowing which of these types is present prior to surgical release.

OPEN CARPAL TUNNEL RELEASE

Since it was popularized by Phalen in 1950, OCTR has been the gold standard for carpal tunnel surgery. It can be done as an outpatient under local or regional anesthesia and, when done for the proper indications, yields consistently good results with few complications. An incision is made in the palm overlying the flexor retinaculum, paralleling the thenar crease. Some surgeons prefer to end the incision at the distal palmar wrist crease; others have preferred to extend the incision proximally into the forearm by curving the incision at the crease. The incision is kept far away from the palmar cutaneous branch of the median nerve. The subcutaneous fat and palmar fascia then are released, exposing the superficial palmar arch and the flexor retinaculum. An incision then is made through the aponeurosis of the thenar and hypothenar muscles, the transverse carpal ligament, and the distal extension of forearm fascia, exposing the entire length of the median nerve within the carpal canal. The motor branch is isolated, identified, and protected. If a synovectomy is necessary, it can be performed at this stage. Any mass lesions can be removed. The bony canal can be palpated. After wound closure, many surgeons prefer to place the hand and wrist in a splint for approximately 10 days until suture removal.

The advantages of this procedure are: (1) There is direct visualization of the vital anatomic structures with direct visual confirmation of complete release. (2) It is a safe, reliable, reproducible procedure that has stood the test of time. (3) It enables the surgeon to identify and address other anomalous or pathologic conditions within the carpal canal. (4) It requires no additional training or equipment and can be performed quickly and safely under local or regional anesthesia.

OCTR is effective in relieving most or all of the symptoms of carpal tunnel syndrome in 85% or more of patients. Serious complications are infrequent in primary OCTR. No neurovascular or tendon injuries occurred in the largest studies by Czeuz, Phalen, Posch, Gainer, and Hanssen. Kushner reviewed 14 studies on OCTR, including 3035 cases. The rate of nerve injury overall was 0.8%. Injury to the palmar cutaneous branch was most common, followed by injury to the digital nerves and the thenar motor branch. The most common complications were hypertrophic or painful scars and persistent symptoms. There are several case reports of complications of OCTR and a few studies of patients who were referred because of complications following OCTR. These complications were infrequent, but included injury to the palmar cutaneous branch of the median nerve palmar cutaneous branch of the median nerve and its contents.
nerve, the radial sensory nerve, the superficial palmar arch, the deep motor branch of the ulnar nerve, and the thenar motor branch.42

After a review of the literature, it is safe to assume that the complication rate of OCTR is approximately 1% to 2%.34 Direct injury to the median nerve, the ulnar nerve, or the superficial palmar arch is extremely rare and should be easily avoidable. Careful placement of the incision avoids damage to the palmar cutaneous branch of the median nerve. Incomplete release should not occur with the open method. There is a small but definite incidence of both RSD and infection. The disadvantages of the open method are scar tenderness, pillar pain, and, perhaps, a slightly prolonged time to return to ADLs and work activities.

ENDOSCOPIC CARPAL TUNNEL RELEASE

Two techniques commonly are used for ECTR in the United States. The two-portal technique of Chow has been modified by many surgeons from the original intrabursal placement of the cannula to a subligamentous or extrabursal placement. The single-portal technique of Agee also is used by many surgeons and a new improved device recently became available.4 Both of these techniques involve the placement of a blunt instrument beneath the deep transverse carpal ligament and division of that structure, with limited visualization via the endoscope. Both techniques have their proponents and neither seems to have a long-term advantage over the other in any reported series.10,22,52 Both release the transverse carpal ligament from within the carpal canal, leaving the palmar structures and skin intact. According to the proponents of these techniques, this is the reason their results are superior. They claim that, by maintaining the integrity of the glabrous skin overlying the deep transverse carpal ligament, postoperative pain is diminished and earlier return to activities is possible. Even the originators of the techniques do not claim better long-term results with ECTR; rather, they report a quicker return of pinch and grip strength, less pillar tenderness, and earlier return to ADL and work.5,15,55

There is no consensus as to what constitutes pillar pain. Some surgeons believe the thickened retracted ends of the transverse carpal ligament cause the swelling, pain, and tenderness. Others believe the incision through the palmar skin, subcutaneous tissue, and small sensory nerve branches in the area causes this phenomenon with prolonged discomfort. Measuring pillar pain is difficult and subjective and the data are difficult to interpret. Measurements of pinch and grip strength are less subjective.

Return-to-work data are notoriously difficult to evaluate. In almost all series reported, patients who are not workers’ compensation cases return to work earlier than those who are claiming workers’ compensation.1,13,23,32,48–50,57 There is no double-blind, randomized, prospective study showing a significant difference in return-to-work data in OCTR versus ECTR in workers’ compensation cases. There are some studies to suggest a 2 to 3 week earlier return-to-work date in those nonworkers’ compensation cases treated with ECTR, but, again, the data are difficult to interpret because of many variables, including surgeon and patient motivation, the type of work, the availability of less demanding jobs, and the influences of employers’ insurance carriers, company physicians, and other factors.37 After carefully reviewing the pertinent literature, however, it probably is fair to say that nonworkers’ compensation cases undergoing ECTR return to ADL and to work perhaps 2 to 3 weeks earlier than those undergoing an OCTR.4,11,22,23,57

ECTR is an effective treatment for carpal tunnel syndrome, with many studies showing greater than 90% of patients having complete relief or significant improvement in their symptoms.9,10,12,24,32,35 Comparative clinical studies show no significant differences between the three methods in relief of pain and paresthesias (primary outcome) or in the results of physiologic measures of carpal tunnel syndrome, such as interstitial pressures, Semmes-Weinstein monofilament tests, motor testing, and electromyographic nerve conduction studies (quantitative secondary outcomes).4,11,22,32,35 Morphologic studies confirm effective decompression of the carpal canal after ECTR. Measurements taken from pre- and postoperative MR imaging scans showed significant increases in canal volume, cross-sectional area, and palmar displacement of the median nerve after both single- and two-portal ECTR. Those values were equivalent to those reported with OCTR.1,30,63 Some authors report that carpal arch width is not increased by endoscopic release of the transverse carpal ligament,1,26 but others disagree.26,72

Functional outcome data from three prospective, randomized comparison studies suggest that ECTR reduces postoperative pain and restores strength earlier than OCTR, but results vary substantially. In a multicenter study, Agee4 found that scars were less tender at early intervals (up to 9 weeks), and that grip and
pinch strength returned to preoperative levels more quickly after ECTR. Significant differences in strength between groups occurred only in the first 3 weeks postoperatively, however. In another multicenter study, Brown14 found no difference in pillar tenderness at any point, and scars were significantly more tender in the open group only after 3 months. Pinch but not grip strength was significantly better in the endoscopic group. Palmer,29 in a single-center study comparing Agee one-portal, modified Chow two-portal, and OCTR, reported that endoscopically treated patients achieved faster recovery of grip and pinch strength and had less mid-palm tenderness. Evaluation of the open and currently recommended two-portal technique only, however, showed that scars were equally tender after the first 6 weeks, grip and pinch strength were not significantly different, and diminution of pain with ADL in the endoscopic group did not appear consistently over the followed intervals.32 Return to preoperative strength took from 1 to 6 months following ECTR in the different studies.

Anatomic factors complicating ECTR relate to the narrow confines of the carpal canal and the close proximity of vital structures to the instrument. Rotman and Manske,64 in an elegant cadaver study, examined the distance of key structures to the device introduced along either the axis of the ring finger (RF) or the long-ring interspace (LRI). The distances were small for all relationships. Along the RF, the distance from the distal margin of the TCL and the investing fat pad of the SPA was 2.8 mm and from the SPA itself, 4.8 mm. The distance between the device and median nerve was 3.1 mm, and 3.8 mm at the distal and proximal margins of the TCL, respectively. Changing the orientation of the cannula altered the relationships between the device and the surrounding soft tissue structures. Along the RF, a distinct junction exists between the perivascular fat pad and the distal margin of the TCL that is obscured in the LRI because the fat pad extends 2 to 3.5 mm proximally over the distal TCL margin. Similarly, an interspace exists between the TCL and the palmar fascia along the RF that disappears in the LRI, where the two are directly apposed. The more ulnarward position along the RF avoids damage to the palmar cutaneous branch of the median nerve. Most anomalies of the motor branch of the median nerve emerge anteroradially. The researchers concluded that cannula placement was safest along the RF axis.54

Anatomic relationships also change with position of the hand. Levy37 found that the distance from the cannula tip to the ulnar artery, SPA, and third common digital nerve significantly increased with extension of the hand and wrist, making this the safer position for ECTR. Scoggin76 reported a near-transsection of a flexor tendon that he attributed to difficulty positioning the device in a patient with limited wrist extension.

Anatomic variations can present significant problems during ECTR. Wolf74 reported a narrow canal, a number of cases of concomitant lesions, including a neurofibroma, a ganglion, and a neurilemmoma. The indications for open surgical release of the carpal tunnel are well established and, in most cases, have been applied to ECTR. Contraindications to ECTR include space-occupying lesions, limited wrist extension, proliferative synovitis, previous carpal tunnel release, inflammatory arthropathy, congenital wrist anomalies, distorted carpal anatomy, floating hook of the hamate, and other factors that affect the anatomy of the region.

The advantages of ECTR over OCTR are (1) less scar tenderness for a short period of time and perhaps (2) an earlier return to ADL and work, although these have not been definitively established. The disadvantages are that visualization is difficult and it may be hard to distinguish between synovium and nerve tissue. One can miss a space-occupying lesion—for example, a ganglion, neurofibroma, neurilemmoma. The bony canal cannot be palpated. Numerous congenital anomalies in the carpal canal can place important structures at risk, and they can not be palpated. The hook of the hamate, and other factors that affect the anatomy of the region.

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The ulnar artery can be radial to the hook of the hamate, placing it at great risk during ECTR. Also listed among the disadvantages must be a steep learning curve for ECTR. The exact incidence of complications with ECTR is unknown. There is a study being undertaken by the American Society for Surgery of the Hand to determine as precisely as possible the number of complications that have been encountered. In a number of cadaver studies, ECTR has produced a disconcertingly high proportion of intraoperative complications and incomplete releases. Lee reported lacerations of an ulnar nerve and an ulnar neurovascular bundle, a flexor tendon wrapped around the annular, an inadvertent release of Guyon’s canal, and 50% incomplete releases with nearly one third of the ligament remaining intact. Rowland reported an overall complication rate of 17%, with one lacerated ulnar artery, one lacerated median nerve, one partial flexor tendon laceration, one hook of the hamate fracture, and 38% incomplete releases. Erdmann had 33% of the cases with SPA lacerations and Schwartz reported a 6% incomplete release rate.

The safety of this procedure seems to have improved as surgical experience has been gained. Improvements in the surgical technique, instrumentation, and knowledge of endoscopic anatomy have been beneficial. The original Agee device was removed from the market and a new, improved version is available. As far as the Chow technique, adoption of the extrabursal, subligamentous approach has significantly reduced the number of complications by allowing precise visualization of the transverse fibers of the transverse carpal ligament. Resnick reported one median nerve laceration and six neuropacl injuries using the intrabursal technique, but no complications using the extrabursal modified Chow technique. Erdmann’s complication rate decreased from 35% to 3.7% after adopting the extrabursal approach. Malek found a 4.8% complication rate for the intrabursal versus 1.2% rate for the extrabursal technique. Complications, however, were serious, with median, ulnar, and radial nerve lacerations and artery and tendon injuries. There were 102 nerve-related, 27 vessel-related, and 15 tendon-related injuries with the original Chow technique compared to 52 nerve-related, 15 vessel-related, and no tendon-related injuries with the modified Chow technique. In a large prospective multicenter study, Nagle found that overall complication rates dropped from 11% with the original Chow method to 2.2% with the modified Chow method.

Other modifications and techniques, such as direct visualization of the SPA through the distal incision and retraction of the median nerve and flexor tendons in the proximal incision also protect the structures from injury. Surgical experience certainly reduces the risks of injury, but the learning curve for ECTR is steep. Malek reported a complication rate of 5.6% for surgeons who performed fewer than 25 releases versus 1% for surgeons who performed greater than 100. This learning curve is well recognized. ECTR is safest when performed by a surgeon who is well trained in a technique and does it with reasonable frequency. One author reported a laceration of the median nerve on his 59th case, however. It therefore can be safely stated that the “minimum” number of cases (if there is such a thing) to train a physician in the technique of ECTR is not yet known. In our opinion, a 1-day course in a laboratory with cadavers certainly is insufficient.

DISCUSSION

Is ECTR better than OCTR or is OCTR safer and therefore preferable? These questions cannot be answered with absolute certainty at this time. According to recent studies, the overall complication rate probably is between 1% and 2% in experienced hands for both ECTR and OCTR. Although the complication rates may be similar, many difficult cases are excluded from ECTR from the start, such as repeat surgery, inflammatory arthritis with the need for synovectomy, lesions of the median nerve, masses within the carpal canal, and stiff arthritic wrists. The quality of the complications also is vastly different. A complete laceration of the median or the ulnar nerve is a devastating injury that can alter the course of a person’s working life forever. This complication is exceedingly rare in OCTR in experienced hands but has been reported in ECTR cases.

In our opinion, the only benefit of a successful ECTR is diminution of early postoperative pain and return to ADL and work a little sooner than with the conventional technique. This point should be understood clearly. Even the originators of the endoscopic techniques do not claim better long-term results with ECTR. Most comparison studies have shown return to ADL several days sooner and return to work (in nonworkers’ compensation cases) a few weeks sooner with ECTR versus OCTR. Differences in strength, scarring, and pillar tenderness between the groups were
short lived. The early improvement in the endoscopic group generally disappeared after the first 6 weeks postoperatively. The late scars from both procedures were unobjectionable.

No one really knows the true incidence of serious complications in the community. There are many anecdotal stories. Overall complication rates in ECTR in recent studies approximate those occurring with the open technique, but the risks for serious complications not seen with OCTR still remain. We have seen lacerations of the ulnar neurovascular bundle, the superficial palmar arch, a partial median nerve injury, a complete median nerve injury, and a partial flexor tendon laceration in our area, all with ECTR during the past 5 years.

The public has been conditioned to think that if an operation can be done with an endoscope, it must be safer, better, quicker, and more “high tech.” In arthroscopy of the knee, visualization is outstanding, the surgery is safe, and the benefits over open knee arthroscopy are obvious. This also is true with other procedures, such as laparoscopic cholecystectomy. With ECTR, however, visualization is markedly limited and the procedure is not yet safer than the open technique.

In recent years, there has been a tremendous increase in the incidence of so-called work-related carpal tunnel syndrome. Many people claim to suffer from a cumulative trauma disorder or repetitive stress injury syndrome. These people often have a constellation of complaints in the upper extremities, including some paresthesias and numbness in their hands. It is tempting to treat some of these patients with ECTR in an attempt to get them back to work as quickly as possible. As Newman pointed out in a recent editorial in the Journal of Hand Surgery, “Neither the open nor the endoscopic release of the transverse carpal ligament will benefit the patient with vague symptoms of hand pain related to alleged work exposure, even if some of those symptoms are due to intermittent nerve compression.”

It is not the intent of this paper to criticize ECTR, only to consider its shortcomings. ECTR may have some early postoperative advantages over OCTR, but do those benefits justify its risks? The indications for recommending ECTR over OCTR are still not clearly defined in our opinion. Are we subjecting our patients to risks of serious complications so they can return to ADL and work a little sooner? Is this the technique we, as hand surgeons, would choose for ourselves? In an informal survey taken at a recent Hand Society meeting, the overwhelming majority voted for OCTR for themselves.

After consideration of all of the facts and alternatives, each surgeon must make his own choice. Each case has to be individualized and the surgeon obviously must take into account his own training and experience. In our opinion, safety is the issue: The risks of ECTR outweigh the possible benefits of the procedure with today’s instrumentation and techniques. Nine hundred and ninety nine good results do not make up for one serious neurovascular complication. Our own personal preference in most cases is OCTR with a single incision. If the person depends on ambulatory aids and should not have an incision in the palm, we use the two-incision open technique.

References

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