ISSN 1669-9106

ORIGINAL ARTICLE MEDICINA (Buenos Aires) 2021; 81: 318-322

ULNAR TWO-POINT DISCRIMINATION FOLLOWING ENDOSCOPIC CARPAL TUNNEL RELEASE

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Abstract Carpal tunnel syndrome is median nerve symptomatic compression at the level of the wrist, characterized by increased pressure within the carpal tunnel and decreased nerve function at the level. Carpal tunnel release decreases pressure in Guyon's canal, via open techniques, with symptom and two-point discrimination improvement in the ulnar nerve distribution. We hypothesize that endoscopic carpal tunnel release improves two-point discrimination in the ulnar nerve distribution as well. This study includes 143 patients who underwent endoscopic carpal tunnel release between April 2016 to June 2019 in a single, community-based teaching hospital. A comprehensive retrospective chart review was performed on patient demographics, pre- and post-operative two-point discrimination test results, and complications. The effects of sex, age, and diabetes mellitus in the ulnar and median nerve territories with two-point discrimination tests were analyzed. As well as the differences in two-point discrimination among patient's based on their smoking status. There were significant post operative improvements in both the median (7.7 vs 4.4 mm, $p < 0.001$) and ulnar (5.7 vs 4.1 mm, $p < 0.001$) nerve territories. Smoking status, sex, age and diabetes did not significantly affect two-point discrimination outcomes. In conclusion the endoscopic release of the transverse carpal ligament decompresses the carpal tunnel and Guyon's canal, demonstrating improvement in two-point discrimination in both the ulnar and median nerve distributions.

Key words: endoscopy, carpal tunnel, median nerve, ulnar nerve, Guyon's canal

Resumen ***La liberación endoscópica del túnel carpiano y la prueba de discriminación de dos puntos del nervio cubital.*** El síndrome de túnel carpiano es la compresión sintomática del nervio mediano al nivel de la muñeca. Se caracteriza por un aumento de presión dentro del túnel y una disminución de la función del nervio a ese nivel. La liberación del túnel carpiano descomprime el canal de Guyon, con mejoría sintomática y en la prueba de discriminación de dos puntos en la distribución del nervio cubital. Hipotetizamos que la liberación endoscópica mejora de la misma manera en la distribución del nervio cubital. Este trabajo incluye 143 pacientes que tuvieron liberación endoscópica del túnel carpiano entre abril del 2016 y junio del 2019 en un hospital Universitario de la comunidad. Se evaluaron retrospectivamente las historias clínicas para los datos demográficos, los resultados pre y post quirúrgicos en la prueba de discriminación de dos puntos y complicaciones. Se analizaron los efectos del sexo, edad, tabaco y diabetes en los resultados de la prueba de discriminación de dos puntos para los nervios cubital y mediano. Hubo mejoría significativa post quirúrgica en la prueba de discriminación de dos puntos para los nervios mediano (7.7 vs 4.4 mm, $p < 0.001$) y cubital (5.7 vs 4.1 mm, $p < 0.001$). Fumadores, sexo, edad, y diabetes no afectaron de forma significativa. Concluimos que la liberación endoscópica del ligamento transverso del carpo descomprime el túnel carpiano y el canal de Guyon con mejoría en la prueba de discriminación de dos puntos para los nervios cubital y mediano.

Palabras clave: endoscopia, túnel carpiano, nervio mediano, nervio cubital, canal de Guyon

Received: 9-X-2020 Accepted: 26-XI-2020

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KEY POINTS
Current knowledge

- Transverse carpal ligament involves carpal tunnel and Guyon's canal
- Historically, open carpal tunnel release decompresses Guyon's canal

Contribution of the article to current knowledge

- Endoscopic carpal tunnel release correlates with anatomy foundation regarding transverse carpal ligament
- Endoscopic or open carpal tunnel release decompress Guyon's canal

Carpal tunnel syndrome (CTS) is the most common peripheral nerve entrapment syndrome, estimated to occur in 3.8% of the general population[1, 2]. When conservative treatments fail, surgical intervention is recommended. Both open and endoscopic carpal tunnel release (CTR) techniques are well established[3, 4]. The carpal tunnel and Guyon's canal are connected anatomically via the transverse carpal ligament[5]. Previous literature has demonstrated that CTR decreases pressure in Guyon's canal, whether performed with open or endoscopic techniques[6, 7]. Following open CTR, patient-reported outcomes improve with regards to ulnar nerve symptoms[8, 9] and two-point discrimination improves in the ulnar nerve distribution[8]. Additionally, the cross-sectional area of the ulnar nerve has been shown to increase in size following CTR[10, 11]. Also, sensory conduction has been shown to improve for the ulnar nerve following open carpal tunnel release on nerve conduction studies[12]. In general, symptoms related to the CTS are known to be worse among the diabetic population[13, 14], however, there have been no significant differences in safety and outcomes compared to the non-diabetic population[15].

Endoscopic carpal tunnel surgery became a widely used and accepted technique in the last two decades, promising early recovery and less pain without any inferior outcomes[16-20]. To our knowledge, there has not been objective evidence reported regarding symptomatic improvement in ulnar nerve pathology following endoscopic CTR. Based on the current available literature, we hypothesize that endoscopic CTR improves static two-point discrimination in both the median and ulnar nerve distributions following surgery. Furthermore, we hypothesize that these changes are apparent in both diabetic and non-diabetic populations.

Materials and methods

Colorado Multiple Institutional Review Board (COMIRB) approval was obtained (protocol 16-2566). All patients who underwent endoscopic CTR at one community hospital, Denver Health, Colorado, USA with the senior surgeon, Dr. Banegas, from April 2016 to June 2019 were reviewed retrospectively with a waiver of informed consent. Included patients underwent endoscopic CTR as their only hand surgery procedure and had pre- and one month post-operative clinic visits with documented two-point discrimination in the ulnar and median nerve distributions. If there was any significant two-point discrimination ulnar territory sensory loss, or no clear correlation of two-point discrimination exam with patient's symptoms, an EMG was performed to diagnose or rule out cubital tunnel syndrome (CuTS). Patients with recurrent CTS or concomitant CuTS and undergoing cubital tunnel release (CuTR), were separated from the main patient population pool. Those with inadequate post-operative data or follow-up, or who needed to be converted to open CTR were all excluded (Fig. 1).

All endoscopic procedures were performed using the standard described single portal technique with the Centerline™ (Arthrex Inc., Naples, FL) endoscopic carpal tunnel system. Two-point discrimination was measured with Semmes-Weinstein Monofilament test and documented by the senior author, Dr. Banegas, with a standard static two-point discrimination wheel in one millimeter (mm) increments pre-operatively and at one month post-operative follow up visit. Significant diminished sensation was defined as the mean two-point discrimination measurement being greater than 6 millimeters (mm) in the median and/or ulnar nerve territory[21-24].

Student's t-test was used to analyze the effects of age, sex, and diabetes mellitus (DM) in the ulnar and median nerve territories with two-point discrimination tests. One-way analysis of variance (ANOVA) was used to test for differences in two-point discrimination among patient's based on their smoking status.

Results

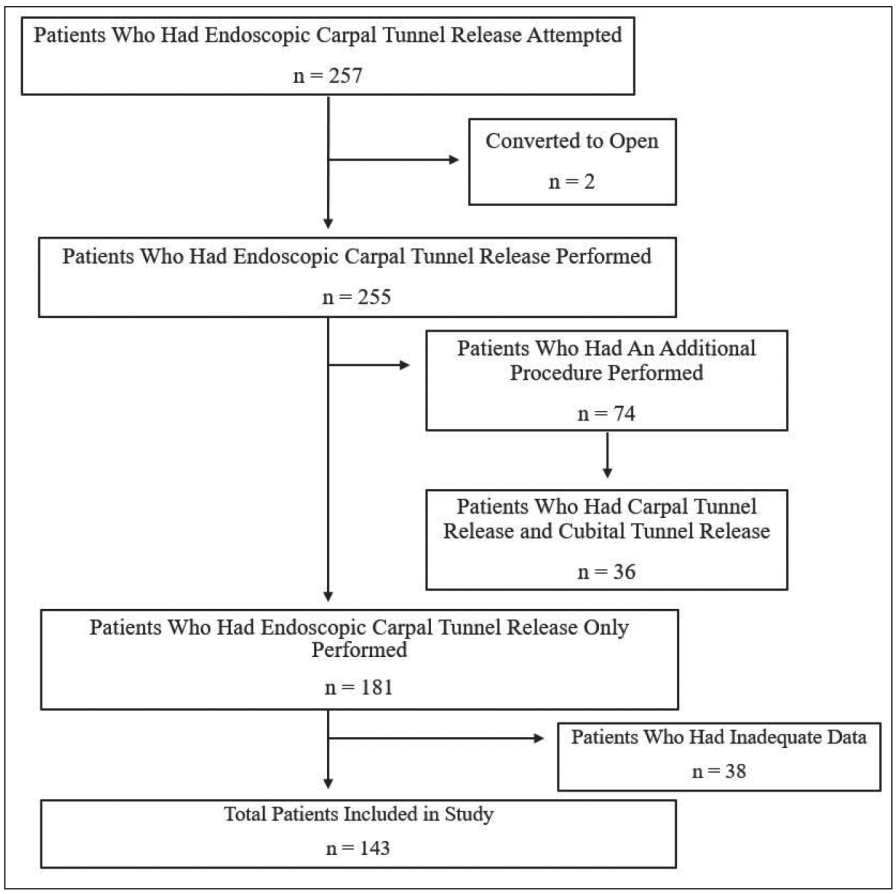
A total of 143 patients with complete pre- and post-operative two-point discrimination data were identified during the study time period. There were 100 female and 43 male, with mean age of 48.5 and 50.1, respectively. Patient demographics data revealed that 25.9% of patients were active smokers and 31.5% had DM (Table 1).

Two-point discrimination in the median nerve distribution improved after surgery by an average of 3.3 ± 2.7 mm (mean difference 7.7 vs 4.4 mm, $p < 0.001$). In addition, 136 patients had over 2 mm two-point discrimination exam results in the ulnar nerve territory, although there was no evidence of CuTS in pre-operative nerve conduction study reports. When two-point discrimination was compared before and after endoscopic CTR surgery, there was also a significant difference in the ulnar nerve territory (mean difference 5.7 vs 4.1 mm, $p < 0.001$) (Table 2).

When age was continuously analysed using the Pearson correlation coefficient test, there were no linear relationships between aging and two-point discrimination outcomes in both the median and ulnar nerve territories. Furthermore, when a statistical comparison was conducted based on gender, DM, and smoking status, there were no statistically meaningful differences, as well (Table 2).

The overall average surgical time was 46.1 minutes, including time between patient presentation to the operative room and transfer to the post-anaesthesia care unit.

Fig. 1.– Patient selection algorithm



Average procedure time was 18.4 minutes, and average tourniquet time was 10.5 minutes. Patients were placed in a soft dressing for 5 days after the surgery. After taking down the dressing, they were advised to continue their daily activities, as tolerated. No one required any narcotic prescriptions. Average follow up time was 11.8 months (range 4 to 17 months). There was only one complication reported, which was a surgical site infection who was an active smoker and responded well to a 5-day course of oral antibiotic treatment. When documented, it was found that all patients were able to return their normal activity levels in less than 3 weeks following surgery.

In addition to these findings, we identified 36 other patients who underwent CuTR simultaneously with CTR, based on the nerve conduction study results. Twenty-eight of these had diminished ulnar two-point discrimination tests. When we compared two-point discrimination improvements in the ulnar nerve territory between CTR only and CTR + CuTR groups, the CuTR group had worse pre-operative values (9.2 ± 3.6 mm vs. 5.7 ± 1.4) and greater improvements compared to the CTR only group (mean of pre- and post-operative difference 5.1 vs 3.4 mm, p = 0.001).

Discussion

CTR is a safe procedure with high patient satisfaction outcomes[25-30]. Silver et al[8] demonstrated anatomic support for the concept that release of the transverse carpal tunnel ligament decompresses both the carpal tunnel and Guyon's canal. Authors also showed that patient-reported outcomes and two-point discrimination, with regards to ulnar nerve symptoms, showed improvement following open CTR alone. This study aimed to evaluate whether these findings were present in a population undergoing endoscopic CTR, while providing objective data, by utilizing a pre- and post-operative two-point discrimination test.

In general, patients in this study showed demonstrable evidence of improved two-point discrimination in both the ulnar and median nerve distributions following endoscopic CTR. It can be inferred that the ulnar nerve changes are due to an indirect release of Guyon's canal, as described with the open procedure. This study supports the idea that compression across the ulnar nerve at Guyon's canal is present in a certain portion of patients with CTS. We also noted that with concomitant EMG-confirmed CuTS, the two-point discrimination measurements were significantly

TABLE 1.– *Patient demographics of enrolled subjects*

Total	N = 143	%
Age, years		
Mean	49.2 ± 10.9	
Mode	48	
Range	(25-73)	
Sex		
Male	43	30.1
Female	100	69.9
Race		
White	87	60.8
Asian	9	0.06
African American	31	21.7
Middle Eastern	6	4.2
Others	10	7.0
Ethnicity		
Hispanic	59	41.3
Non-Hispanic	84	58.7
DM		
No	45	31.5
Yes	98	68.5
Smoking status		
Never	62	43.4
Former	44	30.8
Active	37	25.9
Follow-up		
Mean, months	11.8	
Range	(4-11)	

N: number; DM: diabetes mellitus
Results expressed as mean ± standard deviation

TABLE 2.– *Changes in two-point discrimination in median and ulnar nerve territories*

Factors	Median nerve territory Two-point discrimination				Ulnar nerve territory Two-point discrimination			
	N	Pre-op	Post-op	P-value	N	Pre-op	Post-op	P-value
Total	143	7.7 ± 3.2	4.4 ± 1.3	< 0.001	136	5.7 ± 1.4	4.1 ± 1.1	< 0.001
Age								
≤ 48y	70	7.6 ± 3.5	4.2 ± 1.1	0.742	69	5.6 ± 1.4	4.1 ± 1.1	0.377
> 48y	73	7.8 ± 2.9	4.5 ± 1.5		67	5.8 ± 1.3	4 ± 1.2	
Male	43	7.7 ± 3.3	4.4 ± 1.4	0.954	41	5.9 ± 1.4	4.3 ± 1.3	0.907
Female	100	7.7 ± 3.2	4.3 ± 1.3		95	5.6 ± 1.4	4 ± 1.1	
DM	45	8 ± 3.7	4.5 ± 1.6	0.544	39	5.4 ± 1.3	4 ± 1.2	0.276
No DM	98	7.5 ± 3	4.3 ± 1.2		97	5.8 ± 1.4	4.1 ± 1.1	
Smoking								
Never	62	7.5 ± 2.6	4.2 ± 1.2	0.901	55	5.8 ± 1.4	4 ± 1.2	0.336
Former	44	7.8 ± 3.5	4.6 ± 1.5		45	5.6 ± 1.4	4.1 ± 1.2	
Active	37	8 ± 3.7	4.5 ± 1.4		36	5.8 ± 1.3	4.2 ± 1	

N: number; DM: diabetes mellitus
Results expressed as mean ± standard deviation

greater in the ulnar nerve territory. As such, releasing the cubital tunnel subsequently improved the two-point discrimination more prominently than in the carpal tunnel only group.

This study has limitations. The retrospective nature of the study precluded any observational bias. Also, the pre- and post-operative two-point discrimination measurements may be a subjective test, but it was standardized and consistently performed by the same experienced clinician with a single instrument in each case. Hence, increasing the sensitivity and accuracy of the test. Lastly, continued longitudinal follow-up evaluations of patients' two-point discrimination would be of benefit in determining any temporal effects on post-operative changes.

In conclusion, the results of this study support that endoscopic CTR can be an effective means of decompression for both the median and ulnar nerve at the wrist.

Conflict of interest: None to declare

References

1. Duarte JM, D' Onofrio HM, Rolon JI, Bertotti AC. Alteración de las fibras finas A-delta por entrampamiento del nervio mediano en la muñeca utilizando el período silente cutáneo. *Medicina (B Aires)* 2016; 76: 219-22.
2. Atroshi I, Gummesson C, Johnsson R, Ornstein E, Ranstam J, Rosen I. Prevalence of carpal tunnel syndrome in a general population. *JAMA* 1999; 282: 153-8.
3. Brown RA, Gelberman RH, Seiler JG, et al. Carpal tunnel release: A prospective, randomized assessment of open and endoscopic methods. *J Bone Joint Surg Am* 1993; 75: 1265-75.
4. Kim P, Lee H, Kim T, Jeon I. Current approaches for carpal tunnel syndrome. *Clin Orthop Surg* 2014; 6: 253-7.
5. Rotman MB, Donovan JP. Practical anatomy of the carpal tunnel. *Hand Clin* 2002; 18: 219-30.
6. Ablove RH, Moy OJ, Wheeler DR, Diao E. Pressure changes in Guyon's canal after carpal tunnel release. *J Hand Surg Br* 1996; 21B: 664-5.
7. Okutsu I, Hamanaka I, Yoshida A. Pre- and postoperative Guyon's canal pressure change in endoscopic carpal tunnel release: Correlation with transient postoperative Guyon's canal syndrome. *J Hand Surg Eur 2009*; 34E: 208-11.
8. Silver MA, Gelberman RH, Gellman H, Rhodes CE. Carpal tunnel syndrome: Associated abnormalities in ulnar nerve function and the effect of carpal tunnel release on these abnormalities. *J Hand Surg Am* 1985; 10: 710-3.
9. Green TP, Tolonen EU, Clarke MR et al. The relationship of pre- and postoperative median and ulnar conduction measures to a self-administered questionnaire in carpal tunnel syndrome. *Neurophysiol Clin* 2012; 42: 231-9.
10. Ginanneschi F, Filippou G, Reale F, Scarselli C, Galeazzi M, Rossi A. Ultrasonographic and function changes of the ulnar nerve at Guyon's canal after carpal tunnel release. *Clinic Neurophys* 2010; 121: 208-13.
11. Kang S, Yang SN, Joon JS, Kang HJ, Won SJ. Effect of carpal tunnel syndrome on the ulnar nerve at the wrist: Sonographic and electrophysiologic studies. *J Ultrasound Med* 2016; 35: 37-42.
12. Mondelli M, Ginanneschi F, Rossi A. Evidence of improvement in distal conduction of ulnar nerve sensory fibers after carpal tunnel release. *Neurosurgery* 2009; 65: 696-700.
13. Thomsen NO, Cedarlund R, Rosen I, Bjork J, Dahlin LB. Clinical outcomes of surgical release among diabetic patients with carpal tunnel syndrome: Prospective follow-up with matched controls. *J Hand Surg Am* 2009; 34: 1177-87.
14. Thomsen NO, Cederlund R, Speidel T, Dhalin LB. Vibrotactile sense in patients with diabetes and carpal tunnel syndrome. *Diabet Med* 2011; 28: 1401-6.
15. Thomsen NO, Cedarlund RI, Andersson GS, Rosen I, Bjork J, Dahlin LB. Carpal tunnel release in patients with diabetes: A 5-year follow up with matched controls. *J Hand Surg Am* 2014; 39: 713-20.
16. Gould D, Kulber D, Kuschner S, Dellamaggiorra, Ryan D, Cohen, M. Our surgical experience: open versus endoscopic carpal tunnel surgery. *J Hand Surg Am* 2018; 43: 853-61.
17. 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.
18. Aslani HR, Alizadeh K, Eajazi A, et al. Comparison of carpal tunnel release with three different techniques. *Clin Neurol Neurosurg* 2012; 114: 965- 8.
19. Michelotti B, Romanowsky D, Hauck RM. Prospective, randomized evaluation of endoscopic versus open carpal tunnel release in bilateral carpal tunnel syndrome: an interim analysis. *Ann Plast Surg* 2014; 73 (suppl 2): S157-S160.
20. Atroshi I, Hofer M, Larsson GU, Ranstam J. Extended follow-up of a randomized clinical trial of open vs endoscopic release surgery for carpal tunnel syndrome. *JAMA* 2015; 314: 1399-401.
21. Lundborg G, Ros B. The two-point discrimination test – time for a re-appraisal? *J Hand Surg Am* 2004; 29: 418-22.
22. Jerosch-Herold C. A Study of the Relative Responsiveness of Five Sensibility Tests for Assessment of Recovery After Median Nerve Injury and Repair. *J Hand Surg Am* 2003; 28B: 3: 255-60.
23. Dellon AL. A numerical grading scale for peripheral nerve function. *J Hand Ther* 1993; 6: 152–60.
24. Gellis M, Pool R. Two-point discrimination distances in the normal hand and forearm: application to various methods of fingertip reconstruction. *Plast Reconstr Surg* 1977; 59: 57-63.
25. Jenkins PJ, Duckworth AD, Watts AC, McEachan JE. The outcome of carpal tunnel decompression in patients with diabetes mellitus. *J Bone Joint Surg Br* 2012; 94: 811-4.
26. Sayegh ET, Strauch RJ. Open versus endoscopic carpal tunnel release: a meta-analysis of randomized controlled trials. *Clin Orthop Relat Res* 2015; 473: 1120-32.
27. Tang CQ, Lai SW, Tay SC. Long-term outcome of carpal tunnel release surgery in patients with severe carpal tunnel syndrome. *Bone Joint J* 2017; 99: 1348-53.
28. Stirling PHC, Yeoman TFM, Duckworth AD, Clement ND, Jenkins PJ, McEachan JE. Decompression for recurrent carpal tunnel syndrome provides significant functional improvement and patient satisfaction. *J Hand Surg Eur Vol* 2020; 45: 250-4.
29. 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.
30. Vasiliadis HS, Georgoulas P, Shrier I, Salanti G, Scholten RJPM. Endoscopic release for carpal tunnel syndrome. *Cochrane Database of Systematic Reviews* 2014; CD008265. doi: 10.1002/14651858.CD008265.pub2.