

NEWER TECHNIQUES OF CARPAL TUNNEL RELEASE

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Although carpal tunnel syndrome (CTS) was recognized by Paget in 1853, surgical release for the condition was probably not performed until 1924, by Galloway, with the first formal description in 1933 by Learmonth.^{8,34} Since that time, open carpal tunnel release (CTR) surgery has become the standard method of treatment for cases that do not respond to conservative management. In the past few years, however, two new alternatives to open CTR have developed. The first of these, endoscopic carpal tunnel release (ECTR) procedures, were reported by Chow and Okutsu in 1989 and by Agee in 1990.^{5,16,47} The second approach, limited incision techniques (LIT), a modification of the standard open CTR, was developed in response to apprehension about the early ECTR procedures.^{11,12} Although both these innovative methods effect a significantly more rapid return of strength and function than open CTR, reports of complications have stirred controversy.

In this article, after a brief account of the history and evolution of ECTR and LIT techniques and an overview of the relevant anatomy, we describe various methods and instrumentation. The results, complications, and contraindications are noted. Subsequent discussion of the objections to and the special requirements of the new techniques leads to our judgment regarding the choice of methods.

THE MIXED RECEPTION OF ENDOSCOPIC CARPAL TUNNEL RELEASE

Following the first studies of ECTR in 1989 and 1990, courses were established in various parts of the United States to train surgeons in ECTR techniques. In these classes, didactic presentations of theoretical aspects typically were followed by cadaver workshops monitored by skilled endoscopists. When the surgeons taking these courses returned to perform ECTR procedures in their own practices, some attained good results, but others reported serious complications, such as laceration to the median nerve.²⁵

In response to the ensuing controversy, a 1992 Workshop on CTR convened by the American Academy of Orthopedic Surgeons concluded that "the role of endoscopic carpal tunnel surgery had not been fully defined" but was still evolving and there was a "need to decrease the risks and increase the safety."¹

Surgeons seeking to solve the problems apparent in ECTR are divided into two schools of thought, each seeking a safe way to reduce postoperative loss of strength and function. One has attempted to decrease postoperative morbidity by reducing the size of the open CTR incision (LIT); the other has sought to improve ECTR by modifying techniques or instrumentation.^{11,12,45,60} One pioneer of the procedure, Agee, temporarily withdrew his

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endoscopic retractable blade device from the market for redesign, whereas another, Chow, has refined his two-portal approach by substituting an extrabursal approach for the original transbursal technique, with fewer postoperative complications.^{3,18,24} More recently, Mirza introduced a distal (palmar) uniportal ECTR.⁴¹

ANATOMIC CONSIDERATIONS

A primary reason for complications in surgical release of CTS is the anatomic intricacy of the area. Endoscopy usually is performed in a joint, viscus, or hollow body cavity.²⁹ In con-

trast, the hand surgeon performs ECTR in an area that is none of these and contains structures that, when compromised, result in formidable complications.

The smaller incision(s) used with both ECTR and LIT result in reduced operative exposure of relevant anatomy (Fig. 1). Consequently, increased reliance must be placed on topographical landmarks to define the location of important surgical anatomy.²¹ Surgeons also must maintain a heightened awareness of the anatomic structures at risk for injury. Several of these structures are located near the distal edge of the transverse carpal ligament (TCL) and may vary considerably from patient to patient (Fig. 2).

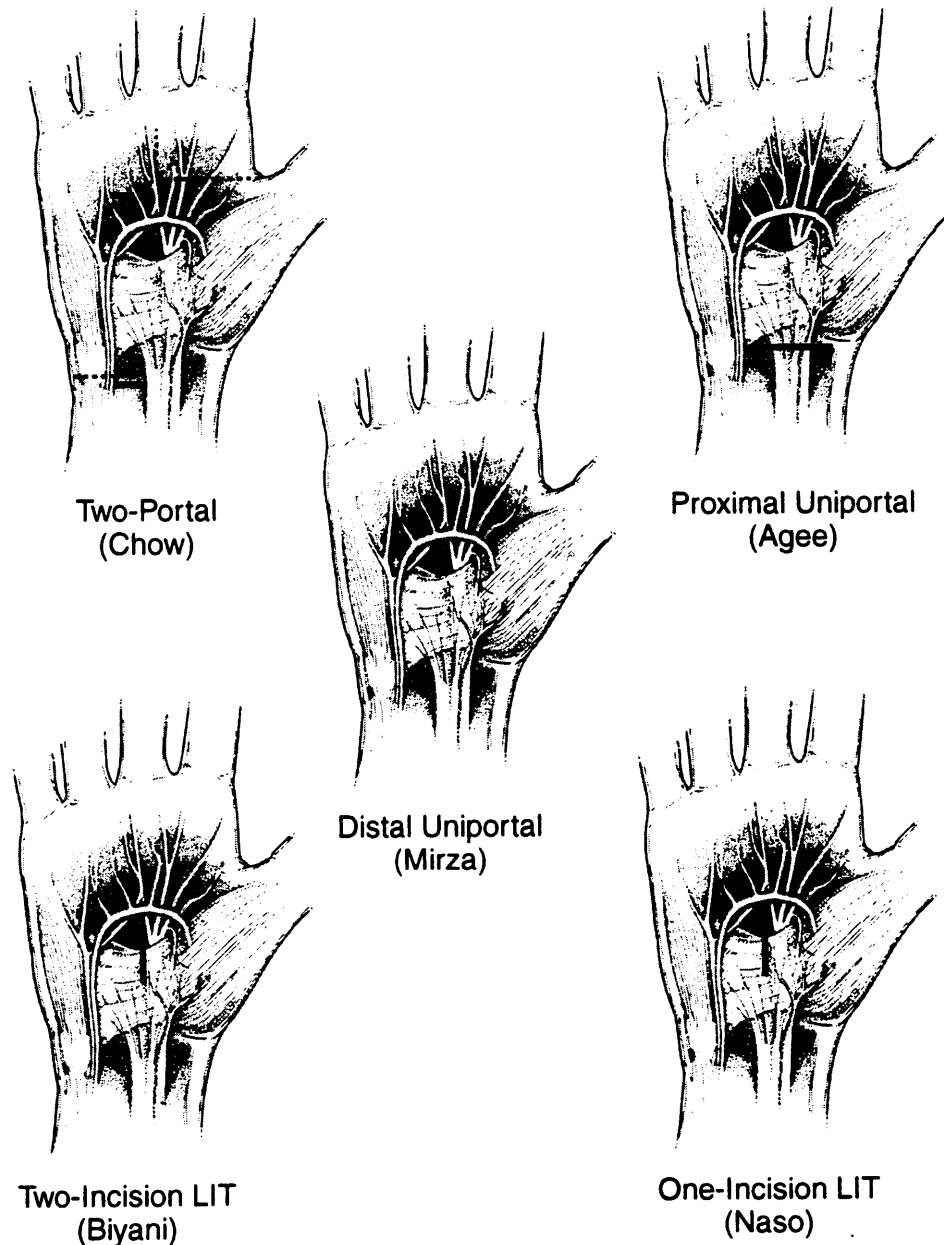


Figure 1. ECTR and LIT incisions. (Courtesy of M. Ather Mirza, MD.)

The Recurrent Motor Branch of the Median Nerve

The recurrent motor branch of the median nerve has three major variants—extraligamentous (46%), subligamentous (31%), and transligamentous (23%)³³ (Fig. 3). The latter two are at risk for injury during ECTR. Among these variants, those at even greater risk travel from the ulnar side of the median nerve, which, at times, may bend around the distal edge of the TCL (Fig. 4).²³ Concern has been expressed that injury to these variants may occur when endoscopic techniques do not provide adequate visualization.^{29,61}

The Superficial Palmar Arch

The superficial palmar arch (SPA) is located from 2 to 26 mm from the distal edge of the TCL (see Fig. 2).²¹ It is contained within and often hidden by the fat pad.³⁰ Consequently, there is very little room for error. This is particularly true for devices that rely on endoscopic visualization without direct exposure of anatomy. Schwartz reported that the blade of the Agee device was less than 2 mm from the

SPA in 4 of 13 cadaver specimens studied.⁵³ Injuries have been reported with proximal uniportal and two-portal methods.^{14,58}

Communicating Branch Between the Ulnar and Median Nerves

The communicating branch between the ulnar and median nerves is present in 80% to 90% of cases and may lie in close proximity to the distal edge of the TCL.^{9,26,39} It typically originates proximally from the fourth common digital nerve and enters the third common digital nerve more distally (see Fig. 2), but several variations have been reported.³⁹ Injuries can result in postoperative paresthesia to the long or ring fingers.^{9,53}

Fat Pad

The fat pad is located in the midpalm.³⁰ It may extend proximal and dorsal to the TCL for a distance of 2 to 3.5 mm (Fig. 5).⁵¹ This may prevent endoscopic devices from visualizing pertinent anatomy, which could lead to an incomplete release of the TCL. Lack of visualization also may result in injury to the SPA, the

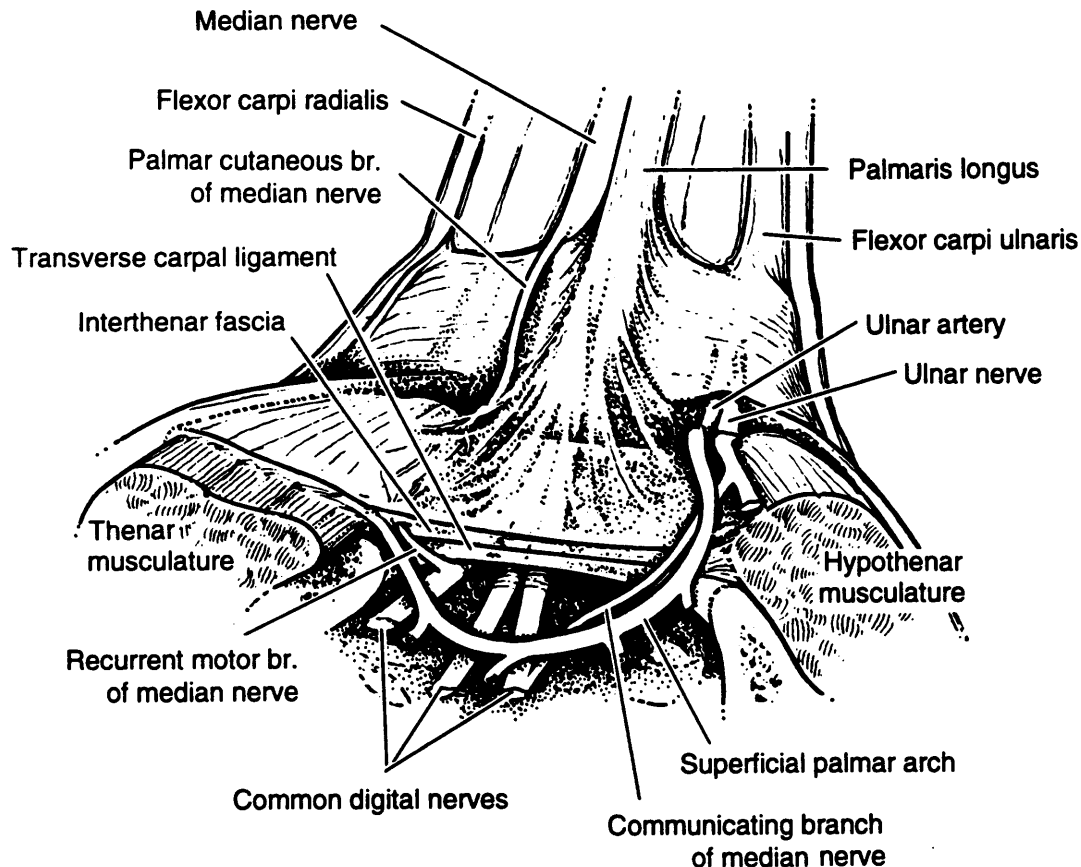


Figure 2. Pertinent anatomy in area of carpal tunnel. (Courtesy of M. Ather Mirza, MD.)

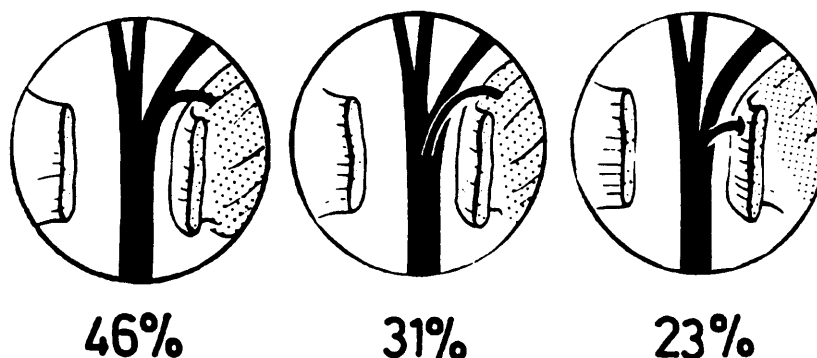


Figure 3. Incidence of the extraligamentous, subligamentous, and transligamentous variations of the recurrent motor branch of the median nerve. (From Lanz U: Anatomical variations of the median nerve in the carpal tunnel. *J Hand Surg* 2:44-53, 1977; with permission.)

communicating branch of the ulnar nerve, or the motor branch of the ulnar nerve.^{9,22,58}

Palmar Cutaneous Branch of Median Nerve

The palmar cutaneous branch originates in the median nerve in the forearm, approximately 8 cm proximal to the wrist crease, and continues

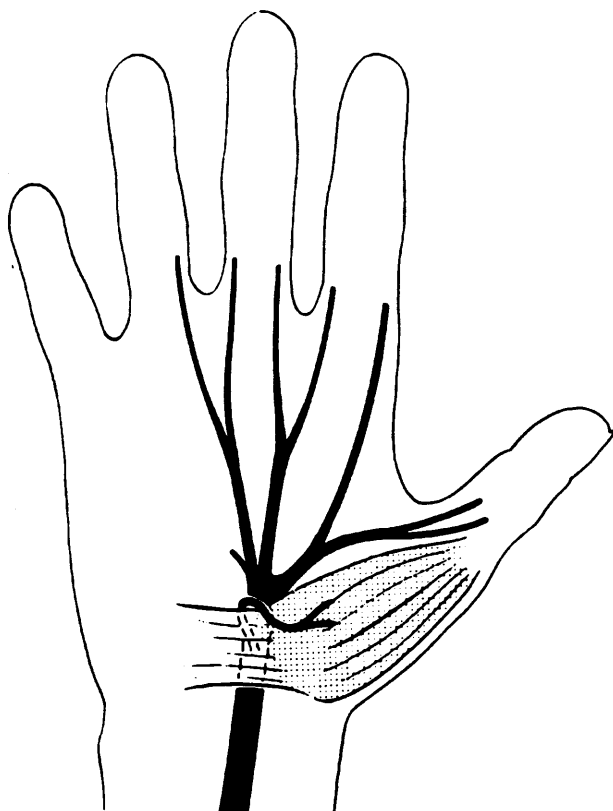


Figure 4. Recurrent motor branch variant, which curves around distal edge of transverse carpal ligament. (From Lanz U: Anatomical variations of the median nerve in the carpal tunnel. *J Hand Surg* 2:44-53, 1977; with permission.)

distally between the flexor carpi radialis and palmaris longus tendons.^{27,57} It becomes superficial at the wrist and is vulnerable to both transverse and oblique wrist incisions (see Fig. 2).

Hook of the Hamate

Because some ECTR techniques require that instrumentation hug the hook of the hamate, it is an important anatomic landmark.^{4,16,40} Accordingly, fracture of the hook of the hamate is a relative contraindication for these techniques. Surgeons also should be aware of potential injury to the ulnar artery if it is located radial to the hook of the hamate. Instrumentation-induced fracture to the hamate hook has been reported as a complication of two-portal ECTR.⁵¹

Guyon's Canal/The Ulnar Nerve and Artery

The proximal entrance to Guyon's canal lies just ulnar to the carpal tunnel at the level of the distal wrist flexion crease. The inadvertent introduction of devices into this area may result in injury to the ulnar neurovascular bundle or release of Guyon's canal.^{35,36}

The ulnar artery, contained within Guyon's canal, traditionally was thought to be positioned ulnar to the hook of the hamate. A recent study demonstrates that in some patients it may lie radial to the hamate hook (Fig. 6).²⁰ As a result, the ulnar artery may be at risk for injury from instrumentation that hug the hook of the hamate.²¹

Transverse incisions at the wrist have caused laceration and traction injuries to the ulnar neurovascular bundle.^{3,8,22,35} The incision,

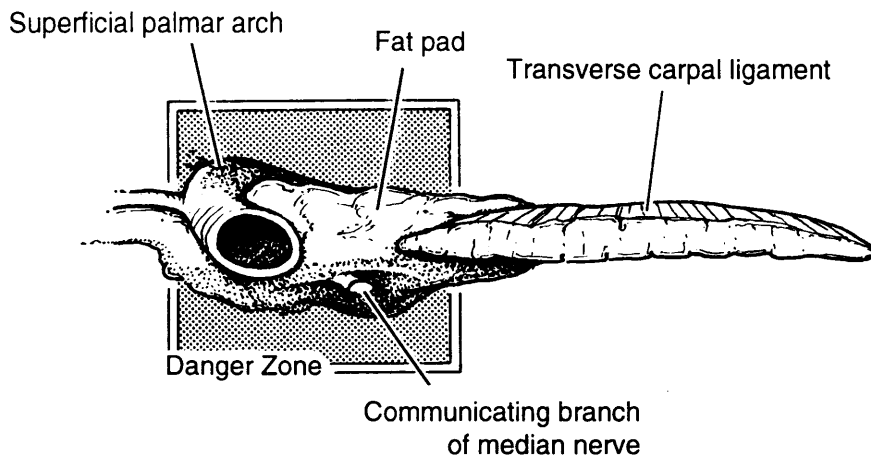


Figure 5. Anatomical relationship of TCL, fat pad, superficial palmar arch, and communicating branch between ulnar and median nerves. (Courtesy of M. Ather Mirza, MD.)

therefore, must be placed so the ulnar artery is protected from injury. Careful retraction in the area of the ulnar nerve is required to prevent postoperative transient ulnar nerve neuropraxia symptoms.

Median Nerve and Flexor Tendons

Another important anatomic consideration is the changing orientation of the median nerve and flexor tendons as these structures travel from the proximal aspect of the carpal canal to the distal segment and then into the palm. The median nerve and flexor tendons are arranged in a fairly consistent longitudinal orientation at the proximal portion of the TCL. As they advance distally, however, their

orientation becomes more oblique and transverse. Because endoscopic devices typically are used parallel to these structures proximally, they pose less risk to proximal anatomy than to distal structures that have the potential to cross over the instrumentation.⁵⁴ Consequently, direct visualization of the distal anatomy is important. Rare anomalies, such as a bifid median nerve and artery have been reported.^{33,56}

Interthenar Fascia

Between the palmar fascia and TCL is a fascial layer that arises primarily from the thenar musculature on the radial side as well as from the hypothenar and palmaris brevis muscles

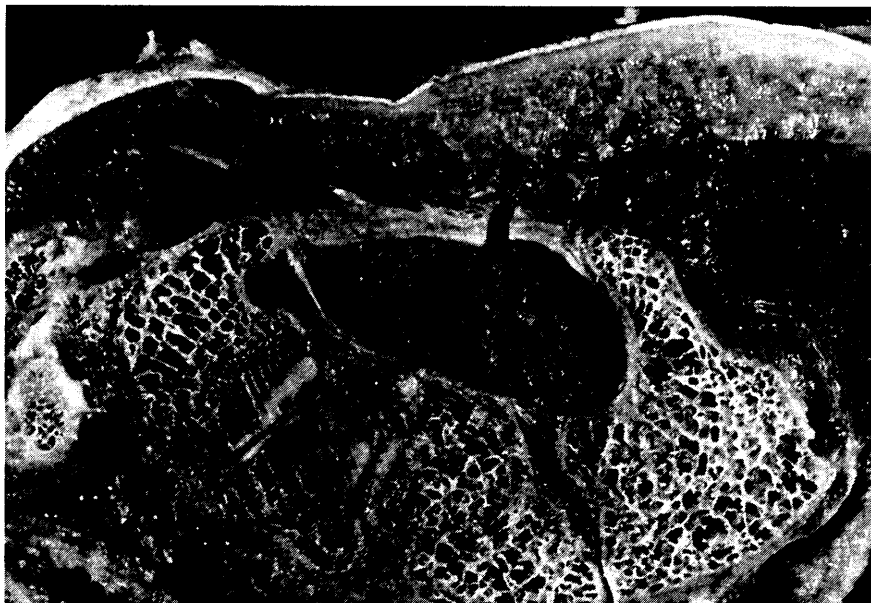


Figure 6. Axial section through hamate hook. The ulnar artery is located radial to the hamate hook. (From Cobb TK, Knudson GA, Cooney WP: The use of topographical landmarks to improve the outcome of Agee endoscopic carpal tunnel release. *Arthroscopy* 11:165-172, 1995.)

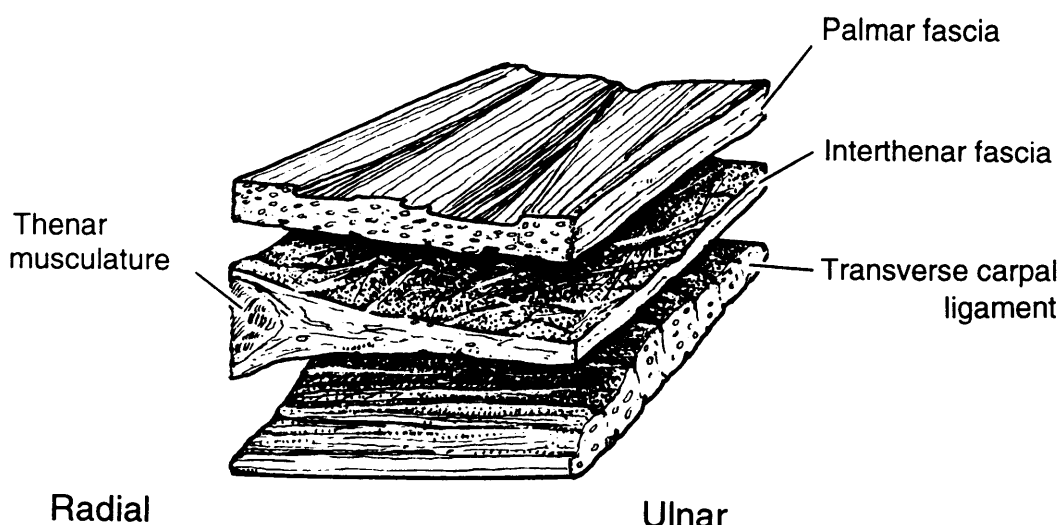


Figure 7. Layers of the palmar fascia, interthenar fascia, and transverse carpal ligament. (Courtesy of M. Ather Mirza, MD.)

on the ulnar aspect of the hand (Fig. 7).^{51,55} This structure has been termed the *interthenar fascia*.⁴²

No studies have been conducted to examine volar migration of the flexor tendons and its effect on grip strength with an intact interthenar fascia. This superficial layer provides soft tissue support to the digital flexor pulley system at the wrist. When superficial support structures remain intact, less postoperative bowstringing of the long flexor tendons may result and, consequently, an earlier return of function and strength may occur.^{2,21,42} Less widening of the carpal arch has been observed when comparing endoscopic with open CTR.⁵⁹ This, in part, may be due to intact interthenar fibers. Early studies demonstrate that leaving the interthenar fascia intact has no adverse effect on either relief or recurrence of symptoms (Fig. 8, 9).⁴²

SURGICAL TECHNIQUES

Because CTS is the disorder treated most often by the hand surgeon, many techniques and methods of treatment have been devised. The procedures discussed here represent recently developed approaches now in clinical use. Endoscopic methods include the two-portal procedures of Chow, Resnick, and Brown; the proximal uniportal techniques of Okutsu, Agee, and Menon; and the distal uniportal approach of Mirza.^{3,13,16,39,42,47,50} The limited open incision methods include the one-incision technique described by Naso and Bromley and the two-incision technique described by Biyani and Wilson (Fig. 10).^{11,12,45,60}

Two-Portal Endoscopic Carpal Tunnel Release (Chow, Resnick, and Brown)

The endoscopic technique of carpal tunnel release described by Chow in 1989 employs two incisions, one in the distal forearm at the wrist and the other in the palm of the hand (see Fig. 1).¹⁶ A 1-cm transverse wrist incision is made, followed by incision of the fascia, which exposes the flexor tendons. The wrist then is hyperextended and a trocar (Smith and Nephew Dyonics, Andover, MA) is inserted into the carpal canal and advanced distally. The trocar hugs the hook of the hamate and is advanced into the distal palm to the level of the subcutaneous tissue. At this point, another

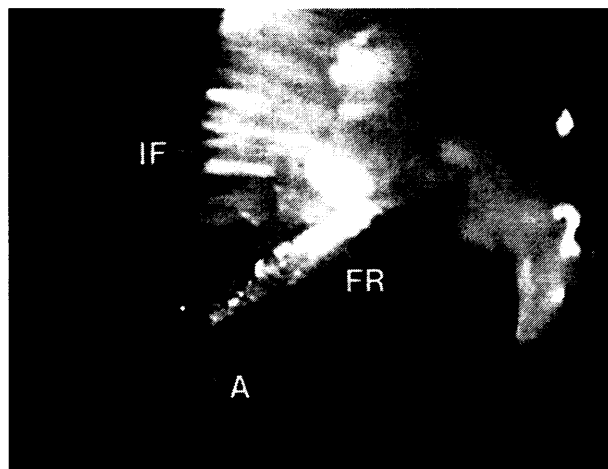


Figure 8. Endoscopic photograph demonstrating the edge of divided transverse carpal ligament (FR) and intact interthenar fascia (IF) superficial to it. A, adipose tissue. (From Mirza MA, King ET, Tanveer S: Palmar uniportal extrabursal carpal tunnel release. *Arthroscopy* 11:82-90, 1995.)



Figure 9. Carpal tunnel of dissected specimen after endoscopic carpal tunnel release. The transverse carpal ligament has been divided with the superficial fibers left intact. (From Cobb TK, Knudson GA, Cooney WP: The use of topographical landmarks to improve the outcome of Agee endoscopic carpal tunnel release. *Arthroscopy* 11:165-172, 1995.)

small incision is made and the trocar is advanced out through the skin in the palm. The endoscope is inserted from the proximal incision and the transverse fibers of TCL are noted. The transverse carpal ligament then is divided in five steps. Three different types of disposable knives are used (retrograde knife, triangle knife, and probe knife) (Fig. 11). The endoscope is introduced through one end of the cannula and the knives are introduced at appropriate times through the other. Both the proximal and distal portals are used to introduce the knives and endoscope.

The original transbursal technique was asso-

ciated with a high complication rate. The extra-bursal modification allows for better visualization and results in fewer complications.^{18,24}

Of the patients treated by Chow's original procedure, 60% regained 80% of their pinch and grip strength within 1 week, and 86% returned to work within 4 weeks.¹⁶ A follow-up study of 1146 cases found a 0.26% complication rate.¹⁹ A later survey by Chow et al of more than 10,000 cases³⁸ reported a total of 154 complications relating to nerves, 38 to vessels, and 15 to tendons. A 4.8% complication rate was found using the subligamentous transbursal approach, which was reduced to 1.2% using

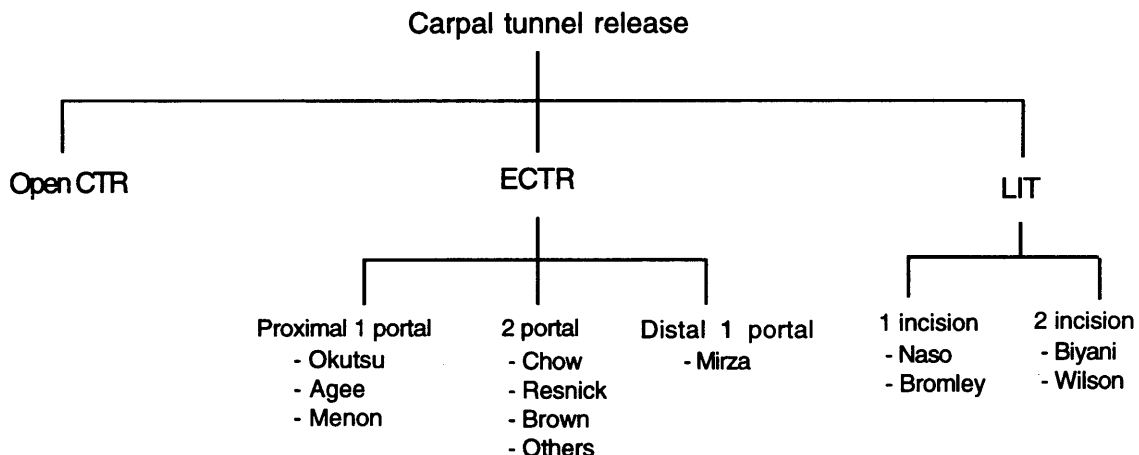


Figure 10. Methods of carpal tunnel release.

the extrabursal approach. Variable complication rates have been reported by others (Table 1).

In 1991, Resnick⁵⁰ reported the subligamentous modification of the Chow technique. In 1992, Brown¹³ described a two-portal technique with instrumentation similar to Chow's (Instratek, Houston, TX). In this modification, division of the TCL is achieved by means of a hooked knife introduced through the proximal portal. The endoscope follows the knife as it is pulled in a proximal direction from the distal edge of the TCL.

Proximal Uniportal Endoscopic Carpal Tunnel Release (Okutsu, Agee, Menon)

In 1990, Agee⁵ described a uniportal proximal method of ECTR. The technique uses a scope with a disposable blade assembly (3-M Health Care, St Paul, MN) through which the transverse fibers of the TCL can be visualized. The blade assembly is attached to a pistol type grip that controls the elevation of the blade. A 2-cm transverse skin incision is made in a wrist flexion crease between the flexor carpi radialis and flexor carpi ulnaris tendons (see Fig. 1). A

U-shaped distally based flap then is made in the forearm fascia. A synovial elevator, followed by a probe, inserted just dorsal to the forearm fascia, hugs the hook of the hamate and creates a proximal-to-distal path in the carpal tunnel. The device then is introduced through this path and directed toward the ring finger. The blade is elevated only after the distal edge of the transverse carpal ligament is clearly defined. The device then is pulled proximally, dividing the transverse carpal ligament (Fig. 12). It may take several passes with the blade (average 2.2; range 1–7) before the ligament is divided completely.^{4,46} The forearm fascia is released proximally using tenotomy scissors.

Studies have cautioned against attempting to view the contents of the carpal canal with the scope, because the blade assembly then may enter the wrong plane or result in a neuropraxia.^{2,46}

The initial multicenter study comparing this method with open CTR revealed a more rapid return of pinch and grip strength with less scarring and pillar tenderness in the ECTR group.³ The median time of return to work was 21.5 days more rapid in the ECTR patients compared with the open CTR control group.

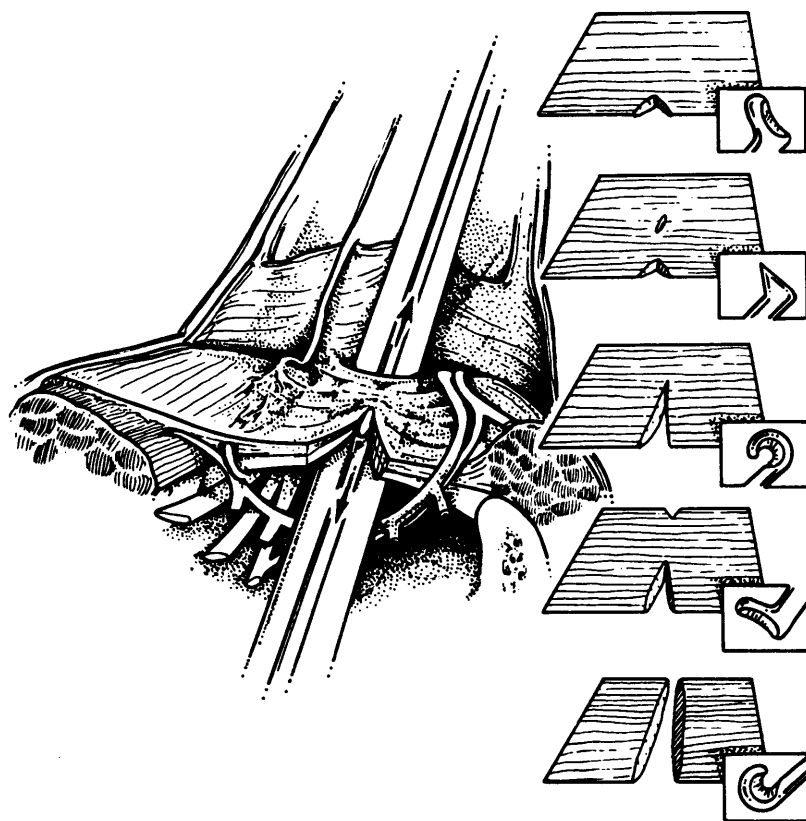


Figure 11. Illustration of two-portal ECTR (Chow technique). (Courtesy of M. Ather Mirza, MD.)

Table 1. COMPLICATIONS REPORTED USING ENDOSCOPIC CARPAL TUNNEL RELEASE TWO-PORTAL TECHNIQUES

Reported Complications	Resnick ⁵⁰ (1991)	Viegas ⁵⁹ (1992)	Palmer ⁴⁹ (1993)	Brown ¹⁴ (1993)	Nagle ⁴⁴ (1994)	Chow ¹⁹ (1994)	Erdmann ²⁴ (1994)	Arner ⁹ (1994)	Rowland ⁵² (1994)
No. cases in study	75	108	72	78	278	1154	73	53	24
Fracture of hamate (%)									4.2
Injury to digital nerve (%)		0.9		1.3	0.4				4.2
Injury to median nerve (%)	1.3	0.9			0.7				2.9*
Incomplete release/recurrence (%)			1.4		1.4	0.3	4.1		
Ulnar nerve neuropraxia (%)	8		12.5		0.7	0.2	5.5	18.9†	
Communicating branch ulnar nerve injury (%)									4.2
Injury to ulnar artery (%)				0.6					
Injury to superficial palmar arch (%)									4.2
Lacerated flexor tendon (%)							2.7		
Hematoma (%)				1.3					
Reflex sympathetic dystrophy (%)					0.4				
Infection (%)					1.1				

*Does not include incomplete release of fibers superficial to transverse carpal ligament.

†Reflects incidence at postoperative days 7 - 10; 11.3% persisted 4 months or more.

The reported incidence of incomplete release was 1%, and 2% of ECTR patients had transient postoperative ulnar nerve neuropraxia.

Statistics from the follow-up prospective study of complications based on surgical experience of 1049 procedures show that 2.5% of the cases were converted to the open CTR procedure.⁴ The complication rate at the 3 to 4 week follow-up examination was 1.8%. There was one transection of the palmar cutaneous nerve; one injury to the communicating branch of the ulnar nerve; one mild RSD; and two ulnar nerve neuropraxias from retraction at the wrist. In 9.4% of cases, difficulty was experienced in inserting the blade assembly into the carpal canal and, in 1% of cases, the device malfunctioned mechanically. Variable complication rates have been reported by others (Table 2). Notwithstanding Agee's reported low (1%) incidence of incomplete release, a more recent cadaver study suggests incomplete release may be a more frequent occurrence using this method.⁵⁸

Okutsu⁴⁷ described another proximal uniportal technique in which the transverse carpal ligament is viewed through a clear cannula inserted into the carpal canal.⁴⁷ A hook knife is introduced within the carpal canal, adjacent to the cannula. The TCL then is divided by pulling the knife proximally with one hand

while operating the endoscope with the other hand.

In a third proximal uniportal technique described by Menon,⁴⁰ the carpal canal is dilated to 7 mm. A plastic cannula (Linvatec, Largo, FL) is inserted into the carpal canal and a needle is inserted into the cannula through the palmar skin at the level of the distal TCL. The knife then is pushed through the cannula from the proximal toward the distal edge of the TCL. The endoscope follows the knife, so the surgeon can view the procedure endoscopically.

Distal Uniportal Endoscopic Carpal Tunnel Release

The palmar uniportal technique reported in 1993, by Mirza⁴¹ uses a 1.5 cm incision in the palm to permit direct visualization of the anatomy at the distal edge of the TCL (see Fig. 1). The superficial palmar arch, distal edge of the TCL, median nerve, and flexor tendons all can be identified. Two longitudinal lines representing the location of the median nerve and the ulnar neurovascular bundles are drawn proximal to the wrist crease. An obturator-dissector-cannula assembly is placed against the dorsal surface of the TCL and advanced into

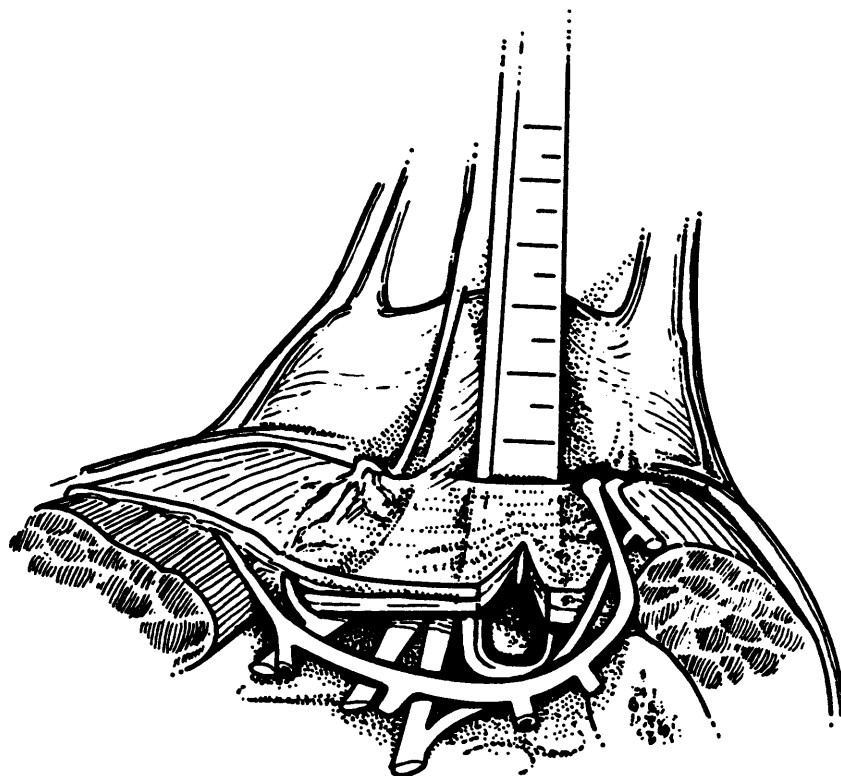


Figure 12. Illustration of proximal uniportal ECTR (Agee technique). (Courtesy of M. Ather Mirza, MD.)

Table 2. COMPLICATIONS REPORTED USING ENDOSCOPIC CARPAL TUNNEL RELEASE UNIPORTAL TECHNIQUES

Reported Complications	Proximal Technique						Distal Technique	
	Agee ³ (1992)	Palmer ⁴⁹ (1993)	Feinstein ²⁵ (1993)	Menon ⁴⁰ (1994)	Cobb ²¹ (1995)	Agee ⁴ (1995)	Van Heest ⁵⁸ (1995)	Mirza ⁴² (1995)
No. cases in study	82	90	61	100	60	1042	49	475*
Release of Guyon's canal (%)								
Injury to digital nerve (%)				2		0.3	29	
Injury to median nerve (%)			1.6	1		0.2		
Incomplete release/recurrence (%)	1.2	1.1	1.6		6.7			
Ulnar nerve neuropraxia (%)	2.4	10				0.2		
Neuropraxia communicating branch between ulnar and median nerves				1		0.1		0.2
Transection palmar cutaneous nerve (%)						0.1		
Injury to ulnar artery (%)							2.3	
Injury to superficial palmar arch (%)							2.3	
Hematoma (%)								
Reflex sympathetic dystrophy (%)						0.1		0.2
Infection (%)						0.1		
Mechanical problem (%)						3.5		0.2

*Includes authors' follow-up data from original 240-patient study.

the carpal canal. The cannula, advanced proximal to the wrist flexion skin crease, is positioned midway between the two lines drawn in the distal forearm to avoid the median nerve and ulnar neurovascular bundle. The obturator then is removed and the slotted cannula left behind.

After a standard 4-mm endoscope is introduced through the cannula to visualize the transverse fibers of the TCL, the median nerve and flexor tendons are visualized by rotating the slotted cannula. The surgeon thereby can confirm endoscopically the correct placement of the cannula and, often, the degree of median nerve constriction as well.

Next, a knife/sleeve device (AM Surgical) that attaches to the endoscope is advanced proximally through the slotted cannula. As the device is advanced, it divides the flexor retinaculum under endoscopic visualization (Fig. 13) to a point proximal to the wrist flexion crease. The interthenar fascia normally is preserved, but if desired, the surgeon may divide it with a second pass of the knife. Once all instrumentation is removed, a direct view of both the distal carpal canal contents and the divided TCL is possible. If any space-occupying masses are seen, they can be managed at this time.

Results of 240 cases using this technique and

device were reported in 1995.⁴² Median return to work and full function was 14 days, with no neurovascular injuries or documented recurrences. Two months after surgery, grip and pinch strength measurements were near or greater than preoperative values. One worker's compensation patient with residual bilateral symptoms underwent open CTR by another surgeon. No median nerve constriction was found and there was no subsequent improvement in symptoms. A follow-up study of 475 cases included one mild RSD, one transient neuropraxia to the communicating branch of the ulnar nerve, and one blade failure in a prototype device (see Table 2) (Mirza MA, King ET, unpublished data). The rate of conversion to open CTR was 2%.

Mini-Incision Limited Incision Technique

A 1.5- to 2-cm incision is made in the mid-palm directly over the TCL (see Fig. 1).⁴⁵ Under direct vision, the incision is deepened to include the distal aspect of the TCL. The superficial palmar arch then can be visualized. The more proximal segment of the TCL and antebrachial fascia are divided under limited vision with scissors as the median nerve is protected

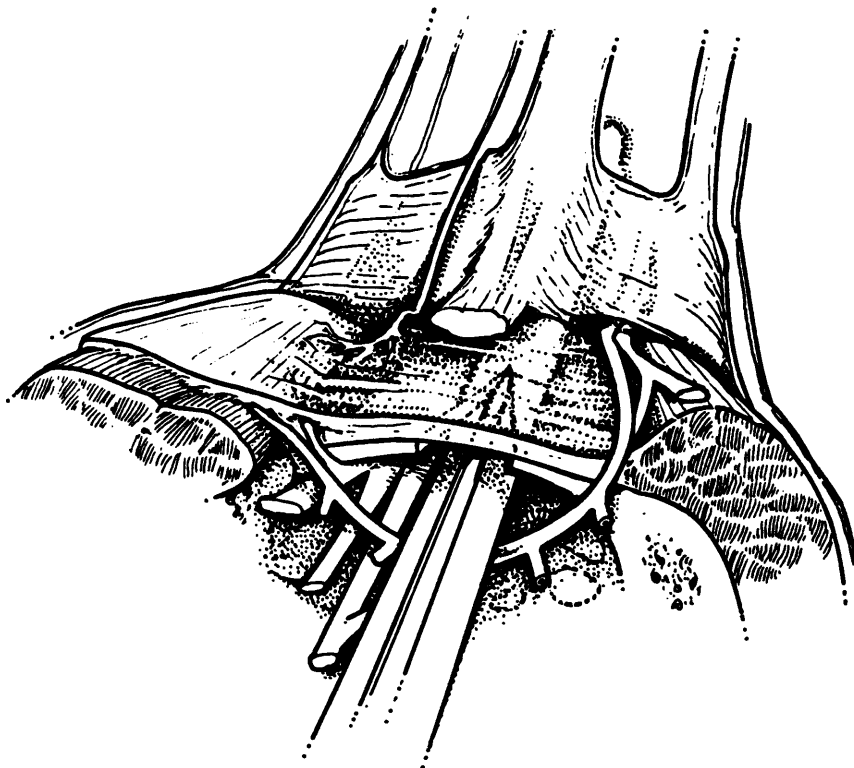


Figure 13. Illustration of distal uniportal ECTR (Palmar Uniportal technique - Mirza). (Courtesy of M. Ather Mirza, MD.)

(Fig. 14). Some surgeons include a repair of the palmar aponeurosis.¹²

A review of 101 cases found an average return to work of 6 weeks for compensation patients and 3.1 weeks for those with private insurance. Grip and pinch measurements were not reported. There were no complications.

Two-Incision Limited Incision Technique (Biyani, Wilson)

In a twin-incision technique described in 1993, a section of skin is left intact at the base of the palm (see Fig. 1).¹¹ A 2- to 3-cm longitudinal incision is made in the palm. The TCL then is divided under direct vision. If there is no pathology within the viewed area of the carpal canal, a second incision is made transversely at the wrist crease between the flexor carpi ulnaris and palmaris longus tendons. Using blunt dissection, a plane is developed between the proximal half of the TCL and the intact skin and subcutaneous tissue. A number 15 blade is used to divide the TCL from a distal to proximal direction. A MacDonald dissector is used to protect the median nerve below. The remaining segment of TCL, not released under direct vision through the distal incision, is released under limited vision with

scissors via the proximal incision at the wrist (Fig. 15).

A subjective questionnaire given to 29 patients treated using this technique demonstrated less early scarring and pillar tenderness than with the open incision. No difference was observed in the late postoperative period. There was one recurrence, two cases of residual symptoms, and one case of slight scar tenderness and occasional palmar discomfort at 13 months after surgery.¹¹ Grip and pinch strength measurements were not recorded for the study.

In 1994, Wilson reported a similar LIT with findings of improved grip and pinch strength and less pillar pain compared with open CTR.⁶⁰

CONTRAINDICATIONS

ECTR and LIT have the same absolute contraindications as open CTR. In addition, if a space-occupying lesion is suspected, an open exploration should be performed. If any pathology is detected in procedures permitting a limited view of the carpal canal, the surgeon should convert to an open CTR procedure for definitive treatment. It should be standard good practice to abandon the procedure in fa-

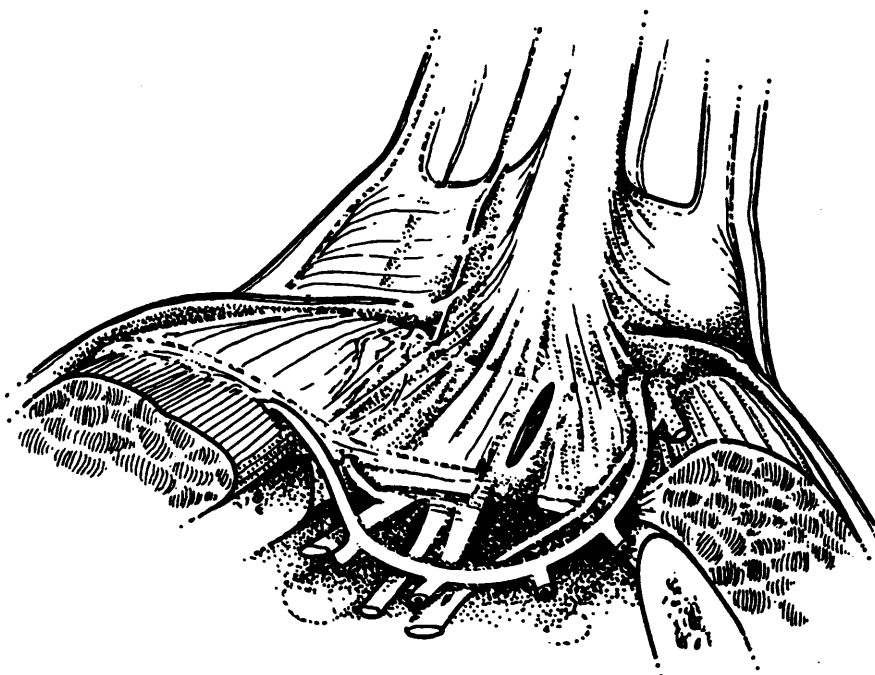


Figure 14. Illustration of mini-incision LIT (Naso). (Courtesy of M. Ather Mirza, MD.)

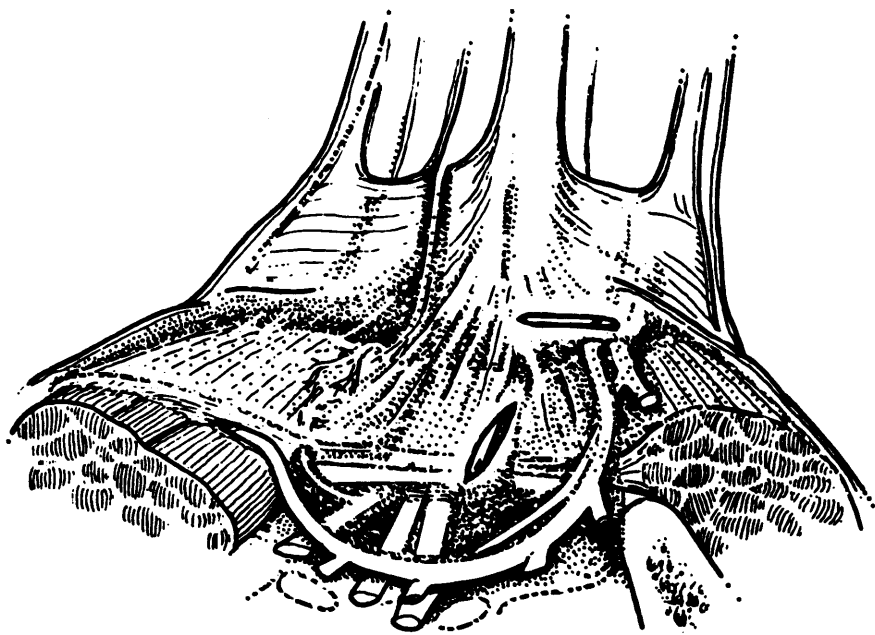


Figure 15. Illustration of two-incision LIT (Biyani). (Courtesy of M. Ather Mirza, MD.)

vor of conventional open CTR if difficulties arise with visualization or instrument placement. The patient should be informed before surgery of a possible conversion. A fracture of the hook of the hamate is a relative contraindication for instrumentation that hug this anatomic structure. Rheumatoid patients with stiff wrists and abundant tenosynovium should be managed with caution. These and other conditions that require direct visualization of the carpal canal are relative contraindications.^{15,48}

DISCUSSION

As might be expected of procedures employing smaller incisions, most studies confirm that ECTR and LIT patients recover strength and function earlier and return to work sooner than do patients treated with the conventional open CTR technique. Financial savings associated with reduced work time lost has been estimated to be considerable.⁴⁹

Although many now choose these newer techniques, some skepticism persists. One source of resistance is the incidence of complications reported in the literature. Potential complications include incomplete release, laceration of the palmar cutaneous nerve or its branches, release of Guyon's canal, injury to the median nerve or its branches, compromise of the ulnar artery and nerve, and injury to the SPA (see Tables 1 and 2). But the complications

actually reported for ECTR are similar to those reported for open CTR.^{28,32} A recent review of the literature estimated nerve lacerations from ECTR to occur in fewer than 1% of patients.¹⁰ Moreover, unlike traditional open CTR, neither ECTR nor LIT has produced any reported excessive bowstringing of the flexor tendons.³⁷ Concerns have been raised about encountering technical problems with visualization or instrumentation. In those circumstances, the surgeon can convert to open CTR rather than risk harm to the patient.

A second objection to the new techniques is the comparative difficulty of learning them. Such a comparison is difficult to quantify. One study of the two-portal ECTR techniques reports an inverse relationship between the number of procedures performed and the rate of complications.³⁸ For surgeons who had performed fewer than 25 ECTRs, there was a 5.6% complication rate; for those who had performed more than 100 operations, the rate fell to 1%. All surgical procedures are associated with a learning curve, which has been reported to be relatively steep with some methods of ECTR.^{19,35} A higher complication rate for surgeons learning the technique is not unique to the newer methods of carpal tunnel release. A higher incidence of incomplete release was reported when the open CTR technique was performed by relatively inexperienced surgeons.³¹ Studies comparing the relative learning curves of the various techniques would be useful.

Underscoring both these concerns about the newer procedures is the inherent complexity of the anatomy in the vicinity of the carpal tunnel. Thorough familiarity with that anatomy is absolutely essential if complications are to be minimized. To review some of the difficulties, the superficial palmar arch is contained within the fat pad and is positioned at a variable distance from the distal edge of the TCL. In some patients, this distance is no more than 2 mm. Because the fat pad extends 2 to 3.5 mm under the dorsal surface of the TCL, it may obscure its distal margins. In addition, the location of the recurrent motor branch of the median nerve may vary considerably. Those arising from the ulnar side of the median nerve are especially at risk.^{23,29,33} The anatomy surrounding the distal edge of the TCL is further complicated by the changing orientation of the flexor tendons and median nerve as they approach it. The median nerve starts to branch and the communicating branch of the ulnar nerve in some cases traverses horizontally close to this distal edge.

These anatomic complexities highlight the importance of adequate visualization at the distal edge of the TCL. Procedures that do not permit this direct exposure prior to the introduction of cutting devices pose a greater risk of injuring these structures. The safest way for a surgeon to proceed is by exploring the distal edge of the transverse carpal ligament and identifying all pertinent structures and potential anomalies before introducing any instrumentation.^{29,43,55}

One way to accomplish this is by modifying the two-portal ECTR with an enlarged distal incision.^{14,43,55} Because it permits identification of the key anatomy at the distal edge of the TCL, this modification should improve the safety of this technique. The two-portal technique, however, requires that the scope be introduced through one portal and the knife or knives through the other while the surgeon simultaneously observes the video monitor. Because this calls for considerable eye-to-hand coordination, it makes the procedure more difficult to learn.

Early findings indicate surgeons experience a flatter learning curve using the palmar uniportal ECTR technique because the sleeve/knife device mounts directly on the endoscope, which results in a technically simpler procedure. Additionally, the distal incision not only allows for the identification of key anatomic structures but also for safe insertion of the instrumentation. The TCL, median nerve, and flexor tendons can be directly and endoscopically visualized before the division of the TCL. If a conversion to an open CTR

is necessary, the small longitudinal incision in the palm is extended proximally, as done with the conventional CTR incision.

This procedure also provides another possible anatomic benefit—the option of preserving the interthenar fascia. In earlier descriptions of ECTR, it was recommended that the flexor retinaculum should be divided inclusive of the TCL and its superficial layers, leaving the palmar fascia intact.⁵ Subsequent studies have concluded that transection of the TCL alone provides symptomatic relief and leaving the interthenar fascia intact may be advantageous.^{21,42}

Choosing a Method Of Carpal Tunnel Release

The most important criteria in choosing a surgical technique are

1. exposure and visualization of the pertinent anatomy
2. reproducibility
3. a reasonable learning curve
4. an acceptable complication rate
5. simply designed and cost-effective instrumentation

The various ECTR techniques, although safely performed by some surgeons, do have the potential for significant complications. We believe the palmar uniportal ECTR technique not only meets the above guidelines but has additional benefits. A summary of its advantages include

1. a single incision in the palm, which obviates the need for a second incision at the wrist and avoids injury to the palmar cutaneous branch of the median nerve
2. a transection of the TCL at a fixed height above the slotted cannula
3. constant endoscopic visualization of the procedure
4. a simple transection of the TCL, usually with only one pass of the device
5. the option of preserving the interthenar fascia
6. a flatter learning curve

The limited open procedures have not yet undergone the intense scrutiny given the more established ECTR techniques. In the senior author's experience, LITs do not provide adequate visualization of the proximal anatomy. We believe that the complications and learning curves of these techniques should be studied further before they are put to wider use.

Table 3. APPROXIMATE COST OF ENDOSCOPIC CARPAL TUNNEL RELEASE INSTRUMENTS*

Company	Initial Cost (\$)	Cost per Case (\$)
Smith Nephew Dyonics	2325	135*
3-M	6171†	187
AM Surgical	2000	30
Linva-tec	N/A	126
Acufex	875	175
Instratek	1350	102*

*1995 Price survey.

†Cost of 3-M device includes dedicated endoscope attachment.

*Cost based on use of 3 disposable knives per case.

CONCLUSION

After 6 years of refinement and increasingly widespread use, ECTR is here to stay. Apprehension concerning complications associated with earlier surgical experiences is being alleviated by newer techniques, increased experience, and improved instrumentation (Table 3). The danger zone for ECTR is at the distal end of the TCL where complex and variable anatomy create the potential for complications (see Fig. 5). Accordingly, it is imperative that this anatomy be identified if complications are to be minimized. Instrumentation should be cost-effective and simple in design, with an acceptable complication rate.

The evolution of the newer techniques of carpal tunnel surgery continues in much the same manner as did that of the standard open CTR method. Learmonth, when asked to describe his scientific philosophy, quoted Francis Bacon: ". . . neither affection for what is new nor admiration for what is old. . . ." With this in mind, we should continue scientific advancement without favoritism for open CTR nor partiality to the newer techniques.

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