World Journal of Orthopedics

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World J Orthop 2023 January 18; 14(1): 6-12

DOI: 10.5312/wjo.v14.i1.6

ISSN 2218-5836 (online)

MINIREVIEWS

Update on surgical procedures for carpal tunnel syndrome: What is the current evidence and practice? What are the future research directions?

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Specialty type: Orthopedics

Provenance and peer review: Invited article; Externally peer reviewed.

Peer-review model: Single blind

Peer-review report's scientific quality classification

Grade A (Excellent): 0
Grade B (Very good): 0
Grade C (Good): C, C
Grade D (Fair): 0
Grade E (Poor): 0

P-Reviewer: Anandan H, India; Tawonsawatruk T, Thailand

Received: September 20, 2022
Peer-review started: September 20, 2022
First decision: November 25, 2022
Revised: December 3, 2022
Accepted: December 21, 2022
Article in press: December 21, 2022
Published online: January 18, 2023

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Abstract

Carpal tunnel syndrome (CTS) is a multifactorial compression neuropathy. It is reported to be very common and rising globally. CTS's treatment varies from conservative measures to surgical treatments. Surgery has shown to be an effective method for more severe cases. However few unclear aspects and room for further research and improvements still remains. We performed a narrative literature review on the most up to date progress and innovation in terms of surgical treatments for CTS. The simple algorithm of leaving the choice of the surgical method to surgeons' preference and experience (together with consideration of patients' related factors) seem to be the best available option, which is supported by the most recent metanalysis and systematic reviews. We suggest that surgeons (unless in presence of precise indications towards endoscopic release) should tend to perform a minimally invasive open approach release, favoring the advantage of a better neurovascular structures visualization (and a consequent higher chance to perform a complete release with long term relief of symptoms) instead of favoring an early reduction (in the first postoperative days) of immobilization and pain. Research towards a universally accepted standardization should be aimed for by the researchers, who have failed to date to sufficiently limit bias and limitations.

Key Words: Carpal tunnel; Carpal tunnel release; Transverse ligament; Endoscopic release; Open release

Core Tip: After reviewing the most up to date literature, it could be said that evidence of superiority of one technique over the others is lacking from a high level of evidence point of view. Specific advantages and disadvantages of surgical methods can however be taken into account when choosing among treatments. The simple algorithm of leaving the choice of the surgical method to surgeons' preference and experience (together with consideration of patients' related factors) seem to be the best available option, which is supported by the most recent metanalysis and systematic reviews.

Citation: Pace V, Marzano F, Placella G. Update on surgical procedures for carpal tunnel syndrome: What is the current evidence and practice? What are the future research directions? *World J Orthop* 2023; 14(1): 6-12
URL: https://www.wjgnet.com/2218-5836/full/v14/i1/6.htm
DOI: https://dx.doi.org/10.5312/wjo.v14.i1.6

INTRODUCTION

Carpal tunnel syndrome (CTS) is a multifactorial neuropathy caused by compression of the median nerve at the carpal tunnel. Its symptoms include pain, tingling or numbness affecting mainly the thumb, index and middle finger (sometimes the ring finger is also involved), with this sensation that could travel up the arm; hand weakness (mainly the thumb's pinching muscles).

The incidence of CTS in the general population is thought to be about 3%-4%; although it could reach 8% in the working population. Figures vary quite significantly among continents and countries, but unequivocally the trends suggest the CTS incidence and subsequent surgical management are rising globally[1-3].

The majority of cases seem to be idiopathic. Other causes such as fractures, infections and systemic diseases should also be taken into account. In fact the primary diseases should be properly assessed and treated, together with CTS in order to achieve complete resolution of symptoms[1-4].

The diagnosis is made with accurate history taking and clinical examination, supported by electromyography (EMG) and nerve conduction studies. Ultrasound has been used to aid diagnosis. Most people with mild to moderate symptoms are initially treated non-operatively. However surgery is thought to provide more effective and durable symptom relief, especially for the most severe cases[4].

Various surgical methods have been proposed and studied, with contradictory results. In fact little agreement on the best surgical procedure to treat CTS has been reached. Most of studies are characterized by significant limitations, which do not allow the clinicians to achieve a consensus on the matter [4,5].

Our aim is to present an update on surgical procedures for carpal tunnel syndrome, highlighting what the current evidence is, with advantages and limitations of the studied surgical methods. The final goal is to provide the most up to date scientific information in order to help the clinicians to maintain good practice with decisions based on the highest possible level of evidence.

DIAGNOSIS

Accurate physical examination is warranted (after full history taking). It should include Tinel sign and Phalen sign, which are commonly utilized to reveal median nerve compression at the carpus. Durkan's compression test could also be used, but it is not useful to discriminate between symptomatic patients with and without EMG disturbances. The closed fist test is specific in these situations. Two-point discrimination is considered positive if greater than 4 mm. EMG shows that the median nerve transmission rate decreases and the latency period extends beyond normal values. Ultrasounds are sometimes used to aid diagnosis[4-7].

SURGICAL MANAGEMENT

Surgical management is recommended after failure of conservative measures (splinting, physiotherapy, manual therapy, steroid injections, platelet-rich plasma injections, Kinesio taping, neurodynamic techniques, gabapentin, therapeutic ultrasound, and extracorporeal shockwave therapy) for mild and moderate cases of CTS, or for the most severe cases (numbness in the hand, atrophy of the hand muscles, restricted hand function). No high-grade clinical evidence currently supports specific surgical

indications. Surgery should be aimed at reduce the compression on the median nerve at the carpus, at the level of the transverse ligament. The cause of CTS should also be clearly identified, as the primary disease should be treated and resolved as well. However most of cases are thought to be idiopathic. For those cases, a carpal tunnel release is indicated[4,6-8].

SURGICAL PROCEDURES

The first reported surgically treated cases of CTS we could found in the literature are the ones presented by Herbert Galloway in 1924. Since then, surgical methods have become more and more common. Many surgical options have been studied and proposed, but in the end the main open uncertainty is about the choice between open surgery and endoscopic assisted surgery. Ultrasound guided methods have also been developed[6-9].

Open carpal tunnel release

Surgeons could use a traditional incision or a mini-incision. The landmarks for the traditional incision are the radial border of the hypothenar muscle, where the incision should be started and extended proximally till the distal wrist crease. 5 cm is the most common length of the incision, but it can be further extended to better visualize the structures. The mini-incision techniques include a transverse incision of about 2 cm on the ulnar side of the wrist stripes or a longitudinal incision starting from the mid-palm and ending at the most proximal portion of the palm. The main issues when using the two latter options are increased complexity, scar pain and increased chance of incomplete transverse ligament release. Other options such as double mini-incisions or other slightly different longitudinal incision options have been presented with promising results. Many studies have proved that all mini-incision technique are safe and provide good results[6,10,11].

After skin incision, the surgeon should go through the palmar fat and fascia, trough which the flexor retinaculum should be visualized. When adequately exposed, it should be completely split longitudinally, with decompression and visualization of the median nerve. Wound closure (skin stitches) and a wound dressing are the last surgical steps. Some authors have presented a method of open release through a small incision using a set of specially designed instruments, retaining advantages of observing the pathology under direct vision and avoiding complications of hazardous injuries to important structures. The instruments consist of a thin metal guide with a groove in the center to accommodate an angled knife holder. The procedure has been performed since 1997 with no complications[10,11].

Open carpal tunnel release (OCTR) has been reported to be a safe procedure overall. Only few cases of wound infections are reported. Scar formation on the palm could also be a complication, especially for traditional size incisions. The palmar nerve branch of the median nerve could also be damaged inadvertently during surgical exposure, as it arises at the distal part of the forearm palmarly and it divides into a medial and lateral branch, passing superficial to the flexor retinaculum of the hand. Another nerve that might be injured is the recurrent motor nerve branch of the median nerve, which normally supplies the thenar muscles. His injury might significantly affect the thumb function[9,11,12].

Endoscopic carpal tunnel release

Single-portal and two-portal endoscopic carpal tunnel release (ECTR) have been reported. The first was introduced in 1986 by Okutsu *et al*[13] who started using the aid of endoscopy to perform carpal ligament release. This technique was used and modified by several other authors in the years, such as Agee and Linvatec[14].

Agee used an entry portal between the palmaris longus and the flexor carpi ulnaris at the level of the proximal wrist striatum. The palmaris longus tendon is then exposed after soft tissue dissection. The endoscope is then placed at the level of the ulnar side of the transverse ligament through the portal, and the ligament is cut from distal to proximal. Not good visualization of the neurovascular structures is the main issue of this approach[14-17].

Linvatec introduced a similar single-portal technique. The main characteristic and difference compared to the previous described technique is that the transverse ligament is cut from proximal to distal[14-17].

Among the two-portal ECTR, the Chow technique is the most widely used method. The first portal is made similarly to Agee method's entry portal, whilst the second portal is made in the palm surface (0.5-0.75 ncm in length) on the bisect line of the angle formed from the distal border of the fully abducted thumb and the third web space and approximately 1 cm proximal to the junction of these lines[18,19].

The surgeon should than push the sleeve till it enters into carpal tunnel from the entry portal and exits through the exit portal with the flexor tendon sliding. Cutting tools are then inserted into the sleeve and surgeons can cut the transverse ligament bilaterally under endoscopic monitoring[18,19].

It is thought that two-portal techniques allow a better visualization of the neurovascular structures and therefore they carry the lowest risk of complications and the higher chance to completely cut the transverse ligament. On the other hand, given the quite distal incision of the Chow technique, we must

say that the risk of injury to the arcus volaris superficialis is higher than in other endoscopic techniques, together with a higher risk of excessive palmar scar formation[15,16,18,19].

Comparison among surgical procedures

A huge amount of work has been carried out and lots of papers published on the matter. Several reviews and metanalysis are also available. From the most up to date evidence it seems that no significant differences exist among the different surgical methods. However it must be said that relevant limitations often bias the results[12,15-17].

Results related to differences among mini-incision and traditional incision surgery are various and contradictory. There are studies reporting good outcomes and lower complication rates with mini-incision techniques. Undoubtedly a smaller approach results in less invasive surgery and this could contribute to better esthetic results both on the short and long run, with potential better patients' satisfaction. However symptoms resolution on the long run is the main objective of the performed surgery, and it is unclear whether open surgery could allow better results due to better visualization of the structures and reduced revision surgery rate. Similar results among mini and conventional approach have also been reported[19-24].

Despite what one could hypothesize regarding potential benefits of endoscopic procedures *vs* open surgery in terms of complication rate, operative time and outcomes and patients' satisfaction, overall data do not clearly highlight such advantages. Moreover most of papers present similar results. More evidence is present with regards to postoperative hand pain and recovery time, in favor of endoscopy procedures, allowing a quicker return to work and his consequent reduction of costs and resources. In fact open surgery (particularly the traditional approach) may prolong the immobilization time and augment postoperative pain and the risk for hypertrophic or hypersensitive scar formation. However the better visualization of the neurovascular structures allowed by the open procedures makes the latter safer from this point of view. However it must be said that most noted nerve injuries were transient, and patients still achieved full recovery after surgery. It should be taken as a worrying sign that often the choice between open and endoscopic surgery is left to surgeons' preference and experience, together with patients' related factors. It seems that a lack of universally accepted evidence on one of the most common syndromes and related surgical management still exist[15,16,20-23].

Among the endoscopic techniques, the majority of the studies have focused their attention on the two-portal technique, whilst fewer studies have reported the results of the Agee's technique. The latter is claimed to be used for his potentials of reducing the higher complication rates of the Chow's technique reported by some authors. Better results in terms of recovery time and return to work has been reported in favor of the single-portal techniques. However the utilization of just one portal could cause a not perfect visualization of the structures (including the transverse ligament), and this could lead to incomplete ligament section and the consequent recurrence of symptoms and the need of revision surgery[22-27].

Intuitively one could relate the endoscopic techniques to mini-incision techniques, as they are based on the same objectives (a smaller approach able to provide good or even better results). In fact surgeons utilizing these techniques aim to a better appearance of the scar (and less complications related to scarring processes) and a quicker recovery, with better patients' satisfaction and acceptance of the procedure. However insufficient evidence with regards of comparison between the two techniques is still present[26-29].

A mention to ultrasound-guided percutaneous carpal tunnel release is needed. Several authors have performed carpal tunnel release with such modality, reporting good results and claiming that it could be an effective treatment for CTS. However the overall level of evidence has been reported by review and metanalysis to be very low, with several studies with at least moderate risk of bias. A low complication rate and fast recovery have often been reported after such procedures[29-32].

Another special mention should be given to epineurotomy and flexor tenosynovectomy. They are often considered as a useful adjunct to the basic surgical procedure, but their indications are still controversial. It seems that tenosynovectomy is only recommended for patients with rheumatic disease (or inflammatory risk factors), or patients undergoing chronic hemodialysis. The intraoperative finding of excessive or abnormal synovial tissues makes a tenosynovectomy also indicated[33-37] Table 1.

CONCLUSION

There has been controversy regarding the superiority of ECTR over OCTR in the last decades. Many original articles have been published on this issue; moreover, several meta-analyses have compared ECTR with OCTR as treatment options for CTS, but relevant bias and limitations have commonly been reported. Therefore a universal consensus has not been achieved yet, even if CTS is a very common pathology and his surgery is routinely and widely performed[26,27].

Over the years the wrist anatomy knowledge has improved and various surgical instruments and methods have been studied and presented. Sufficient effectiveness has always been reported, but a high quality evidence is lacking.

Table 1 Advantages of surgical options (risk of hypertrophic or hypersensitive scar formation should be considered secondary, despite temporary discomfort for the patients)

Advantages of open release	Advantages of endosopic release
Good outcomes	Good outcomes
Low complication rates	Low complication rate (slightly better the open release)
Mini-incision: best approach and better patients' satisfaction	Better esthetic results (much smaller scars)
Reduced revision surgery rate	Reduced risk for hypertrophic or hypersensitive scar formation
Better visualization of structures	Reduced postoperative hand pain
Safest approach for neurovascular structures	Reduced recovery time
Possibility to use a mini-incision approach	Quicker return to work
Possibility to perform epineurotomy and flexor tenosynovectomy	Reduced costs and resources

Many studies determined that ECTR was superior to OCTR in terms of higher satisfaction rates, improved key pinch strengths, earlier recovery times, and fewer scar-related complications. This suggests that patients with CTS can be effectively managed with ECTR; however, the possibility of transient nerve injury should be considered. However most of studies are characterized by significant limitations, which do not allow the clinicians to achieve a consensus on the matter. Clear and high level of evidence advantages of one technique over the others have not been provided yet, and sufficient results seem to be provided with any of the studied methods[4,5,26-29,38].

We believe that the lack of high level of evidence regarding the surgical techniques should be taken as a worrying sign, especially because clear evidence is most of the time provided for the most common diseases and related management options. In fact it seems that often the choice between open and endoscopic surgery is left to surgeons' preference and experience, together with patients' related factors. To date, this simple algorithm has shown to be able to provide the best results. Surgeons should refrain from attempting potentially less invasive procedures if not familiar with the technique, as the risks of arming would outweigh the potential better results.

Relevant authors tend to strongly recommend their proposed technique, commonly providing evidence of excellent results and elements in favor of their method over the other ones. However when it comes to systematic reviews and metanalysis, data suggest that relevant bias and limitations do not allow standardization and do not provide sufficient evidence of the superiority of a technique over the others.

We suggest that surgeons (unless in presence of precise indications towards endoscopic release) should tend to perform a minimally invasive open approach release, favoring the advantage of a better neurovascular structures visualization (and a consequent higher chance to perform a complete release with long term relief of symptoms) instead of favoring an early reduction (in the first postoperative days) of immobilization and pain. Moreover, in view of higher chances to obtain long term symptoms relief, the risk of hypertrophic or hypersensitive scar formation should be considered secondary, despite temporary discomfort for the patients Table 1.

We believe there is room for further research evidence, possibly high level of evidence works (level 1 or 2) which should separately study specific aspects and provide detailed and clear advantages and disadvantages of every single treatment option. Cohorts should be sufficiently big and bias reduced to the minimum. The problem of the current heterogeneity should also be overcomed.

CTS is becoming more and more common, as is its surgical management. This constitutes a significant economic burden for societies. All surgical techniques have provided satisfactory results and have been proven to be effective options. After reviewing the most up to date literature, it could be said that evidence of superiority of one technique over the others is lacking from a high level of evidence point of view. Specific advantages and disadvantages of surgical methods can however be taken into account when choosing among treatments. The simple algorithm of leaving the choice of the surgical method to surgeons' preference and experience (together with consideration of patients' related factors) seem to be the best available option, which is supported by the most recent metanalysis and systematic reviews. Research towards a universally accepted standardization should be aimed for by the authors, who have failed to date to sufficiently limit bias and limitations.

FOOTNOTES

Author contributions: Pace V, Marzano F, and Placella G designed the article, performed research and literature review, analyzed data and wrote the review.

Conflict-of-interest statement: All the authors declare that they have no conflict of interest.

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S-Editor: Liu JH
L-Editor: A
P-Editor: Liu JH

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