Original Article

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Carpal Tunnel Release with a Minimally Invasive Surgical Approach at the Proximal of the Distal Wrist Crease: The Evaluation of the Efficacy of the Technique with Clinical and Magnetic Resonance Imaging

Minimal İnvaziv Cerrahi Yaklaşım ile Distal El Bilek Kırışıklığının Proksimalinde Karpal Tünel Gevşetmesi: Tekniğin Etkinliğinin Klinik ve Manyetik Rezonans Görüntüleme ile Değerlendirilmesi

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ABSTRACT

Objective: *In this prospective study, we aimed to evaluate the efficacy of minimally invasive surgical technique at the proximal of the distal wrist crease for carpal tunnel release with clinical and pre- and postoperative magnetic resonance imaging (MRI) findings.*
Method: *Carpal tunnel release was performed on 102 wrists of 65 patients with a mini-incision at the proximal of the distal wrist crease. Clinical assessment of the patients was made with the Boston Carpal Tunnel Questionnaire. Preoperative and postoperative third month MRIs were examined.*
Results: *There was a clinically significant difference between the preoperative and postoperative third month results (p<0.001). The findings from the preoperative MRIs have significantly decreased in number in the postoperative MRIs (p<0.001). None of the patients experienced pillar pain or scar tissue sensitivity. No resurgery was required.*
Conclusion: *Carpal tunnel release with a minimally invasive approach performed at the proximal of the distal wrist crease is an efficient method. Early return to physiological activities has increased the patient comfort.*

Keywords: *carpal tunnel syndrome, decompression, minimally invasive surgical procedures, wrist, magnetic resonance imaging*

ÖZ

Amaç: *Bu prospektif çalışmada, karpal tünel gevşetmesi için distal el bileği kırışıklığı proksimalinde minimal invasiv cerrahi tekniğin etkinliğini klinik ve pre- ve postoperatif manyetik resonans görüntüleme (MRG) bulguları ile değerlendirmeyi amaçladık.*
Yöntem: *65 hastanın 102 eline, distal el bileği kırışıklığı proksimalinde yapılan mini insizyon ile karpal tünel gevşetmesi uygulandı. Olguların klinik değerlendirilmesi Boston Karpal Tünel Anketi ile yapıldı. Preoperatif ve postoperatif 3. ayda MRG incelendi.*
Bulgular: *Klinik değerlendirmede ameliyat öncesi ve ameliyat sonrası 3. ay değerleri arasında anlamlı fark vardı (p<0.001). Preoperatif MRG'de tesbit edilen bulgular postoperatif MRG'de anlamlı oranda azaldı (p<0.001). Hiçbir hastada pillar ağrısı ve skar dokusu hassasiyeti görülmedi. Yeniden ameliyat gerekmedi.*
Sonuç: *Distal el bileği kırışıklığı proksimalinde, mini invasiv yaklaşımla uygulanan karpal tünel gevşetmesi etkin bir yöntemdir. Hastaların fizyolojik aktivitelerini erken başarmaları yaşam konforlarını artırmıştır.*

Anahtar kelimeler: *karpal tünel sendomu, dekompresyon, minimal invasiv cerrahi işlemler, el bileği, manyetik rezonans görüntüleme*

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INTRODUCTION

Carpal tunnel syndrome (CTS) is the entrapment neuropathy of the median nerve due to the increased pressure in the carpal tunnel. It is the most common chronic compression neuropathy of the peripheral nerves, with a prevalence of 4% in the general population [1]. Increasing pain at nights and paraesthesia on the area of the hand innervated by the median nerve are the most characteristic complaints [2]. If the etiology of CTS cannot be identified, then it has been defined as primary (idiopathic) CTS in vast majority of the cases [3].

Conventional surgical treatment of CTS is usually performed with standard open technique, limited incision and endoscopic procedures [4]. Surgical decompression of the carpal tunnel with a longitudinal incision results in a minimal rate of complications [1]. However, carpal tunnel release via standard open surgery has been reported to result in delayed wound healing, scar tissue sensitivity, pillar pain and late return to work [1,5-7]. Mini open palmar incisions, mini open transverse wrist incisions and endoscopic procedures allow for faster wound healing and return to work whereas scar tissue sensitivity and pillar pain will be still present [5,7-9] and endoscopic procedures have led to incomplete release of the flexor retinaculum and iatrogenic nerve injuries [10-14]. On the other hand, carpal tunnel release via a mini longitudinal incision made to the proximal of the wrist crease has been discussed in a limited number of studies [15,16]. We performed decompression of the carpal tunnel with a mini-incision at the proximal of the distal wrist crease, in an attempt to avoid the pillar pain and scar tissue sensitivity seen following CTS surgery and to achieve patients' early return to their daily activities. We evaluated the efficacy of our method with clinical and pre- and postoperative magnetic resonance imaging (MRI) findings.

MATERIALS and METHODS

In this prospective study, 65 consecutive patients (63 females, 2 males; median age: 49.1 years, range: 37 to 68 years) with CTS who had undergone carpal tunnel decompression at the orthopedics clinic of our tertiary research and training hospital between October 2010 and December 2016 and followed up for 12 months were evaluated. Approval from the local research ethics committee was obtained before the study. For a total of 102 hands carpal tunnel surgeries were performed; 37 patients (56.9%) underwent bilateral and 28 patients (43.1%) unilateral releases. Patients with diabetes mellitus, osteoarthritis, autoimmune disease, space occupying lesion on the wrist, cervical radiculopathy, tuberculosis tenosynovitis, or those who were pregnant or had a history of wrist trauma or carpal tunnel surgery were excluded. Existence of recurring or persistent paresthesia at the innervation area of the median nerve, history of pain, and disturbed sleep due to paresthetic complaints or pain were investigated for clinical diagnosis. Positive physical examination findings (Tinel's sign, Phalen test, carpal compression test, thumb abduction and opposition weakness and thenar atrophy) were investigated. Clinical diagnosis was made in existence of the combination of three or more of these symptoms and findings [5]. In clinical staging of the CTS; cases with subjective symptoms alone were considered to be in the 'early stage', cases with combination of subjective symptoms and positive diagnostic test results for CTS were considered to be in the 'intermediary stage', and cases with weakness in abduction and opposition of the thumb and thenar atrophy in addition to the symptoms and positive diagnostic test results for CTS were considered to be in the 'advanced stage'. Nerve conduction studies (NCS) for all hands clinically diagnosed with CTS were performed. NCS grading was done according to Bland's criteria from "very mild" through "extremely severe" [17]. Electrophysiological studies were repeated in cases initially diagnosed as early stage of CTS but without any response to three months-of conservative treatment. Among these cases, patients whose disease proceeded to the advanced stage during clinical evaluation and nerve conduction studies, those in the intermediary stage who did not respond to three months-of conservative treatment and cases with an initial diagnosis of 'advanced stage CTS ' were included in the study.

All patients scheduled for surgery were evaluated using the Boston Carpal Tunnel Questionnaire (BCTQ), defined by Levine et al. [18], which included the symptom severity and functional capacity scales. MRIs of all hands diagnosed with CTS were obtained within one week before surgery and checked for the

presence of an increase in the signal intensity of the median nerve, palmar bowing of the flexor retinaculum or nerve flattening. All patients gave written informed consent before surgery. The surgery was performed under local anesthesia in 93 and general anesthesia in 9 hands, with a pneumatic tourniquet wrapped around the arms. A curved incision on the ulnar side of the thenar crease, starting from 2 cm proximal to the distal wrist crease and ending at the same crease, was made on the medial aspect of the palmaris longus (Figure 1). After observing the fusion of the palmaris longus muscle with the flexor retinaculum, the elevators were placed in a fashion that the palmaris longus muscle would be on the ulnar side. The proximal aspect of the transverse carpal ligament and the entry of the median nerve into the tunnel were exposed through the palmaris longus and flexor carpi radialis tendons. With a blunt dissection, using scissors and a periosteal elevator with a 4 mm-wide blunt tip, the carpal ligament was released on the volar and dorsal sides and along the line thought to pass through the radial aspect of the fourth finger. The elevators were placed accordingly and the carpal ligament was fully exposed in a proximal to distal orientation (Figure 2). The distal aspect of the carpal ligament was clearly exposed. Using a right angle clamp, the distal part of the carpal ligament was released from the palmar aponeurosis with a blunt dissection. The periosteal elevator was inserted through the carpal tunnel entrance and advanced distally and adjacent to the carpal ligament. Thus, the periosteal elevator was placed in a fashion to protect the median nerve. Attention was paid not to position the median nerve and palmar artery at the distal aspect of the carpal ligament incision to be made. Using a curved Mayo scissors and keeping the curved shanks on the ulnar side, the transverse carpal ligament was cut off the ulnar side (Figure 3). The skin was closed and the hand and the wrist were bandaged (Figure 4). For bilateral CTS cases the same procedure was applied. The patients were discharged the same day.

The patients were instructed to use their hands for eating, dressing, and combing their hair the same day and were asked to meet their hygienic needs after putting on big gloves with assistance. In patients that underwent unilateral and bilateral carpal tunnel decompression time intervals elapsed till they used their hands actively were recorded and the difference between the two groups was compared using the chi-square (X^2) test ($p<0.05$). The BCTQ was applied to all patients on the postoperative third month and their wrist MRIs were taken. Pre-, and postoperatve BCTQ scores and MRI findings were compared. The BCTQ was repeated at the postoperative 6th and 12th month follow-ups. The repeated measures ANOVA was performed to determine the presence of any differences among the preoperative and postoperative 3rd, 6th and 12th month BCTQ scores in terms of symptom severity and functional capacity scales ($p<0.05$). Hands with an increase in

Figure 1. Mini-incision line over the wrist, with ulnarly curved.

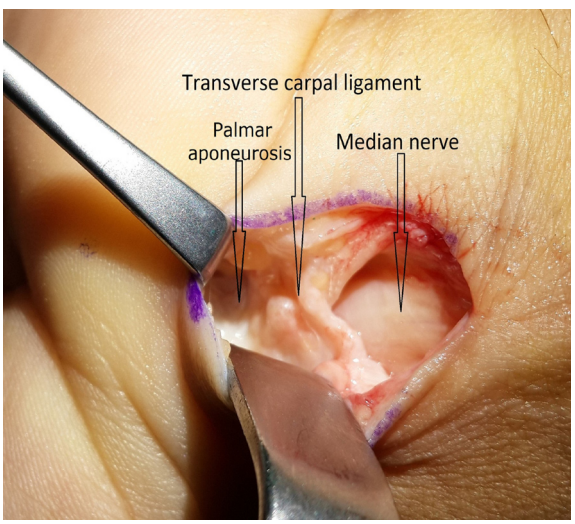

Figure 2. The picture shows the fully exposed transverse carpal ligament and the entry of the median nerve into the carpal tunnel.

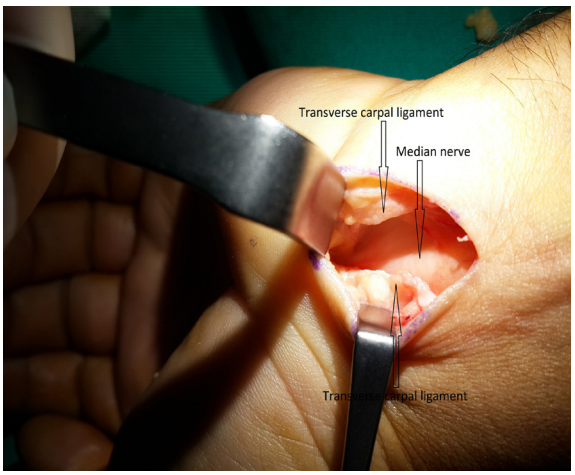

Figure 3. Decompression of the carpal tunnel following the release of the transverse carpal ligament.

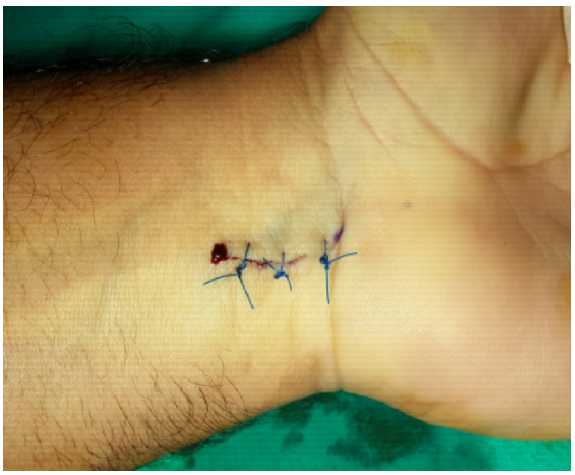

Figure 4. Postoperative appearance .

the signal intensity of the median nerve and with persistence of palmar bowing of the flexor retinaculum and flattening of the median nerve revealed in the MR images obtained at the third month, were noted. Differences between the preoperative and postoperative MRI findings were compared using the chi-square (X^2) test ($p<0.05$).

RESULTS

All patients had nocturnal pain and paresthetic complaints before surgery. In clinical examination, the Phalen test was positive in 91 (89.2%), Tinel's test in 82 (80.4%) and carpal tunnel compression test in 84 (82.4%) hands. Thenar atrophy was observed in 11 (10.8%) hands. Intermediary stage CTS in 76 (74.5%) and advanced stage CTS in 26 (25.5%) hands were diagnosed following preoperative clinical and electrophysiological staging of the patients. The outcomes of the preoperative clinical staging and electrophysiological staging were the same in all patients. Pain and paresthetic complaints were completely resolved in 97 of the 102 hands (95.1%) at the postoperative third month follow-up. There was a statistically significant difference between the preoperative and postoperative third month results of the Boston carpal tunnel symptom severity and functional capacity scale scores ($p<0.001$). Postoperative 6th and 12th month BCTQ scores were even lower (Table 1).

All unilateral carpal tunnel decompression cases were able to eat, dress, meet their hygienic needs, and wear gloves on the day of surgery. Of the 37 bilateral CTS cases, 26 (70.3%) were able to eat, dress, meet their hygienic needs and wear gloves with assistance on the day of surgery and the remaining 11 patients could achieve the same functions on

Table 1. Boston carpal tunnel symptom severity and functional capacity scale scores (Mean±SD).

Operated wrist (n=102)	± Standard deviation	Test statistic	p	Test	Difference
Preoperative and postoperative follow-up symptom severity scales					
Preoperative symptom severity scale	3.685±0.302	F=8.327	<0,001	Repeated measures	1-2, 1-3, 1-4
Symptom severity scale at the postoperative 3rd month	1.180±0.130				
Symptom severity scale at the postoperative 6th month	1.128±0.103			ANOVA	
Symptom severity scale at the postoperative 12th month	1.099±0.085				
Preoperative and postoperative functional capacity scales					
Preoperative functional capacity scale	3.497±0.458	F=3.239	<0,001	Repeated measures	1-2, 1-3, 1-4
Functional capacity scale at the postoperative 3rd month	1.266±0.153				
Functional capacity scale at the postoperative 6th month	1.83±0.131			ANOVA	
Functional capacity scale at the postoperative 12th month	0.125±0.118				

Table 2. MRI findings before surgery and at the postoperative third month (%).

Operated wrist (n=102)	Number	Percentage	Test Statistic	p	Test
Increase in signal intensity of the median nerve					
Preoperative	96	94.1%	X^2=13,32	<0,000	Chi-square test
Postoperative	4	3.90%			
Bowing of the median nerve					
Preoperative	64	62.7%	X^2=36,02	<0,000	Chi-square test
Postoperative	0	0%			
Flattening of the median nerve					
Preoperative	54	52.9%	X^2=13,24	<0,000	Chi-square test
Postoperative	13	12.7%			

the second postoperative day. Patients who underwent unilateral carpal tunnel release could use their hands actively after a median period of 12.7 (range: 11 to 23) days while bilateral cases could actively use their hands after a median period of 13.1 (range: 11 to 34) days. The difference between the unilateral and bilateral groups in terms of time to using their hands actively was statistically insignificant (p>0.05). The improvement in the postoperative third month MRI results of all three symptoms were statistically significant (p<0.001) (Table 2). None of the patients had pillar pain or scar tissue sensitivity. No neurological or vascular complications were observed in any patient. No resurgery was required.

DISCUSSION

Conservative treatment has been necessitated for the early and intermediary stage CTS patients. In CTS cases initially diagnosed as advanced stage and where conservative treatment yields no results, surgical release of the transverse carpal ligament is consensually recommended. Mini palmar incision and endoscopic procedures have gained popularity with time over the standard open surgical carpal tunnel release [5,7]. The leading reason for a revision surgery is irresolution of the complaints due to incomplete release of the flexor carpal ligament during primary surgery [7,11.12].

The efficacy of the surgical treatment of CTS was evaluated with clinical symptoms and findings in some studies [18,19]. In some other studies, radiological examinations such as MRI [20] or ultrasonography [21,22] were utilized to support the clinical findings. MRI has been defined as a reliable technique in validating the incomplete release of the flexor retinaculum in postoperative assessments [23]. Electrophysiological studies have been employed to assist with the clinical evaluations during postoperative follow-up [24,25]. In clinical evaluation of the response to treatment in CTS, the American Academy of Orthopaedic Surgeons (AAOS) have recommended the use of the BCTQ, defined by Levine et al. [18] which includes the symptom severity and functional capacity scales [26]. Levine et al. performed the clinical evaluation of 38 CTS patients, followed up for a median period of 14 months using the BCTQ scoring system [18]. In their study, the mean preoperative symptom severity score of 3.4 and functional capacity score of 3 were recorded as 1.9 and 2, respectively, in the postoperative period. In another study, the postoperative BCTQ scale scores were found significantly lower [19]. In a comparison of the clinical results of carpal tunnel release performed with standard open surgery versus mini open surgery, postoperative 6th and 12th month results of the mini open surgery were significantly better [7]. With our significantly better postoperative third month results in comparison to the preoperative BCTQ scores, we can assert that clinical recovery in CTS is possible within the first three months. In our opinion, clinical evaluation should suffice in postoperative follow-up. The significant difference between our pre- and postoperative MRI findings can be considered important since it indicates the efficacy of our technique.

The release of the flexor retinaculum with the standard incision technique results in a longer incision line, pillar pain and scar tissue sensitivity that might last up to two years or a delayed return to daily activities [1]. The prevalence of scar tissue sensitivity

was reported as 10%, pillar pain as 5% and recurrence as 3.6% in the postoperative period [7]. Recently, mini open palmar incisions [5,8,24] and endoscopic release procedures [5,19] have been employed to avoid the unfavorable results of the standard open carpal tunnel surgery and a decrease was observed in the postoperative morbidity rates and in the time to return to work [1,7]. The time to return to work reportedly vary from three to six weeks after standard open carpal tunnel surgery, however it is merely 10 to 21 days following mini open and endoscopic surgery [5,7,14]. Carpal tunnel release procedures using both endoscopic technique, and mini palmar incision were reported to decrease the morbidity rate whereas pillar pain and scar tissue sensitivity rates ranging from 3.1 to 33% were reported with the same procedures [5,7,8]. In addition, incomplete release of the carpal ligament in 0.5 to 1.2% [10-12], iatrogenic nerve injuries in 0.007 to 10% [10-14] and converting to open surgery due to failure in distinguishing the anatomical structures in 0.5 to 3.4% of the cases [10,12] were reported following endoscopic carpal decompression in various studies. Practicing the technique is challenging and has a long learning curve [27].

In some studies, carpal tunnel release was performed via transverse incisions performed at the wrist level [9,28]. In a study comparing limited open carpal release with mini open transverse incision at the distal wrist crease, there was no difference between both groups in terms of functional recovery, scar tissue sensitivity, pillar pain and recurrence rates [9]. In another study where conventional longitudinal incision and transverse mini incision made at 1 cm proximal to the wrist crease were compared, less pillar pain and scar tissue sensitivity was reported after carpal ligament release performed via transverse incision. The authors attributed the low incidence of pillar pain following the transverse incision performed at the proximal part of the flexor ligament to making the incision outside the pressure area of the hand [28]. Carpal tunnel surgery via a mini longitudinal incision made to the proximal of the distal wrist crease has been discussed in a limited number of studies [15,16]. In a study where a 1-cm incision at the proximal of the distal wrist flexion crease was performed using a surgical microscope, no pillar pain or scar tissue sensitivity was reported which is related to the fact that the skin at the proximal of the wrist crease is thinner than the skin of the wrist and the palmar region was highlighted better using this approach. Recurrence was reported in three cases. The authors stated that, in their technique, the proximal portion of the carpal ligament was dissected after it was exposed with a scalpel and subsequently the distal portion was dissected using surgical scissors. No information was provided regarding the total exposure of the carpal ligament [15]. In another study comparing the carpal tunnel release via incisions performed to the 2 cm proximal and 2 cm distal of the wrist crease, the pillar pain and scar tissue sensitivity following the carpal ligament release via proximal incision was significantly low. It was asserted that the mini incision made at the proximal of the wrist reduced the scar tissue formation due to decreased possibility of tissue damage. No recurrence was observed in either of the groups [16].

The time to using hands actively in our study conforms to the literature data on endoscopic and mini open carpal tunnel release procedures. However, our unilateral CTS cases were able to eat, dress and meet their hygienic needs, and wear gloves on the day of surgery and bilateral cases could achieve the same functions on the first or second postoperative day which was a significant finding in assessing the patient comfort. We believe that our minimally invasive surgical approach at the proximal of the transverse carpal ligament, in the thin dermis layer, was an important factor in not observing any pillar pain or scar tissue sensitivity. In carpal tunnel surgery, both the volar and dorsal side of the carpal ligament should be completely released and the proximal and distal of the ligament should be well exposed. Ample exposure of the transverse carpal ligament could be achieved with our surgical approach. The lack of a comparison group is a limitation of our study.

In conclusion, minimally invasive surgical technique applied at the proximal of the distal wrist crease for carpal tunnel release is an efficient method. No pillar pain or scar tissue sensitivity develops after surgery. Early return to physiological activities increases the patient comfort.

Ethics Commitee Approval: Approval was obtained from Adana Numune Training and Research Hospital Ethics Committee (08.09.2010, decision no. 34).
Conflict of interest: The author declares that there is no conflict of interest.
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Informed Consent: Informed consent was obtained from all individual participants included in the study.

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