Long-Term Functional Outcomes of Open Carpal Tunnel Release Surgery

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ABSTRACT

Introduction: Carpal tunnel syndrome (CTS) is the most common entrapment neuropathy that causes compression of the median nerve. Open median nerve release surgery plays an important role, especially in patients with failed conservative management or with a diagnosis of severe CTS. The purpose of the following study is to describe the functional outcomes, satisfaction, and objective strength in the medium (6 to 24 months) and long term (greater than 24 months) with the conventional open technique in the local population. **Materials and Methods:** Descriptive observational study based on retrospective data of functional clinical outcomes in the medium and long term in patients undergoing open release surgery of the median nerve as a treatment for CTS. Functional level according to BCTQ and FSS, grip strength with an electronic dynamometer, and satisfaction were determined. **Results:** 100 procedures were performed between May 2012 and September 2018, with a follow-up of more than 6 months. The majority were women (83%) with a total median age of 59 years showing good to excellent outcomes in the 97% in the medium term and 90% in the long term, with a median strength of 17 kg (Interquartile range: 7.4) and satisfaction of 90 (Interquartile range: 20). **Conclusions:** Open surgery to release the median nerve in patients with CTS shows good to excellent functional outcomes, satisfaction, and strength in the medium and long term.

Keywords: Carpal Tunnel Syndrome, Electromyography, Muscle Strength Dynamometer, Hand Strength, Operative Surgical Procedures, Treatment Result.

Level of Evidence: IV

Resultados funcionales a largo plazo de la cirugía abierta de liberación del túnel carpiano

RESUMEN

Introducción: El síndrome del túnel carpiano es la neuropatía por atrapamiento más común que genera compresión del nervio mediano. La cirugía de liberación abierta del nervio mediano tiene un papel importante, especialmente, en pacientes que no responden al manejo conservador o con diagnóstico de síndrome del túnel carpiano con criterios de gravedad. El propósito de este estudio fue describir los resultados funcionales, la satisfacción y la fuerza objetiva a mediano (6-24 meses) y largo plazo (>24 meses) con la técnica abierta convencional en la población local. **Materiales y Métodos:** Estudio observacional descriptivo con datos retrospectivos de resultados clínicos funcionales a mediano y largo plazo en pacientes sometidos a cirugía de liberación abierta del nervio mediano como tratamiento del síndrome del túnel carpiano. Se determinaron el nivel funcional según el BCTQ y la FSS, la fuerza de agarre con un dinamómetro electrónico y la satisfacción. **Resultados:** Se realizaron 100 procedimientos entre mayo de 2012 y septiembre de 2018, con un seguimiento posoperatorio > 6 meses. La mayoría eran mujeres (83%) con una mediana de la edad de 59 años. El 97% obtuvo resultados buenos y excelentes a mediano plazo y el 90%, a largo plazo, con una mediana de fuerza de 17 kg (RIC 7,4) y una satisfacción de 90 (RIC 20) a mediano y largo plazo. **Conclusiones:** La cirugía abierta de liberación del nervio mediano en pacientes con síndrome del túnel carpiano logra resultados buenos y excelentes a mediano y largo plazo en cuanto a funcionalidad, fuerza y satisfacción.

Palabras clave: Síndrome del túnel carpiano; electromiografía; fuerza muscular; fuerza de la mano, satisfacción.

Nivel de Evidencia: IV

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INTRODUCTION

Carpal tunnel syndrome (CTS) is the most common entrapment neuropathy that causes compression and traction of the median nerve. A prevalence of 4-5% in the general population is estimated, with a peak incidence between 40 and 60 years, and a predominance in women.[1] This condition can be unilateral or bilateral and causes symptoms such as paresthesia, burning, heaviness, or pain in the territory innervated by the median nerve, which can radiate to the forearm, elbow, and even shoulder. The symptoms are present predominantly during the night or morning or triggered by prolonged and progressive positions.[2,3] Its etiology is considered multifactorial, perhaps the anatomical-structural and genetic factors are more important than occupational or repetitive use factors.[4,5]

The diagnosis of CTS is based on semiological findings, according to the clinical characteristics of the symptoms and signs. The Tinel test has a sensitivity of 26-79% and a specificity of 40-100%.[6] The Phalen test that seeks to generate paresthesia with wrist flexion has a sensitivity of 46-80% and a specificity of 51- 91% .[7] Likewise, the Durkan test has been described, with which symptoms are reproduced by compression of the carpus, and which is more sensitive and specific than previous tests.[8] Nocturnal paresthesia has a sensitivity of 96%.[9] Given the lack of a reference standard for diagnosis, all reasonable diagnostic measures should be used, including signs, symptoms, electromyography, and nerve conduction, which will increase the precision of the diagnosis and also allow stratifying the severity of the CTS to generate treatment strategies.[10]

Among the multiple therapeutic options to address this condition, we can mention prevention, splints, physical therapy, infiltrations, activity modifications, or open or endoscopic surgery.[1,3] The surgical management consists of the release of the content of the carpal tunnel with a longitudinal cut of the transverse carpal ligament reducing the pressure inside the tunnel using an open technique (long longitudinal incision of the wrist and direct visualization of the ligament), mini-open (short incision), or endoscopic technique.[11] No significant differences have been demonstrated in long-term functional outcomes when comparing the open and endoscopic techniques.[12-14]

The open technique used and the use of questionnaires or scales in the postoperative period are useful since they demonstrate that the open technique is still in force and, secondly, they allow quantifying, objectifying, and monitoring the results under study. For this reason, although there are multiple published trials with different follow-up periods and surgical methods, this study highlights the efficacy of the conventional open technique and describes whether the results in the local population are similar to those previously described.

In clinical research, the definition of follow-up is highly variable and depends on the type of disease, the treatment, and the population under study. The texts tend to polarize short or long term; according to the cited source, these time intervals are considered in months or years indistinctly. Domínguez et al. consider a period of one month as short-term,[15] Ishida et al. define as medium-term a period ranging from three months to five years,[16], and Louie et al., Kouyoumdjian et al., and Tang et al. consider a period ranging from two years to as much as nine years as long term.[17,18,19] Given the variability in the times of these definitions, two studies were taken as reference: short term (<6 months) and medium-term (from 6 to 24 months), according to Domínguez et al.,[15] and long term (> 24 months), according to Louie et al.[17]

The purpose of this study was to describe the functional outcomes, satisfaction, and objective strength in the medium (6-24 months) and long term (> 24 months) with the conventional open technique of release of the median nerve for the treatment of CTS in the local population, performed by a hand surgeon in a university clinic.

MATERIALS AND METHODS

We carried out a descriptive observational study from retrospective data of patients who had undergone surgery in a university clinic, taking into account periods randomly stipulated by the research group and based on the duration of the study, given that the time lapses were heterogeneous. These were defined as medium-term (6-24 months) and long-term (25-70 months), according to the studies by Domínguez et al. and Louie et al.[15,17]

The inclusion criteria were: patients ≥18 years of age who had undergone primary open-release carpal tunnel surgery operated by a single orthopedic hand surgeon. The exclusion criteria included patients with revision surgery for median nerve release, acute CTS due to trauma or infection, or secondary to masses. Cases with concomitant upper median nerve neuropathy or those treated by endoscopic technique were also excluded, as

well as those who were lost to follow-up and not evaluated with the Boston Carpal Tunnel Syndrome Questionnaire (BCTQ), the Functional Status Scale (FSS), and global satisfaction scale, or who did not perform the grip strength test with a dynamometer at some point in the control at a time >6 months after surgery.

The study was approved by the institutional ethics committee. Clinical evaluation and data collection were carried out by the research team (treating surgeon and two third-year orthopedic residents). The patients were included, retrospectively, from May 2012 to September 2018, the minimum follow-up was 6 months. The medical records were reviewed to verify that the patients had carried out the evaluations with the BCTQ, the FSS, and the overall satisfaction expressed in percentage, where they were asked: if you had to decide to undergo surgery again, would you do it? With a yes or no for an answer. Finally, a grip strength test was performed with a portable dynamometer (CAMRY EH101) recording the results in kg of force of both hands without taking dominance into account.

The BCTQ consists of 11 questions that assess the clinical characteristics and severity of the CTS and it is validated in Spanish.[20] It was used as a means to determine the improvement of symptoms in patients already diagnosed and operated on.[21,22] The FSS is linked to the BCTQ and it assesses functional status according to activities of daily living.[23]

Patient satisfaction is reported from 0% to 100% by calculating the average and the percentage of patients who would undergo surgery again, taking into account the improvement in their symptoms. The strength is reported in kg of grip strength.

Statistical analysis

The results of the BCTQ, the FSS, the percentages of satisfaction, and grip strength measured in kg were analyzed descriptively, and are reported as absolute frequencies and relative to the qualitative variables. The quantitative variables were presented through measures of central tendency and dispersion according to the distribution of the data using the Shapiro-Wilk test. A medium and long-term comparative exploratory analysis was carried out where the qualitative variables were compared with the chi-square test and the quantitative variables, with the Mann-Whitney U test. Given the distribution of the data, none had a normal distribution. A p value <0.05 was considered statistically significant. The data were analyzed with the statistical program Stata 15.

Surgical technique

The surgical technique used consists of an open approach, following a systematic order and using the Kaplan lines as a reference.[1] The patient is placed in the supine position with the shoulder abducted and the upper limb resting on the hand table. A pneumatic tourniquet is placed, elevated to an average of 250 mmHg based on systolic blood pressure. The procedure is performed under general anesthesia, sedation, or local anesthesia. The surgical area is infiltrated with 4 cc of both lidocaine and bupivacaine without epinephrine in two points, a proximal one reaching between the flexor carpi radialis and the palmar longus at the space of Parona at about 2 cm from the distal fold of the wrist, performed from proximal to distal with an inclination of 45°, and another point of distal infiltration at the proximal end of the incision generating a wheal in the surgical area (Figure 1). An incision is performed at the level of the carpal tunnel of 2 to 3 cm according to Kaplan's references (Figure 2), and the skin is dissected together with the subcutaneous cellular tissue until reaching the transverse carpal retinaculum (Figure 3). It is incised with a scalpel blade with the cut facing upwards, protecting the nerve up to the distal fat, avoiding injuring the arterial arch (Figure 4). A grooved probe is proximally introduced between the median nerve and the residual retinaculum and, with the blade of the scalpel, the retinaculum is incised using the probe as a rail (Figure 5). The complete release is confirmed with a digital maneuver and the nerve is released from the radial and ulnar border of the retinaculum, the tourniquet is removed and hemostasis is performed before closure (Figure 6). A short palmar splint is placed, allowing full mobility of the metacarpophalangeal joints (Figure 7), and is maintained for eight days as well as the sutures. The surgical scar is small and aesthetically adequate (Figure 8).

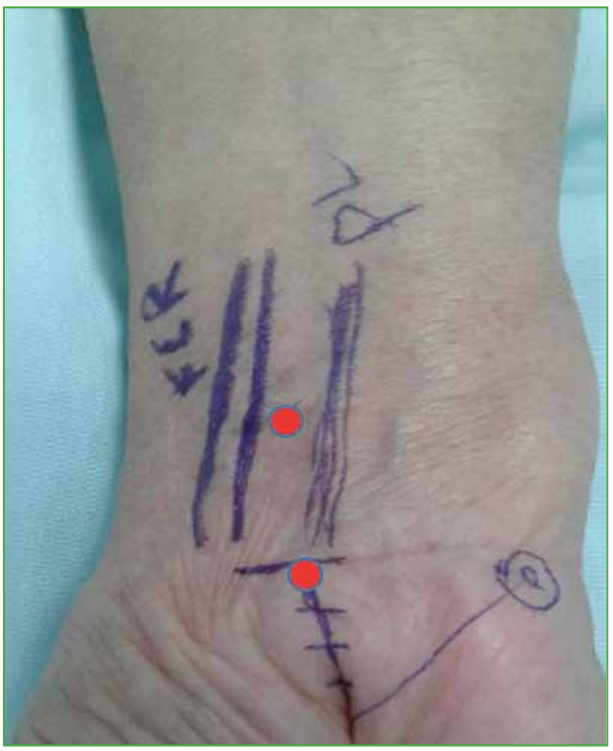

Figure 1. Infiltration of the surgical site. The red dots correspond to the infiltration zone. PL = palmaris longus, FCR = flexor carpi radialis, P = pisiform.

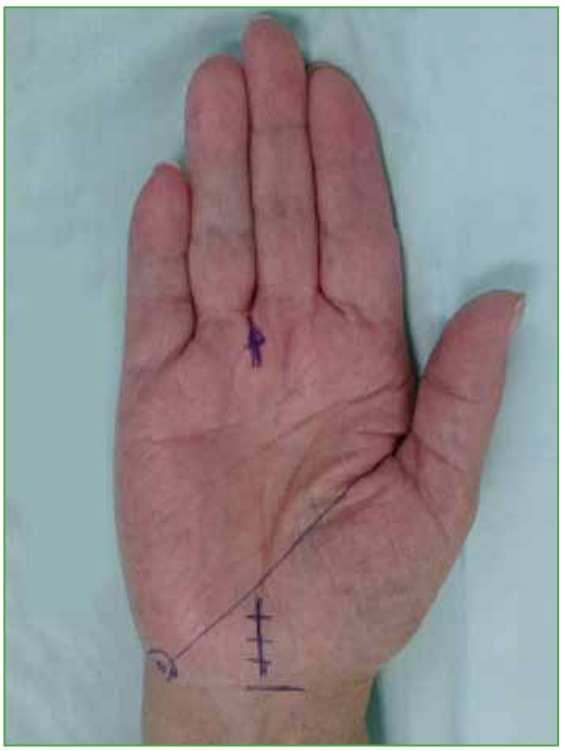

Figure 2. Approach according to Kaplan lines.

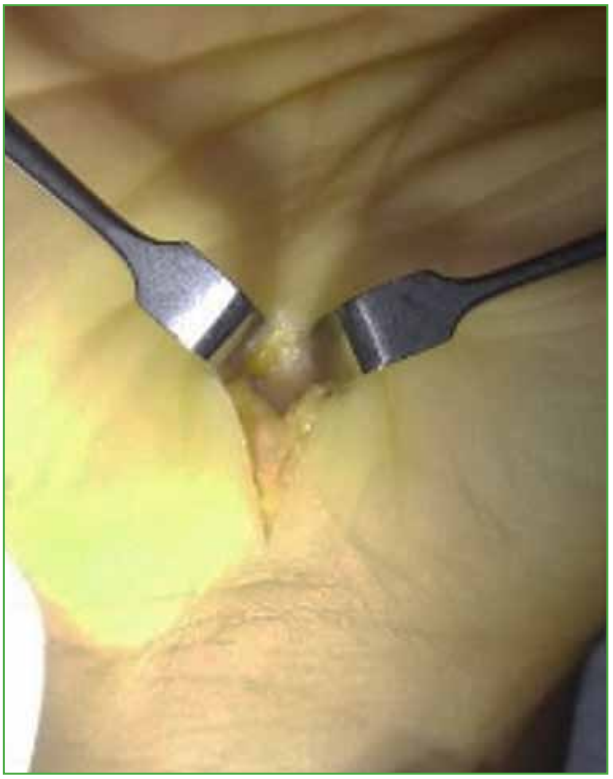

Figure 3. Superficial dissection.

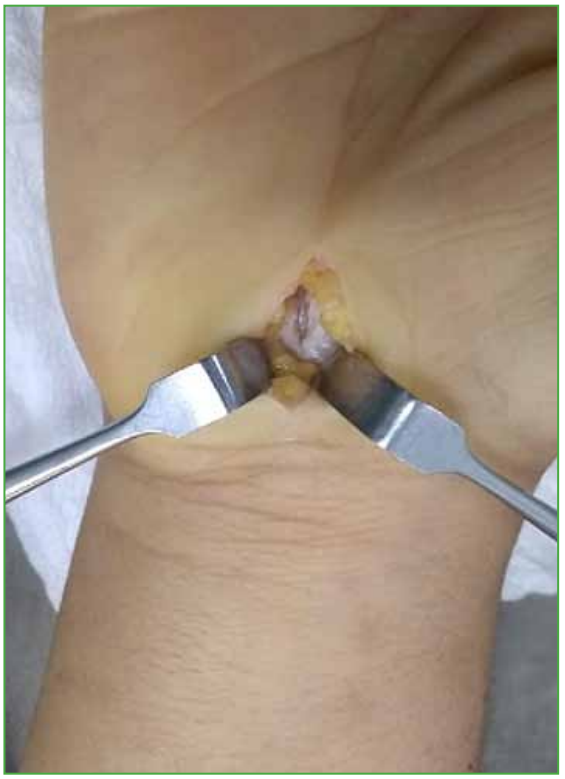

Figure 4. Deep dissection.

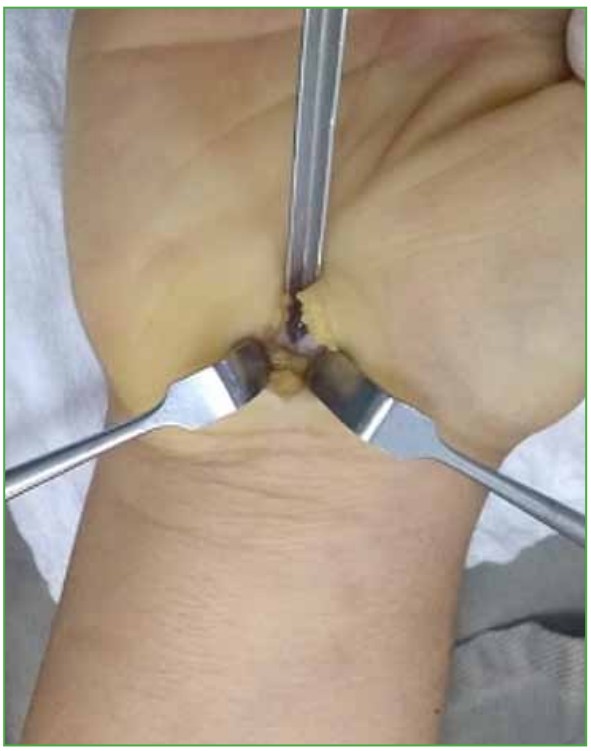

Figure 5. The grooved probe is inserted between the median nerve and the residual retinaculum.

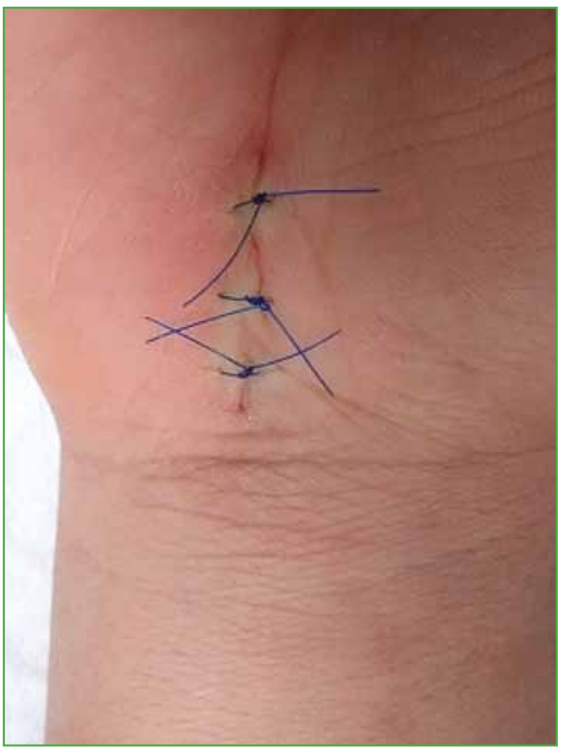

Figure 6. Closure of the surgical procedure.

Figure 7. Immobilization with a short palmar splint allowing full mobility of the metacarpophalangeal joints.

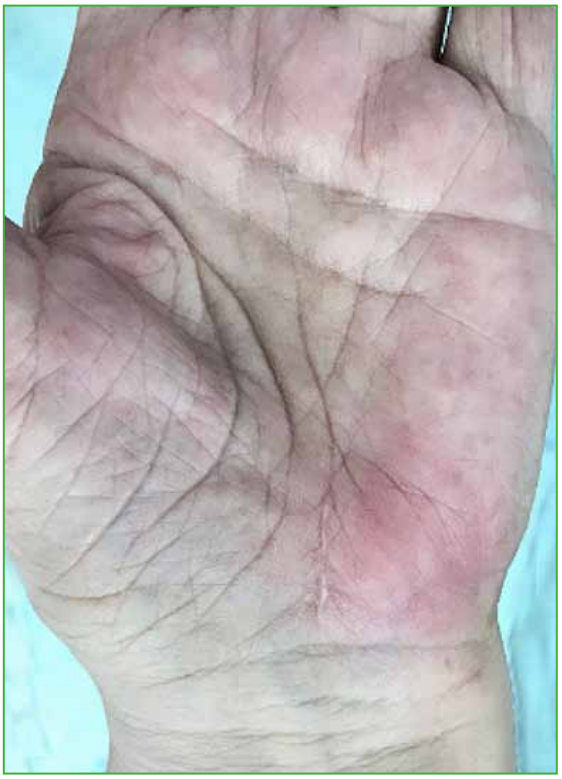

Figure 8. Small and aesthetically suitable scar.

RESULTS

We collected information from 100 open median nerve release surgery procedures performed in 81 patients who met the inclusion and non-exclusion criteria. Seventy-eight patients were excluded because they had not completed the BCTQ, FSS, overall satisfaction, nor grip strength tests. The patients included were 14 men (17.2%) and 67 women (82.8%). In 97% of the procedures, the target grip was measured with a dynamometer. The remaining 3% of the patients gave their assent by telephone and information was obtained from the BCTQ and the FSS. The average age was 60 years. 62% of the procedures were in the right hand and 38% in the left hand. In the 100 procedures, different anesthetic techniques were used: controlled local anesthesia as described in the surgical technique (86%), local anesthesia (7%), and Bier block (7%). Local anesthesia was safe and provided an adequate anesthetic effect during the surgical procedure and good pain control in the postoperative period. Therefore, the anesthetic technique used makes it possible to release the median nerve with the open technique in a procedure room and not necessarily in an operating room, which reduces costs and surgical time.

The median follow-up was 38 months (interquartile range [IQR] 24), the median score on the Boston scale was 15 (IQR 11): good (25 patients) and excellent (56 patients); the median of the functional scale was 11 (IQR 6), in most cases, it was excellent (77%) and, in 15%, good. The median grip strength of both hands measured with an electronic hand dynamometer was 17 kg (IQR 7.4) and the median contralateral strength in the non-operated hands (measured only in 57 patients), 18 kg (IQR 5.3). We collected information on electromyographic results before surgery in 63%, 75% of them corresponded to severe disease and 25% to moderate disease; there were no operated cases with mild disease. The satisfaction evaluation yielded a median of 90 (IQR 20), no patients reported an improvement (0%). Of the 17 patients with poor outcomes, 15 would undergo surgery again. 94% would undergo surgery again taking into account the improvement in their symptoms (Table 1).

Results of the differences and similarities according to the severity

The majority of the sample was made up of women, which showed that, at an older age, the symptoms were more severe. The group with moderate symptoms had a median follow-up of 36 months (IQR 36), a Boston scale median of 12 (IQR 11), a satisfaction score of 90 (IQR 20), a median strength on the affected side of 18.4 kg (IQR 5.2%), and a median contralateral strength of 18.3 kg (IQR 8.4), while the group with severe symptoms had a median follow-up of 38 months (IQR 24), a median on the Boston scale of 14 (IQR 8), a satisfaction score of 95 (IQR 20), a median strength on the affected side of 18.2 kg (IQR 9.4), and a median contralateral strength of 18.2 kg (IQR 9.4). The outcomes in patients with moderate and severe symptoms were similar (Table 2).

Results according to follow-up time

The patients with a medium-term follow-up had a median age of 64 years (IQR 18), with a median follow-up of 12.5 months (IQR 16), and a median on the Boston scale of 13 (IQR 8). The outcomes were excellent in 73% and good in 15%; the score on the functional scale was 10 (IQR 3), an excellent outcome in 79% of this group. The satisfaction score was 90 (IQR 20); the median strength was 16.7 kg (IQR 8.4); and the contralateral strength, 16.5 kg (IQR 6.1), similar in both extremities. In the group with long-term follow-up, the median age was 58 years (IQR 10), with a median long-term follow-up of 48 months (IQR 20), and a median on the Boston scale of 16 (IQR 11). The outcomes were excellent in 47% of the cases—less than in the medium-term group—and good in 33%; the score on the functional scale was 11 (IQR 7), an excellent outcome in 76%, a percentage similar to that of the medium-term group; the median strength was 18 kg (IQR 8.3), and the contralateral strength, 19 kg (IQR 5.1) (Table 3).

Table 1. Description of the variables

Variable	n (%)
Age in years, median (IQR)	59 (14)
Sex Male Female	 17 (17) 83 (83)
Laterality Right Left	 62 (62) 38 (38)
Severity classification Moderate Severe	 15 (15) 48 (48)
Electromyography Yes	 63 (63)
Anesthesia Local Bier block General	 86 (86) 7 (7) 7 (7)
Follow-up time in months, median (IQR)	38 (24)
Boston scale, median (IQR)	15 (11)
Classification on the Boston scale Poor Good Excellent	 17 (17) 27 (27) 56 (56)
Functional scale	11 (6)
Classification on the functional scale Poor Fair Good Excellent	 4 (4) 4 (4) 15 (15) 77 (77)
Satisfaction, median (IQR)	90 (20)
Strength, median (IQR)	17 (7.4)
Contralateral strength (n = 57), median (IQR)	18 (5.3)
Would undergo surgery again Yes No	 94 (94) 6 (6)

Numerical data reported with median and interquartile range (IQR), given a result of the Shapiro-Wilk test $p < 0.05$.

Table 2. Description of variables according to severity

Variable	Moderate (%)	Severe (%)
Age in years, median (IQR)	53 (15)	59 (13)
Sex Male Female	 2 (13) 13 (87)	 7 (15) 41 (85)
Laterality Right Left	 11 (73) 4 (27)	 32 (67) 16 (33)
Anesthesia Local Bier block General	 11 (73) 2 (13) 2 (13)	 40 (83) 4 (8) 4 (8)
Follow-up time in months, median (IQR)	36 (36)	38 (24)
Boston scale, median (IQR)	12 (11)	14 (8)
Classification on the Boston scale Poor Good Excellent	 2 (13) 3 (20) 10 (67)	 7 (15) 12 (25) 29 (60)
Functional scale	10 (5)	10 (6)
Classification on the functional scale Poor Fair Good Excellent	 0 (0) 0 (0) 3 (20) 12 (80)	 3 (6) 2 (4) 5 (10) 38 (79)
Satisfaction, median (IQR)	90 (20)	95 (20)
Strength, median (IQR)	18.4 (5.2)	18.2 (9.4)
Contralateral strength (n = 57), median (IQR)	18.35 (8.4)	18.8 (6.5)
Would undergo surgery again Yes No	 15 (100) 0 (0)	 42 (88) 6 (12)

IQR = interquartile range.

Table 3. Comparison of variables according to medium to long-term follow-up.

Variable	Medium term (%)	Long term (%)	p
Age in years, median (IQR)	64 (18)	58 (10)	**0.0068***
Sex Male Female	 7 (21) 27 (79)	 10 (15) 56 (85)	 0.49
Laterality Right Left	 21 (62) 13 (38)	 41 (62) 25 (38)	 0.972
Classification Moderate Severe	 6 (18) 16 (47)	 9 (14) 32 (49)	 0.86
Anesthesia Local Bier block General	 28 (82) 3 (9) 3 (9)	 58 (88) 4 (6) 4 (6)	 0.59
Follow-up time in months, median (IQR)	12.5 (16)	48 (20)	**0.000***
Boston scale, median (IQR)	13 (8)	16 (11)	**0.045***
Classification on the Boston scale Poor Good Excellent	 4 (12) 5 (15) 25 (73)	 13 (20) 22 (33) 31 (47)	 **0.038***
Functional scale, median (IQR)	10 (3)	11 (7)	0.11
Classification on the functional scale Poor Fair Good Excellent	 1 (3) 0 (0) 6 (18) 27 (79)	 3 (5) 4 (6) 9 (14) 50 (76)	 0.39
Satisfaction, median (IQR)	90 (20)	90 (20)	0.93
Strength, median (IQR)	16.7 (8.4)	18 (8.3)	0.84
Contralateral strength (n = 57), median (IQR)	16.5 (6.1)	19 (5.1)	0.23
Would undergo surgery again Yes No	 33 (97) 1 (3)	 61 (92) 5 (8)	 0.35

* p <0.05 statistically significant. IQR = interquartile range.

DISCUSSION

Some studies have shown that women represent up to 69% of the affected population and the average age is around 60 years,[24] data similar to those of this study, in which there were more women (80%), with a female: male ratio of 1: 6.5. Most of the patients obtained good and excellent results according to the BCTQ and the FSS, this shows that open carpal tunnel release surgery with the described technique is an adequate therapeutic option. Oteo-Álvaro et al.[20] concluded that the scale validated in Spanish has good psychometric properties, so it was decided to use it in this study, not as a predictive factor for CTS, but as an indicator of improvement in symptoms and current functional status. This shows that the outcomes in the medium and long term are similar. Although the sample size is small, this study is a good approximation to know the outcomes in the medium and long term, since few studies report the outcomes after more than six months due to the difficulties in the follow-up of these patients. Good and excellent outcomes corresponded to both symptom improvement and functional status, a subjective satisfaction rate consistent with the objective data obtained. The majority of patients would undergo surgery again based on the improvement in their symptoms.

The BCTQ and FSS scales are valid, reliable instruments that also reflect good functionality and improvement of symptoms in patients with CTS. It was observed that the best results in the BCTQ and the FSS corresponded to better functional outcomes in agreement with the published studies.[25,26] Likewise, it was observed that the patients with better scores on the BCTQ presented greater grip and better strength scores. Procedures with good outcomes were within the average and were better than those with insufficient outcomes. On the other hand, the FSS also showed to be related to greater strength among the groups with excellent outcomes compared to the other procedures with good, fair, and poor outcomes. As with the BCTQ, the procedures with excellent outcomes had grip measures that were higher than the global average. However, no differences in grip strength were observed between the procedures with good, fair, and poor outcomes according to the FSS.

According to the BCTQ, poor outcomes, categorized as 'poor', and according to the FSS categorized as 'poor' and 'fair' were found in 17% and 8%, respectively. (Table 2). Despite having poor outcomes according to the scales, all patients reported some degree of improvement with the procedure. Even those with poor outcomes, for the most part, would undergo surgery again. According to the BCTQ, 17% had procedures with poor outcomes, which may be related to the reports of electromyography with severe diagnosis. However, it was not possible to access the results of the electromyography of all patients, so we cannot rule out that this is related to the presence of comorbidities, older age, laterality, or secondary gain. Nevertheless, five of these 17 procedures had a strength measurement above the median. Likewise, of the eight procedures with fair and poor outcomes, three patients had a measured strength above the median.

The satisfaction scores agree with those published by Weber et al. in 2010, who reported a satisfaction rate of 85% in the five-year follow-up of patients undergoing carpal tunnel decompression,[20] with a median of 90% for both medium and long term. All patients had some degree of satisfaction after surgery, this was reflected in that only 6% would not have surgery again.

Due to its retrospective nature, this study has certain limitations, such as the relatively high loss to follow-up. 78 patients were excluded from the study because they had not fulfilled the BCTQ, the FSS, the global satisfaction score, or the grip test with a dynamometer; this decreased the sample size to 100 procedures. Likewise, there is no complete classification in the severity of all patients. Although there are electromyography data that partially contribute as a preoperative evaluation, it was not performed in all cases and, in this study, only 63 patients had it. Although CTS is stratified into moderate and severe according to electromyography, there are no objective sensitivity measurements that would ratify each category of the disease.

Surgical management of CTS is considered to be an option that achieves good and excellent outcomes in the medium and long term in terms of functionality, strength, and satisfaction in patients with severe CTS or who do not respond to medical management.

Conflict of interest: The authors declare they do not have any conflict of interest.

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REFERENCES

1. Chammas M. Carpal tunnel syndrome. *Chir Main* 2014;33(2):75-94. https://doi.org/10.1016/j.main.2013.11.010
2. Genova A, Dix O, Saefan A, Thakur M, Hassan A. Carpal tunnel syndrome: a review of literature. *Cureus* 2020;12(3):e7333. https://doi.org/10.7759/cureus.7333
3. Thomsen JF, Gerr F, Atroshi I. Carpal tunnel syndrome and the use of computer mouse and keyboard: a systematic review. *BMC Musculoskelet Disord* 2008;9:134. https://doi.org/10.1186/1471-2474-9-134
4. Lozano-Calderón S, Anthony S, Ring D. The quality and strength of evidence for etiology: example of carpal tunnel syndrome. *J Hand Surg Am* 2008;33(4):525-38. https://doi.org/10.1016/j.jhsa.2008.01.004
5. Palumbo CF, Szabo RM. Examination of patients for carpal tunnel syndrome sensibility, provocative, and motor testing. *Hand Clin* 2002;18(2):269-77. https://doi.org/10.1016/S0749-0712(01)00007-5
6. Keith MW, Masear V, Chung K, Maupin K, Andary M, Amadio PC, et al. Diagnosis of carpal tunnel syndrome. *J Am Acad Orthop Surg* 2009;17(6):389-96. https://doi:10.5435/00124635-200906000-00007
7. Durkan JA. A new diagnostic test for carpal tunnel syndrome. *J Bone Joint Surg Am* 1991;73(4):535-8. Erratum in: *J Bone Joint Surg Am* 1992;74(2):311. PMID: 1796937
8. Chammas M, Boretto J, Burmann LM, Ramos RM, Dos Santos Neto FC, Silva JB. Carpal tunnel syndrome - Part I (anatomy, physiology, etiology and diagnosis). *Rev Bras Ortop* 2014;49(5):429-36. https://doi.org/10.1016/j.rboe.2014.08.001
9. Sonoo M, Menkes DL, Bland JDP, Burke D. Nerve conduction studies and EMG in carpal tunnel syndrome: Do they add value? *Clin Neurophysiol Pract* 2018;3:78-88. https://doi.org/10.1016/j.cnp.2018.02.005
10. Chammas M, Boretto J, Burmann LM, Ramos RM, Neto FS, Silva JB. Carpal tunnel syndrome - Part II (treatment). *Rev Bras Ortop* 2014;49(5):437-45. https://doi.org/10.1016/j.rboe.2014.08.002
11. 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(13):1399-401. https://doi.org/10.1001/jama.2015.12208
12. Vasiliadis HS, Georgoulas P, Shrier I, Salanti G, Scholten RJ. Endoscopic release for carpal tunnel syndrome. *Cochrane Database Syst Rev* 2014;1:CD008265. https://doi.org/10.1002/14651858.CD008265.pub2
13. Sayegh ET, Strauch RJ. Open versus endoscopic carpal tunnel release: a meta-analysis of randomized controlled trials. *Clin Orthop Relat Res* 2015;473(3):1120-32. https://doi.org/10.1007/s11999-014-3835-z
14. 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(2):S157-S160. https://doi.org/10.1097/SAP.0000000000000203
15. Domínguez A, Mira LL, Sallent A, Seijas R, Escalona C, Cugat R, et al. Short-term outcomes after median nerve release for carpal tunnel syndrome. *Intern J Orthop* 2017;4(3):758-62. https://doi.org/10.17554/j.issn.2311-5106.2017.04.214
16. Ishida K, Matsumoto T, Tsumura N, Kubo S, Kitagawa A, Chin T, et al. Mid-term outcomes of computer-assisted total knee arthroplasty. *Knee Surg Sports Traumatol Arthrosc* 2011;19(7):1107-12. https://doi.org/10.1007/s00167-010-1361-4
17. Louie D, Earp B, Blazar P. Long-term outcomes of carpal tunnel release: a critical review of the literature. *Hand (N Y)* 2012;7(3):242-6. https://doi.org/10.1007/s11552-012-9429-x
18. Kouyoumdjian JA, Morita MPA, Molina AFP, Zanetta DMT, Sato AK, Rocha CED, et al. Long-term outcomes of symptomatic electrodiagnosed carpal tunnel syndrome. *Arq Neuro Psiquiatr* 2003;61(2A):194-8. https://doi.org/10.1590/S0004-282X2003000200007
19. Tang CQY, Lai SWH, Tay SC. Long-term outcome of carpal tunnel release surgery in patients with severe carpal tunnel syndrome. *Bone Joint J* 2017;99-B(10):1348-53. https://doi.org/10.1302/0301-620X.99B10.BJJ-2016-0587.R2
20. Oteo-Álvaro Á, Marín MT, Matas JA, Vaquero J. Validación al castellano de la escala *Boston Carpal Tunnel Questionnaire*. *Med Clin (Barc)* 2016;146(6):247-53. https://doi.org/10.1016/j.medcli.2015.10.013

21. Andani Cervera J, Balbastre Tejedor M, Gómez Pajares F, Garrido Lahiguera R, López Ferreres A. Valoración del cuestionario de BOSTON como screening en patología laboral por síndrome del tunel carpiano. *Rev Asoc Esp Espec Med Trab* 2017;26:31-8. Disponible en: http://scielo.isciii.es/scielo.php?script=sci_arttext&pid=S1132-62552017000100004&lng=es&nrm=iso
22. Levine DW, Simmons BP, Koris MJ, Daltroy LH, Hohl GG, Fossel AH, et al. A self-administered questionnaire for the assessment of severity of symptoms and functional status in carpal tunnel syndrome. *J Bone Joint Surg Am* 1993;75(11):1585-92. https://doi.org/10.2106/00004623-199311000-00002
23. Luchetti R. Palmar incision. En: Luchetti R, Amadio P (eds.). *Carpal tunnel syndrome*. Berlin: Springer; 2007: 121-9.
24. Weber RA, DeSalvo DJ, Rude MJ. Five-year follow-up of carpal tunnel release in patients over age 65. *J Hand Surg Am* 2010;35(2):207-11. https://doi.org/10.1016/j.jhsa.2009.10.020
25. Badalamente M, Coffelt L, Elfar J, Gaston G, Hammert W, Huang J, et al. Measurement scales in clinical research of the upper extremity, part 2: outcome measures in studies of the hand/wrist and shoulder/elbow. *J Hand Surg Am* 2013;38(2):407-12. https://doi.org/10.1016/j.jhsa.2012.11.029
26. Leite JC, Jerosch-Herold C, Song F. A systematic review of the psychometric properties of the Boston Carpal Tunnel Questionnaire. *BMC Musculoskelet Disord* 2006;7:78. https://doi.org/10.1186/1471-2474-7-78