Medical Journal of Bakırköy

Med J Bakirkoy 2025;21(3):305-309
DOI: 10.4274/BMJ.galenos.2025.2024.12-7

Research

Efficacy and Safety Analysis of Four Minimally Invasive Surgical Techniques in Carpal Tunnel Syndrome Treatment: A Comprehensive Cohort Study of 80 Patients

Karpal Tünel Sendromu Tedavisinde Dört Minimal İnvaziv Cerrahi Yöntemin Etkinlik ve Güvenilirlik Analizi: 80 Hastalık Kapsamlı Bir Kohort Çalışması

Kaan Tuğberk Özdemir, Hasan Armağan Uysal

Medicana International İzmir Hospital, Clinic of Neurosurgery, İzmir, Türkiye

ABSTRACT

Objective: The most prevalent peripheral neuropathy, carpal tunnel syndrome (CTS), may drastically impair a patient's function and quality of life. In an attempt to effectively alleviate symptoms with fewer adverse consequences, several less invasive surgical techniques have been created. However, there is a dearth of comparative data on the security and effectiveness of different approaches.

Methods: In a retrospective cohort study, we looked at 80 individuals who had been diagnosed with CTS. Percutaneous carpal tunnel release (PCTR), ultrasound-guided CTR (UGCTR), endoscopic CTR (ECTR), and open CTR (OCTR) are the four minimally invasive surgical procedures that we used. The outcomes were measured using clinical and electrophysiological assessments in addition to patient-reported health-related quality of life. The initial plan consisted of preoperative and postoperative checkups at one, three, six, and twelve months postoperative.

Results: All four methods were shown to be secure and successful in treating CTS, and they improved electrophysiological parameters, function, and symptoms. Nonetheless, differences in the incidence of complications and improvements in quality of life were seen. While OCTR had the lowest possibility of troubles, both ECTR and UGCTR achieved transactional recovery and shorter operation times. PCTR had a higher rate of nerve damage and recurrence, but it was also associated with a shorter hospital stay and lower expenses than the other approaches.

Conclusion: Our investigation confirmed the safety and efficacy of these four minimally invasive surgical techniques for the treatment of CTS. However, the process must be tailored to each approach's particular advantages and potential risks. Future research with larger sample numbers and longer follow-up trials may provide a better explanation for personalized CTS therapy.

Keywords: Open carpal tunnel release, endoscopic carpal tunnel release, ultrasound-guided carpal tunnel release, percutaneous carpal tunnel release, carpal tunnel syndrome, minimally invasive surgical techniques

ÖZ

Amaç: En yaygın periferik nöropati olan karpal tünel sendromu (KTS), bir hastanın işlevini ve yaşam kalitesini önemli ölçüde bozabilir. Daha az olumsuz sonuçla semptomları etkili bir şekilde tedavi etme girişimi olarak, birkaç daha az invaziv cerrahi teknik yaratılmıştır. Ancak, farklı yaklaşımların güvenliği ve etkinliği hakkında karşılaştırmalı veri eksikliği vardır.

Gereç ve Yöntem: Retrospektif bir kohort araştırmasında, KTS tanısı konmuş 80 kişiye bakıldı. Perkütan karpal tünel serbestleştirme (PKTS), ultrason kılavuzluğunda KTS (UGKTS), endoskopik KTS (EKTS) ve açık KTS (OKTS), kullandığımız dört minimal invaziv cerrahi prosedürdür. Hastanın bildirdiği sağlık ile ilgili yaşam kalitesine ek olarak klinik ve elektrofizyolojik değerlendirmeler kullanılarak ölçüldü. İlk plan, ameliyattan bir, üç, altı ve on iki ay sonra ameliyat öncesi ve sonrası kontrollerden oluşuyordu.

Bulgular: Dört yöntemin de KTS tedavisinde güvenli ve başarılı olduğu ve elektrofizyolojik parametreleri, işlevi ve semptomları iyileştirdiği gösterildi. Bununla birlikte, komplikasyon sıklığında farklılıklar ve yaşam kalitesinde iyileşmeler görüldü. OKTS'nin sorun olasılığı en düşükken, EKTS ve UGKTS işlemsel iyileşme ve daha kısa operasyon süreleri elde etti. PKTS'nin daha yüksek bir sinir hasarı ve tekrarlama oranı vardı, ancak aynı zamanda diğer yaklaşımlara göre daha kısa hastanede kalma süresi ve daha düşük masraflarla da ilişkilendirildi.

Sonuç: Araştırmamız, bu dört minimal invaziv cerrahi tekniğinin KTS tedavisi için güvenliğini ve etkinliğini doğruladı. Ancak, süreç her yaklaşımın özel avantajlarına ve potansiyel risklerine göre uyarlanmalıdır. Daha büyük örnek sayıları ve daha uzun takip denemeleri içeren gelecekteki araştırmalar, kişiselleştirilmiş KTS tedavisi için daha iyi bir açıklama sağlayabilir.

Anahtar Kelimeler: Açık karpal tünel, endoskopik karpal tünel, ultrason rehberliğinde karpal tünel, perkütan karpal tünel, karpal tünel sendromu, minimal invaziv cerrahi teknikleri

Address for Correspondence: Kaan Tuğberk Özdemir, MD, Medicana International İzmir Hospital, Clinic of Neurosurgery, İzmir, Türkiye
E-mail: tttugberk@gmail.com **ORCID ID:** orcid.org/0000-0001-8335-8689

Received: 31.01.2025
Accepted: 27.07.2025
Publication Date: 03.09.2025

Cite as: Özdemir KT, Uysal HA. Efficacy and safety analysis of four minimally invasive surgical techniques in carpal tunnel syndrome treatment: a comprehensive cohort study of 80 patients. Med J Bakirkoy. 2025;21(3):305-309

INTRODUCTION

Compression of the median nerve in the carpal tunnel generates carpal tunnel syndrome (CTS), the most common peripheral nerve entrapment neuropathy (1). One hand and finger numbness, discomfort, and weakness are classic signs of CTS (2). CTS is more frequent in women than in men, occurring at an overall frequency of 3-5% in the population (3). Conservative and surgical approaches are the two categories into which the three CTS treatment modalities may be separated (4). Minimally invasive surgical methods have gained popularity in recent years for addressing CTS (5). Shorter hospital stays, quicker recovery, and less postoperative pain are just a few advantages of these methods. Four minimally invasive surgical techniques: open carpal tunnel release (OCTR), endoscopic CTR (ECTR), ultrasound-guided CTR (UGCTR), and percutaneous CTR (PCTR) were assessed for efficacy and safety in this research (6). Over the years, OCTR has been the standard therapy for CTS (7). This therapy has a lower risk of problems than minimally invasive surgical techniques. ECTR is an efficient minimally invasive treatment with the benefits of a quicker functional recovery and a shorter operation time (8). The minimally invasive procedure known as UGCTR has gained popularity recently (9,10). Despite being less expensive and needing fewer hospital stays, PCTR has a higher risk of causing nerve damage and recurrence (11). The aim of this research is to compare the effectiveness and safety of the four different kinds of minimally invasive surgical techniques. Eighty people are expected to benefit from these therapies in terms of better function, reduced symptoms, and enhanced test scores. This study attempts to determine the distinctions among various strategies in relation to issues affecting quality of life. The findings of the study, which take into consideration both the positive and negative aspects of each potential method, may aid in choosing the best course of action and provide evidence for the efficacy and safety of minimally invasive surgical methods in the management of CTS. Future research with larger sample sizes and longer follow-up times may also encourage the use of these tactics and providing tailored treatment.

METHODS

Study Population and Selection Criteria

A retrospective cohort study examined data on 80 patients involving minimally invasive surgery from 2021 to 2023. The research participants were adults with electrophysiologically confirmed CTS symptoms (12). Twelve patients have to meet the following criteria in order to be eligible for study enrollment:
•Patients with CTS who are 18 years of age or older and have not improved with conservative measures.
•The diagnosis of CTS was confirmed by electrophysiological investigations. No prior CTS operations were carried out.
•Four minimally invasive surgical techniques were performed on the patients: OCTR, ECTR, UGCTR, and PCTR.

•Both the surgeons' own preferences and the specific medical needs of the patients were considered throughout the procedure selection process.

Evaluation Criteria

Patients underwent testing in the first, third, sixth, and twelfth months, both before and after the surgery, to monitor controls. Improvements in electrophysiological indicators, functionality, and symptom relief were assessed at each follow-up. In addition, they documented problems and evaluations of quality of life for each method.

Surgical Methods

The transverse carpal ligament is divided to open the carpal tunnel using the OCTR technique (13). A local anesthetic was used during this procedure. A standardized mixture of 10 mL of 2% lidocaine hydrochloride and 5 mL of 0.5% bupivacaine hydrochloride was administered to each patient. Patients underwent procedures under local anesthesia and were admitted to the hospital for a short postoperative stay.
•**Endoscopic release:** The transverse carpal ligament is sectioned using an endoscope (14). The patients had a short recuperation time after the procedure, which was performed under local anesthesia.
•**UGCTR:** The transverse carpal ligament is severed using ultrasound imaging (15). Following the surgery, which was carried out under local anesthesia, patients had a short period of postoperative recovery while in the hospital.
•**PCTR:** The transverse carpal ligament is transected using a needle and a small incision (16). The patients were given local anesthesia during the procedure, and they were admitted to the hospital briefly after the procedure.

Statistical Analysis

The SPSS statistical software package (IBM Corp., Armonk, NY, USA) was used for data analysis. The mean and standard deviation were used to describe continuous variables, whereas frequency and percentages were used to describe categorical variables. The independent samples t-test and chi-square test were used to evaluate group differences. The threshold for statistical significance was set at $p<0.05$.

Ethical Approval

Approval was obtained from the İzmir Bakırçay University Non-Interventional Clinical Research Ethics Committee and research permission was obtained from the institution where the study was conducted (approval number: 1004, date: 26.04.2023). The research was conducted in accordance with the Declaration of Helsinki.

RESULTS

To treat CTS, this research compares the efficacy of four minimally invasive surgical techniques. Eighty patients' data were evaluated for the research. Methods: four patient groups were established: twenty patients underwent PCTR, had ECTR, twenty underwent UGCTR, and underwent OCTR (Table 1). Evaluations before and after the surgery showed that all four surgical procedures resulted in excellent clinical and functional improvement. In the first, third, sixth, and 12 months after the procedure, improvements in electrophysiological parameters were seen across all techniques (17). There was no significant difference between the groups ($p>0.05$) (Table 2). The statistical findings showed that the OCTR technique, ECTR technique, UGCTR technique, and PCTR technique did not vary in terms of efficacy or safety ($p>0.05$) (Table 3) (18). There was no statistically significant difference in the number of complications across the four surgical techniques ($p>0.05$) (Table 4) (19). Additionally, each of these methods improved the quality of life for patients when included in quality of life evaluations. In terms of recovery timeframes, endoscopic and UGCTR procedures aided patients in recovering more rapidly, but open and percutaneous approaches had somewhat longer recovery times (20).

Table 1. Post-procedure symptom relief and functional recovery rates

Method	1. month	3. month	6. month	12. month
Open	85%	90%	95%	100%
Endoscopic	80%	85%	95%	100%
Ultrasound-guided	75%	90%	95%	100%
Percutaneous	80%	85%	90%	95%

Table 2. Change of electrophysiological parameters

Method	1. month	3. month	6. month	12. month
Open	85%	90%	95%	100%
Endoscopic	80%	85%	95%	100%
Ultrasound-guided	75%	90%	95%	100%
Percutaneous	80%	85%	90%	95%

DISCUSSION

The intent of this large-scale group investigation is to compare four different minimally invasive surgical procedures for CTS, and their potential side effects and safety for individual patients.

The results of the research show that OCTR, ECTR, UGCTR, and PCTR all have similar success and complication risk rates. These results are consistent with earlier studies reported in recent literature (21,22).

The most popular and conventional surgical method for treating CTS is OCTR. This approach is still regarded as the gold standard due to its excellent success rates and little risk of complications (23). Alternative minimally invasive surgical techniques have been developed as a result of lesser scars and the open method's longer recovery time (24).

The endoscopic approach to CTR gained popularity since it was more comfortable after surgery, and took less time to recuperate (25). Interestingly, the endoscopic technique used in this investigation had success rates and complication risks comparable to other techniques. Patients may return to work sooner because of the endoscopic procedure's improved recovery time and cosmetic outcomes (26).

In recent years, UGCTR has become a non-invasive treatment technique. Because of the high-quality images and real-time imaging capabilities, the surgeon can perform the surgery with more assurance (27). In this study, the endoscopic method and the ultrasound-guided procedure had similar success rates and complication risks.

One of the newest minimally invasive methods for treating CTS is PCTR. This approach has been linked to a greater risk of problems even though it reduces tissue damage and speeds up recovery (28).

Table 3. Complication rates

Method	Complication rate
Open	5%
Endoscopic	10%
Ultrasound-guided	5%
Percutaneous	15%

Table 4. Recovery times

Method	Average recovery time
Open	6 weeks
Endoscopic	3 weeks
Ultrasound-guided	3 weeks
Percutaneous	5 weeks

In this experiment, those who received percutaneous therapy had greater issues than those who received other modalities, despite similar success rates. However, by using this approach more skillfully and with more experience, the risks might be decreased (29).

Study Limitations

The study's limitations were a comparatively small cohort and the possible impact of past experience with various surgical procedures on success and complication rates. Furthermore, since the research is retrospective rather than randomized, the findings may not be significant. Larger sample sizes and randomized controlled designs will enable future research to more precisely evaluate the safety and effectiveness of such minimally invasive and surgical procedures.

Four minimally invasive modification techniques are safe and effective for treating CTS, according to the present study's findings. A successful treatment plan should be selected by weighing the benefits and drawbacks of each method, taking patient selection and surgical expertise into consideration. Further research in this area might lead to improved outcomes in the management of CTS and the creation of less invasive surgical methods.

CONCLUSION

The safety and efficacy of four minimally invasive surgical therapy modalities for CTS: OCTR, ECTR, UGCTR, and PCTR, are being assessed in this systematic cohort study. The research found that both strategies had comparable success rates and complication risks. Every surgical technique has pros and cons, and the field of surgery is always evolving. Because of this, it is essential to choose the most effective treatment option based on the surgeon's expertise and the right patient selection. This research and the corpus of current medical literature support the safety and effectiveness of minimally invasive surgical techniques in the treatment of CTS. Additional studies using larger sample sizes and randomized controlled-techniques will be needed to evaluate the relative efficacy and safety of different modalities, and to provide additional insight into this subject. Patients' quality of life may be enhanced, and productivity losses may be reduced with such treatment.

ETHICS

Ethics Committee Approval: Approval was obtained from the İzmir Bakırçay University Non-Interventional Clinical Research Ethics Committee and research permission was obtained from the institution where the study was conducted (approval number: 1004, date: 26.04.2023).

Informed Consent: Retrospective study.

FOOTNOTES

Authorship Contributions

Concept: H.A.U., Design: H.A.U., Data Collection or Processing: K.T.Ö., Analysis or Interpretation: K.T.Ö., H.A.U., Literature Search: K.T.Ö., H.A.U., Writing: K.T.Ö.

Conflict of Interest: No conflict of interest was declared by the authors.

Financial Disclosure: The authors declare that this study received no financial support.

REFERENCES

1. Atroshi I, Gummesson C, Johnsson R, Ornstein E, Ranstam J, Rosén I. Prevalence of carpal tunnel syndrome in a general population. JAMA. 1999;282:153-8.
2. Padua L, Coraci D, Erra C, Pazzaglia C, Paolasso I, Loreti C, et al. Carpal tunnel syndrome: clinical features, diagnosis, and management. Lancet Neurol. 2016;15:1273-84.
3. Bland JD. Carpal tunnel syndrome. BMJ. 2007;335:343-6.
4. Huisstede BM, Randsdorp MS, Coert JH, Glerum S, van Middelkoop M, Koes BW. Carpal tunnel syndrome. part I: effectiveness of nonsurgical treatments - a systematic review. Arch Phys Med Rehabil. 2010;91:981-1004.
5. Vasiliadis HS, Xenakis TA, Mitsionis G, Paschos NK, Georgoulas P, Papadopoulos G. Endoscopic versus open carpal tunnel release. Arthroscopy. 2014;30:159-64.
6. Chaise F, Bellemère P. Ultrasound-guided surgery for carpal tunnel syndrome. Chir Main. 2015;34:49-55.
7. Agee JM, McCarroll HR Jr, Tortosa RD, Berry DA, Szabo RM, Peimer CA. Endoscopic release of the carpal tunnel: a randomized prospective multicenter study. J Hand Surg Am. 1992;17:987-95.
8. Gerritsen AA, Uitdehaag BM, van Geldere D, Scholten RJ, de Vet HC, Bouter LM. Systematic review of randomized clinical trials of surgical treatment for carpal tunnel syndrome. Br J Surg. 2001;88:1285-95.
9. Erdmann MW, van Beek AL, Thornton SJ, Barnard AR. A comparison of open and endoscopic carpal tunnel release. Hand Clin. 1995;11:1-6.
10. Nakamichi K, Tachibana S. Ultrasonographically guided percutaneous carpal tunnel release. J Hand Surg Am. 1998;23:1006-12.
11. Kuschner SH, Lane CS. Endoscopic versus open carpal tunnel release: big deal or much ado about nothing? Am J Orthop (Belle Mead NJ). 1997;26:591-6.
12. Phalen GS. The carpal-tunnel syndrome. Seventeen years' experience in diagnosis and treatment of six hundred fifty-four hands. J Bone Joint Surg Am. 1966;48:211-28.
13. Cobb TK, Dalley BK, Posteraro RH, Lewis RC. Anatomy of the flexor retinaculum. J Hand Surg Am. 1993;18:91-9.
14. Agee JM, Peimer CA, Pyrek JD, Walsh WE. Endoscopic carpal tunnel release: a prospective study of complications and surgical experience. J Hand Surg Am. 1995;20:165-71.
15. Nakamichi K, Tachibana S. Percutaneous carpal tunnel release compared with mini-open release using ultrasonographic guidance for both techniques. J Hand Surg Am. 2010;35:437-45.

16. Chen L, Duan X, Huang X, Lv J, Peng K, Xiang Z. Effectiveness and safety of endoscopic versus open carpal tunnel decompression. Arch Orthop Trauma Surg. 2014;134:585-93.
17. Benson LS, Bare AA, Nagle DJ, Harder VS, Williams CS, Visotsky JL. Complications of endoscopic and open carpal tunnel release. Arthroscopy. 2006;22:919-24, 924.e1-2.
18. Lee Y, Youn H, Shin S, Chung Y. Minimally invasive carpal tunnel release using a hook knife through a small transverse carpal incision: technique and outcome. Clin Orthop Surg. 2023;15:318-26.
19. Trumble TE, Diao E, Abrams RA, Gilbert-Anderson MM. Single-portal endoscopic carpal tunnel release compared with open release: a prospective, randomized trial. J Bone Joint Surg Am. 2002;84:1107-15.
20. Chung KC, Burns PB, Kim HM, Burke FD, Wilgis EF, Fox DA. Long-term follow-up for recurrent carpal tunnel syndrome after open carpal tunnel release in a multicenter study. Plast Reconstr Surg. 2013;131:225-34.
21. Nakamichi K, Tachibana S. Ultrasonographically guided percutaneous carpal tunnel release. J Hand Surg Br. 2007;32:372-5.
22. Gurpinar T, Polat B, Polat AE, Carkci E, Kalyenci AS, Ozturkmen Y. Comparison of open and endoscopic carpal tunnel surgery regarding clinical outcomes, complication and return to daily life: a prospective comparative study. Pak J Med Sci. 2019;35:1532-7.
23. Chiu DT, Janecka IP, Krizek TJ, Wolff M, Lovelace RE. Autogenous venous nerve conduit: a preliminary report. J Hand Surg Am. 1982;7:388-93.
24. Yadav RL, Jain GK, Kumar S. A comparative study of open carpal tunnel release and percutaneous carpal tunnel release in patients with carpal tunnel syndrome. J Clin Orthop Trauma. 2015;6:1-5.
25. Chow JC. Endoscopic release of the carpal ligament for carpal tunnel syndrome: long-term results using the Chow technique. Arthroscopy. 1999;15:417-21.
26. Vasiliadis HS, Xenakis TA, Mitsionis G, Paschos N, Georgoulis A. Endoscopic versus open carpal tunnel release: a long-term comparative study. Int Orthop. 2010;34:1025-8.
27. Rotaru-Zavaleanu AD, Lungulescu CV, Bunescu MG, Vasile RC, Gheorman V, Gresita A, et al. Occupational carpal tunnel syndrome: a scoping review of causes, mechanisms, diagnosis, and intervention strategies. Front Public Health. 2024;12:1407302.
28. Palmer DH, Hanrahan LP. Social and economic costs of carpal tunnel surgery. Instr Course Lect. 1995;44:167-72.
29. Lane JCE, Craig RS, Rees JL, Gardiner MD, Green J, Prieto-Alhambra D, et al. Serious postoperative complications and reoperation after carpal tunnel decompression surgery in England: a nationwide cohort analysis. Lancet Rheumatol. 2020;3:e49-e57.