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# What is true endoscopic surgery for carpal tunnel syndrome ? – 5 880 clinical experiences in 18 years

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## 什么是腕管综合征的真正内镜手术？——18 年 5 880 例临床经验

【摘要】 腕管综合征是常见的卡压性周围神经病变,由正中神经在腕管内受到卡压引起。它的手术治疗方法在于从掌侧切开腕管,减压正中神经。术式有最初非开放的盲切手术、开放手术、以及利用内镜手术(主要分为单切口和双切口法两类)等。笔者在 1986 年首创了应用 USE ( universal subcutaneous endoscope )系统单切口法治腕管综合征,力求创伤最小、最安全的手术方式。USE 系统由透明闭锁外套管和 30°斜视内镜组成。这是真正意义上的内镜手术,与内镜辅助下的手术在视野、绝对禁忌证等多方面都不同。笔者术中在局麻下,透过透明外套管在内镜直视下在腕管内用钩刀或改良方法于腕管外用推刀彻底切断腕横韧带和 DHFFR( distal holdfast fibers of the flexor retinaculum ) ,达到腕管开放减压的目的,并可于术中通过透光实验及腕管压力测定等方法判断腕管是否完全开放以保证手术效果。另外,笔者还在腕管综合征的诊断方面,新创一种神经诱发体征,命名为 Okutsu Test。它的阳性率高于 Phalen Test,而且在正常人群中未发现假阳性。然而最准确的腕管综合征诊断方法是腕管压力测定。通过正常对照,确定在腕管综合征术前休息位腕管内压力高于 15 mm Hg,握拳位是腕管内压力高于 135 mm Hg 的诊断指标。采用腕管压力测定不仅可以用于诊断,还可以在术中测定判断腕管减压程度。笔者应用 USE 系统在 18 年中进行了 5 880 例腕管综合征的治疗,经过最少 6 月、平均 2.4 年的随访,近 90% 的患者在术后 24 周痛、触觉恢复正常,电生理检查和 MRI 检查结果也提示了良好的临床效果。并发症的发生率为 0.34%,包括假性动脉瘤、局部血肿形成、暂时性尺神经麻痹等,无屈肌腱和神经损伤。本文介绍的应用 USE 系统取前臂切口内镜下治疗腕管综合征的方法是真正的眼镜下微创手术,对健康组织损伤最小、并发症发生危险性最低,治疗效果满意可靠。

【关键词】 腕管综合征； 内镜

中图分类号: R686.5

文献标识码: C

文章编号: 1009 – 6604( 2005 )05 – 0342 – 05

### Introduction

Carpal tunnel syndrome is a compression neuropathy, wherein the median nerve is compressed inside of the carpal canal for a variety of reasons. The treatment of carpal tunnel syndrome is release of the volar structures of the carpal canal and decompression of the median nerve ( Okutsu, 2001a ). Release of the transverse carpal ligament ( which has been known as the flexor retinaculum since 1955 ), using a blind procedure, was first performed by Learmonth ( Learmonth, 1933 ) in 1930. This blind procedure includes a possibility of injury to the median

nerve and flexor tendon, and incomplete release of the flexor retinaculum. To avoid these problems, an open procedure was developed by Cannon et al. ( Cannon, 1946 ), Brain et al. ( Brain, 1947 ) and Phalen et al. ( Phalen, 1950 ). This became the standard procedure until 1986. Open procedures, however, cause healthy tissue damage during the surgical approach, cause postoperative scar formation, may lead to postoperative discomfort and a need for long rehabilitation periods before returning to work.

In 1986, I developed the world's first minimally

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invasive approach to carpal canal release and decompression, using the Universal Subcutaneous Endoscope (USE) system which consists of a transparent closed sheath and a standard 30 degrees anterior oblique viewing arthroscope (Okutsu, 1987, 1989 a) (Fig. 1). This paper describes our evidence-based true endoscopic operative procedure for carpal tunnel syndrome.

### Historical Background of Endoscopic Procedures

Okutsu et al. reported the world's first one portal endoscopic technique for carpal tunnel syndrome using the Universal endoscope in the Journal of the Japanese Orthopaedic Association in 1987 (Okutsu, 1987). Futami et al. developed a two portal procedure using a translucent, open sheath and a special arthroscope with irrigation (Futami, 1989). Chow developed another two-portal technique using an opaque open sheath with a standard arthroscope without irrigation (Chow, 1989). Agee et al. developed a single portal technique using an opaque open sheath with a small diameter endoscope (Agee, 1992).

### Anatomical Considerations

Almost all orthopaedic surgeons who use the standard open surgical procedure consider the flexor retinaculum (FR) to be the sole target in carpal tunnel release. Cobb et al. (Cobb, 1993) reported that the flexor retinaculum consisted of the "original transverse carpal ligament", the "distal portion of the flexor retinaculum", and the "proximal portion of the flexor retinaculum". In 1955, the Paris Nomina Anatomica decided that the transverse carpal ligament should, henceforth, be referred to as the flexor retinaculum manus. Cobb's terminology may lead to some confusion as a result.

We performed more meticulous endoscopic observations as well as microscopic observations however, and learned that the distal portion of the flexor retinaculum, which was described by Cobb, is a separate and distinct structure from the original transverse carpal ligament (Okutsu, 1996a, Tanabe, 1997). We, therefore, termed the distal portion of the flexor retinaculum the "distal holdfast fibers of the flexor retinaculum" (DHFFR) from a functional point of view (Okutsu, 1996a).

The DHFFR is separated from the flexor retinaculum by a thin layer of adipose tissue, deep relative to the palmar aponeurosis and superficial to the flexor retinaculum, between the thenar and hypothenar fascia. We discovered the "Distal Holdfast Fibers of the Flexor Retinaculum" or DHFFR, which are located at the distal end of the carpal canal, and function as a "holdfast" or anchor to the distal part of the flexor retinaculum (Fig. 2) (Okutsu, 1996a).

### Carpal Canal Pressure Measurement and Anatomical Structures Relevant to Decompression

Open surgery approaches from the surface of the skin to the flexor retinaculum, and, coincidentally, releases all intervening structures. Endoscopic surgery approaches from within the carpal canal, and thus can release only the flexor retinaculum.

We wondered if this was sufficient to completely

decompress the carpal canal and, hence, the median nerve.

Carpal canal pressure measurement using a continuous infusion technique was first reported by Gelberman et al. (Gelberman, 1981) in 1981. We also became interested in preoperative carpal canal pressure measurement due to the fact that carpal tunnel syndrome is a compression neuropathy. Based on our clinical experience, and data from healthy volunteers, we determined that in carpal tunnel syndrome cases, preoperative carpal canal pressure in resting position is higher than 15 mmHg and/or higher than 135 mmHg with active power grip (Okutsu, 1989b). Hashizume et al. (Hashizume, 1997) also reported usefulness of the carpal canal pressure measurement test results.

We were interested in postoperative carpal canal pressure measurement results to determine if release of the flexor retinaculum alone is enough for complete decompression of the carpal canal or not. Since 1986, we have analyzed our operative results using carpal canal pressure measurement with a continuous infusion technique (Okutsu, 1998b). We noticed that some patients achieved optimal postoperative carpal canal pressure while others did not. We suspected the existence of an additional structure that needed to be released to achieve complete decompression in true endoscopic surgical procedure.

To confirm the relevance of DHFFR release, we measured carpal canal pressure preoperatively, release of the FR alone, release of the DHFFR in addition to the FR and finally release of the forearm fascia.

Release of the forearm fascia did not cause a significant difference in pressure between release of the DHFFR in addition to the FR and release of the forearm fascia. We have concluded release of the forearm fascia is not necessary (Okutsu, 1996a).

From these measurements we concluded that release of the DHFFR in addition to release of the FR is necessary to achieve complete decompression of the carpal canal using the true endoscopic surgical procedure (Okutsu, 1996a, 1996b).

### Median Nerve Pressure Measurement

Postoperative carpal canal pressure measurements demonstrated that the true endoscopic procedure decompressed the carpal canal, however, some doctors have been expressing skepticism regarding whether or not decompression of the carpal canal is equivalent to decompression of the median nerve. We, therefore, measured intraneural median nerve pressure (Okutsu, 2001a) and statistically compared it to carpal canal pressure (Okutsu, 2004). We found that there was a positive correlation, and that a postoperative decrease in carpal canal pressure is indicative of a corresponding decrease in median nerve pressure.

We found that preoperative mean median nerve pressure and carpal canal pressure were both higher than postoperative pressure in resting position. Preoperatively median nerve and carpal canal pressure were correlated in resting position. We also found that preoperative mean

median nerve pressure and carpal canal pressure were both higher than postoperative pressure in Okutsu test position which is described in diagnosis section ( Okutsu 2001b ) and with active power grip. Postoperatively median nerve and carpal canal pressures were correlated in Okutsu test position and with active power grip ,excluding resting position results ( Okutsu 2004 ).

### Magnetic Resonance Imaging

Kato et al. reported an average postoperative increase in the carpal canal cross sectional area of 30% ( Kato , 1994 ) in comparison to preoperative measurements ,using demonstrated MRI after our endoscopic procedure ( Fig.3 ).

### Diagnoses

Diagnoses of carpal tunnel syndrome are confirmed by clinical signs ,such as tingling sensations ,abnormal touch and pain sensations ,a decrease in the power of the abductor pollicis brevis muscle ,and by clinical induction testing.

Clinical induction tests are the median nerve percussion test ,median nerve compression test ,median nerve extension test and tourniquet test.

I developed the new clinical induction test in 2001. In the Okutsu test ( Okutsu 2001b ) ,the patient and doctor 's hands are clasped in a palm - to - palm grip ,and the patient 's hand is maximally deviated to the radial side for one minute ( Fig.4 ). Aggravation of symptoms in this position is considered a positive indicator of carpal tunnel syndrome. The positive rate of the Okutsu test is higher than that of the wrist flexion test known as the Phalen test ( Phalen ,1966 ). In healthy subjects the Okutsu test has shown no false positive results.

The objective test for carpal tunnel syndrome is electrophysiological testing for distal sensory and motor latency. This test ,however ,sometimes yields false negative results as reported by Hamanaka ( Hamanaka ,1995 ).

The most accurate diagnostic tool for carpal tunnel syndrome is carpal canal pressure measurement.

### Operative Techniques

Operations are performed under local anesthesia without pneumatic tourniquets on an out - patient basis. We apply 1 to 1.5% lidocaine containing epinephrine to the forearm skin located 1.5 cm proximal to the distal wrist crease and just ulnar to the palmaris longus tendon. We wait for five minutes and then perform preoperative carpal canal pressure measurements.

A one - centimeter skin incision is made in the same area. A mosquito haemostat is advanced between the skin and forearm fascia and then advanced into the carpal canal between the proximal portion of the flexor retinaculum and the distal portion of the forearm fascia.

### Original Operative Procedure Using a Hook Knife

The USE system is inserted into the carpal canal until it makes contact with the flexor tendons. From the very beginning ,all operative procedures are observed on a monitor ( Okutsu ,1987 ,1989a ) ( Fig.5 ). We positively ,visually confirm the exact location for resection of the flexor retinaculum before any structure is released. We do not cut anything that we have not identified. The hook knife is then advanced to the distal end of the flexor

retinaculum beside the ulnar side of the sheath and the flexor retinaculum is then released ( Fig.6 ).

When only the flexor retinaculum is released ,the sectioned ends are only separated by four millimeters ,which we refer to as " incomplete release " ( Fig.7 ). To safely achieve complete release of the volar structure of the carpal canal ,the USE system is inserted between the DHFFR and the superficial palmar arch. In this location the common digital nerve is located dorsal to the superficial palmar arch. After release of both the flexor retinaculum and the DHFFR ,the sectioned ends of the flexor retinaculum are separated by eight millimeters or more ( complete release ) ( Fig.7 ) ( Okutsu ,1996 a ,b , 2001c ).

### Modified Operative Procedure Using a Push Knife

In our modified procedure ,the USE system is located inside of the carpal canal ,however ,the push knife is located outside of the carpal canal. The push knife is guided by the sheath shelf. We first release the flexor retinaculum and then the DHFFR just as in the original procedure and both procedures are equally successful.

Following the operation ,the wound is closed without any stitches using sterilized dressing material. A compression bandage is applied for twenty - four hours to prevent postoperative bleeding. The patients are instructed to remove the bandages themselves on the first postoperative day. We recommend patients begin using their hands immediately after the operation.

### Clinical Recovery and Complications

In Japan ,at present ,220 ,000 patients are undergoing long - term haemodialysis ,and many of them suffer from carpal tunnel syndrome. For this reason ,we separate their operative data from that of idiopathic patients ,and then statistically compare the results. There is ,however ,no significant statistical difference in the data ( Okutsu ,1993 ).

The minimum follow - up period was six months ,and the mean follow - up period was 2.4 years.

The relationship of postoperative time and clinical recovery depends on postoperative carpal canal pressure ( Okutsu ,1998b ). We have demonstrated that lower postoperative pressure results in a more rapid clinical recovery.

The clinical recovery rates of idiopathic and long - term haemodialysis patients following complete release and decompression of the carpal canal are equal.

In 75% of the patients who underwent our true endoscopic procedures ,recovery time to normal tingling sensation occurred within 12 weeks. The recovery rate at 24 postoperative weeks was close to 90% .

Recovery time to normal pain sensation as measured by a three - gram algometer occurred in 8 weeks in 75% of our patients. The recovery rate at 24 postoperative weeks was close to 90% . Recovery time to normal touch sensation as measured by a 2 - gram von Frey hair also occurred in 8 weeks in 75% of our patients. The recovery rate at 24 postoperative weeks was also close to 90% . Manual muscle testing results were good. Many cases in which preoperative manual muscle testing revealed zero recovered to within the normal range.



Fig. 1 The Universal Subcutaneous Endoscope ( USE ) system. The USE system consists of a transparent closed sheath and a 30 degree anterior oblique viewing arthroscope

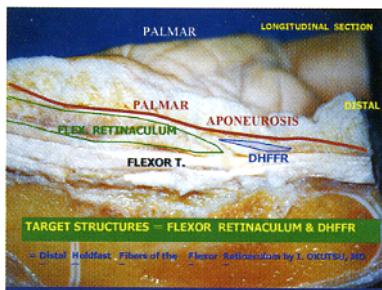


Fig. 2 Longitudinal section of the carpal canal. Distal holdfast fibers of the flexor retinaculum ( DHFFR ) is located at distal end of the flexor retinaculum

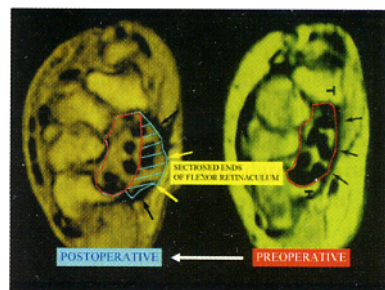


Fig. 3 Pre and postoperative axial MRI of the carpal canal. Cross sectional area of the carpal canal is increased by release of the flexor retinaculum and DHFFR

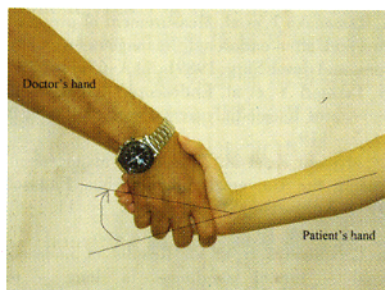


Fig. 4 Okutsu test : New clinical induction test for carpal tunnel syndrome



Fig. 5 Operation.



Fig. 6 Identification of the flexor retinaculum ( FR ) and the hook knife ( arrow ). Fibers of the flexor retinaculum run transversely

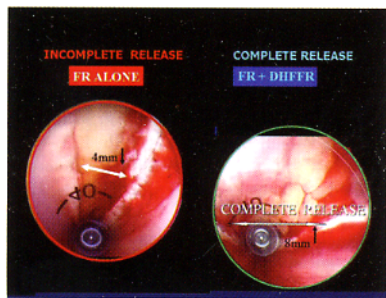


Fig. 7 Incomplete and complete release of the carpal canal

Preoperatively 80% and 95% of the patients exhibited abnormalities in DSL and DML ,respectively. Postoperatively 70% and 60% of those patients who had demonstrated abnormalities preoperatively recovered to within normal range.

In 5 880 hands operated on using our procedures we have a complication rate of 0. 34% . Our most serious complications were pseudo - aneurysm formations in two hands. One aneurysm was removed by open surgery. Other complications have included postoperative haematoma formation at the operative site ,and temporary ulnar nerve palsy. Both of these problems eventually disappeared without further treatment. We have had no flexor tendon or nerve injuries.

## Discussion

We created the Universal Subcutaneous Endoscope system to allow a minimally invasive surgical approach for

carpal tunnel syndrome ( Okutsu ,1987 ,1989a ) ,shoulder impingement syndrome ( Okutsu ,1991 ) ,tendon transfer ( Okutsu ,2000 ) , cubital tunnel syndrome ( Okutsu ,1999 ) ,ulnar tunnel syndrome ,tarsal tunnel syndrome and benign bone tumors ( Okutsu ,1992 ,1998 ) in the orthopedic field. Our primary goal was to create a procedure that caused minimal damage to healthy tissues and the safest possible procedure ,and so we use a transparent , closed sheath , which enables complete endoscopic visualization of the entire procedure.

In cases of carpal tunnel syndrome ,we operate from a one - centimeter skin incision at the forearm. This small skin incision does not require a general or block anesthesia and is performed without a pneumatic tourniquet.

Some doctors have been expressing concern about injuries to the median nerve. In our procedure ,the nerve is protected from the hook knife by the intervening sheath when a sheath is inserting just ulnar to the palmaris longus tendon and the hook knife is inserting just ulnar to a sheath ,and can be observed by inserting the sheath just radial to the palmaris longus tendon and making contact with the median nerve. We have had no nerve injuries using our procedure.

Our true endoscopic surgery differs from other endoscopically - assisted surgery in a number of ways. Most importantly ,in true endoscopic surgery ,all relevant structures are visually identified throughout the entire the operation. Every structure is confirmed prior to its release , and there is no risk of damage to other healthy tissue. In contrast , in endoscopically - assisted surgery , the

instrument is inserted in a blind fashion ,with the operator relying on anatomical landmarks. With open endoscopic sheaths ,blood or adipose tissue can easily obstruct vision ,creating a high risk of complications.

In the International Federation of Societies for Surgery of the Hand ( IFSSH ) Minimally Invasive Committee report on the contraindications to endoscopic carpal tunnel release ,Chow has listed ten absolute contraindications to his dual portal endoscopically - assisted technique. These contraindications are not relevant to true endoscopic surgery.

Neurolysis is not required ,as it has no effect on the recovery rate of patients that have undergone true endoscopic surgery.

In rheumatoid patients ,synovitis can be controlled by medication following decompression.

The frequency of ulnar tunnel syndrome ( compression of the ulnar nerve inside of the Guyon 's canal ) is very low ,and has no relationship to endoscopic carpal tunnel release. We have also performed endoscopic decompression of the ulnar nerve in the Guyon 's canal.

Even in patients with lesions ,anatomic abnormalities ,i. e. ,thalidomide hands or bone deformities ,i. e. ,distal radius fractures ,the target structures can all be observed in the true endoscopic procedure ,and the carpal canal can still be safely released and decompressed. Endoscopically - assisted procedures ,which have a limited field of vision ,and rely on anatomical landmarks ,are rendered impossible by abnormalities.

In some long - term haemodialysis patients ,carpal tunnel syndrome recurs after either open or endoscopic carpal canal release. We have re - operated in such cases using our true endoscopic procedure ,with no complications and have achieved clinical recovery rates comparable to that of initial operations ( Yoshida 2004 ). We have had no recurrences among idiopathic patients.

We conclude ,therefore ,that our one forearm portal true endoscopic procedure for carpal tunnel syndrome using the Universal Subcutaneous Endoscope ( USE ) system is ,by definition ,minimally invasive surgery. It causes minimal damage to healthy tissue ,it is a true endoscopic procedure with minimal risk of complications ,and it is evidence - based ,confirmed by carpal canal pressure measurements , median nerve pressure measurements , MRI , electrophysiological and clinical results.

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