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Median nerve and carpal tunnel volume changes after two different surgical methods: A comparative magnetic resonance imaging study of mini-open and endoscopic carpal tunnel release

Farklı iki cerrahi yöntem sonrası median sinir ve karpal tünel hacim değişimleri: Mini açık ve endoskopik karpal tünel gevşetmenin karşılaştırmalı manyetik rezonans görüntüleme çalışması

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ABSTRACT

Objectives: This study aims to compare endoscopic carpal tunnel release versus mini-open carpal tunnel release regarding volume changes in the carpal tunnel and median nerve by magnetic resonance imaging (MRI).

Patients and methods: The study included 17 wrists of 13 patients (1 male, 12 females; mean age 55 years; range, 51 to 64 years) who were diagnosed with carpal syndrome. Ten wrists underwent mini-open carpal tunnel release, while seven wrists underwent uni-portal endoscopic carpal tunnel release. Carpal tunnel and median nerve volumetric changes were evaluated by MRI pre- and postoperatively.

Results: Surgical section of transverse carpal ligament significantly increased the postoperative volume of the carpal tunnel and median nerve compared to preoperative ($p<0.05$). However, the endoscopic and mini-open carpal tunnel techniques had no superiority over one another regarding volume expansion ($p>0.05$).

Conclusion: Both methods can be preferred to release the transverse carpal ligament in patients with idiopathic carpal tunnel syndrome. The surgeon should decide on which method to use considering the advantages and disadvantages reported in the literature.

Keywords: Carpal tunnel syndrome, carpal tunnel volume, endoscopic release, median nerve volume, transverse carpal ligament, volume expansion.

ÖZ

Amaç: Bu çalışmada, endoskopik karpal tünel gevşetmeye karşı mini açık karpal tünel gevşetme karpal tünel ve median sinir hacim değişimleri açısından manyetik rezonans görüntüleme (MRG) ile karşılaştırıldı.

Hastalar ve yöntemler: Çalışmaya karpal tünel sendromu tanısı konulmuş 13 hastanın (1 erkek, 12 kadın; ort. yaş 55 yıl; dağılım, 51-64 yıl) 17 elbileği dahil edildi. On elbileğine mini açık karpal tünel gevşetme, yedi elbileğine ise tek portal endoskopik karpal tünel gevşetme uygulandı. Karpal tünel ve median sinir hacim değişimleri ameliyat öncesi ve sonrası MRG ile değerlendirildi.

Bulgular: Transvers karpal ligamanın cerrahi olarak kesilmesi ameliyat sonrası karpal tünel ve median sinir hacmini ameliyat öncesine göre anlamlı derecede artırdı ($p<0.05$). Ancak endoskopik ve mini açık karpal tünel tekniklerinin hacim genişlemesi açısından birbirlerine herhangi bir üstünlüğü yoktu ($p>0.05$).

Sonuç: İdiyopatik karpal tünel sendromlu hastalarda transvers karpal ligamanın gevşetilmesi için her iki yöntem tercih edilebilir. Hangi yöntemin kullanılacağına cerrah literatürde bildirilen avantaj ve dezavantajları göz önünde bulundurarak karar vermelidir.

Anahtar sözcükler: Karpal tünel sendromu, karpal tünel hacmi, endoskopik gevşetme, median sinir hacmi, transvers karpal ligaman, hacim genişlemesi.

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Carpal tunnel is a fibro-osseous tunnel, and its inner boundaries are made up of soft tissues and carpal bones. Transverse carpal ligament (TCL) forms the volar margin of the tunnel (Figure 1). Proximally, the TCL attaches to the scaphoid tuberosity and pisiform; distally, it attaches to the hook of the hamate and the ridge of the trapezium. Carpal tunnel syndrome (CTS) is the most common entrapment neuropathy syndrome.[1] The prevalence of CTS is approximately 3% in females and 2% in males and ranges between 2.7% and 5.8% in the general adult population.[2]

Surgical treatment should be considered in the treatment of this disease if it cannot be treated conservatively. The primary aim of surgical treatment is to increase the volume of the carpal tunnel, to reduce pressure on the median nerve, and to restore the impaired intraneural perfusion and normal function of the median nerve. Currently, varied approaches are used to release the TCL.[3] Open or mini-open procedures remain the standard treatment choice for the majority of surgeons.

The endoscopic release has been proposed as a method of decompressing the tunnel through a smaller incision sited away from the middle of the palm.[4] In this study, we aimed to compare endoscopic carpal tunnel release (ECTR) versus mini-open carpal tunnel release (MOCTR) regarding volume changes in the carpal tunnel and median nerve by magnetic resonance imaging (MRI).[5]

PATIENTS AND METHODS

This study was conducted at İstanbul Bahçelievler State Hospital between June 2016 and December 2018 and included 17 wrists of 13 patients (1 male, 12 females; mean age 55 years; range, 51 to 64 years) who were diagnosed as CTS. Study inclusion was based on clinical history, physical examination, and nerve conduction study. Patients underwent surgical decompression after failed conservative treatment. Seven wrists underwent single portal method ECTR and 10 wrists underwent MOCTR. Both procedures were performed under regional anesthesia by a single surgeon who had experience in both open and endoscopic techniques. Patients with previous carpal bone fracture, distal radius fracture or previous surgery related to the hand, pregnancy, current renal dialysis, recurrent CTS, or Dupuytren disease were excluded. The study protocol was approved by the University of Health Science, Bakırköy Dr. Sadi Konuk Training and Research Hospital Ethics Committee. A written informed consent was obtained from each patient. The study was conducted in accordance with the principles of the Declaration of Helsinki.

For the MOCTR, a longitudinal incision was performed in line with the fourth ray not extended more than 2-3 cm in length and not crossing the distal wrist crease (Figure 2). The TCL was divided under 2.5 loupe magnification.

For the single-portal ECTR technique, MicroAire Endoscopic Carpal Tunnel Release System (MicroAire Surgical Instruments LLC Charlottesville, VA, USA) was selected (Figure 3).

One centimeter transverse incision was performed between palmaris longus and flexor carpi ulnaris tendons over most of the determined proximal wrist crease (Figure 4). The direction of the blade was again

Figure 1. Transverse carpal ligament.

Figure 2. Incision for mini-open technique.

aimed at the fourth ray, and the TCL was sectioned in the distal to proximal and inferior to superior direction.

After completion of the surgery, the incision site was closed with absorbable interrupted monofilament sutures (Monocryl 4-0, Ethicon, Somerville, New Jersey, USA) and Band-Aid (Johnson & Johnson, New Brunswick, New Jersey, USA) coverage was applied. Postoperative (post-op) management was identical for both groups with the removal of sutures at two weeks when the wounds were covered with an adherent dressing. In the post-op period, patients were told to maintain regular movements of hand and fingers; however, excessive stretching, stringent or rotator activity of the wrist joint was not allowed for three months from the operation. A splint was used for only two weeks postoperatively.

Postoperative analysis with MRI examinations was performed for three to eight months (mean 5 months) with a 1.5 Tesla MR scanner (Avanto; Siemens, Erlangen, Germany). Carpal tunnel and median nerve volumes (within the carpal tunnel) were analyzed based on measurements performed in T2 and T2 water-fat shift slices with patients positioned in the prone position with the hand extended overhead in a neutral position within a wrist coil.[6-10] Inlet and outlet borders of the carpal tunnel (pisiform bone and hook of the hamate) were determined in the coronal plane, and four to eleven axial sections 2 or 3-mm wide were generated section width (W) depending on carpal tunnel length.[10] The image was enlarged and the carpal tunnel and the median nerve were each outlined to obtain the axial section area (mm^2) (Figure 5). Each section was outlined thrice and the mean value for each section was obtained (mean axial area (MAA), mm^2). The volume of each axial carpal tunnel section and each axial median nerve section was determined from section area and width (MAA × W); their summation yielded total estimated carpal tunnel volume and median nerve volume. Since the number of individual axial sections varied, the mean value (total carpal tunnel volume

Figure 3. Endoscopic carpal tunnel release by using MicroAire System.

Figure 4. Incision for endoscopic technique.

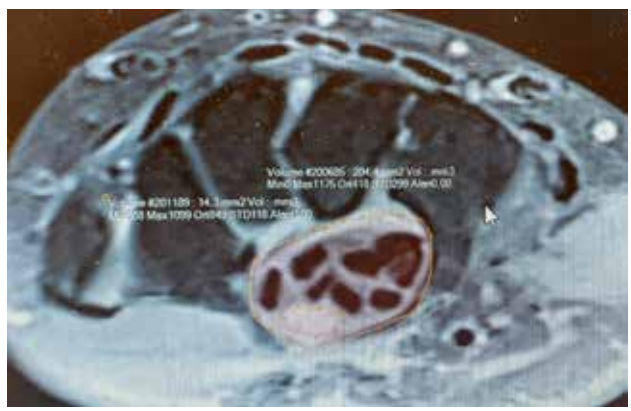

Figure 5. Carpal tunnel and median nerve were each outlined.

or total median nerve volume/number of the axial section) was determined. All MRI assessments were performed by the same radiologist who was blinded to the method used for carpal tunnel release.

Statistical analysis

Shapiro Wilk test was used for assessing whether the variables follow normal distribution or not. Continuous variables were presented as the mean ± SD. Independent samples t-test was used in comparison between two groups according to the normality test result. IBM SPSS version 21.0 (IBM Corp., Armonk, NY, USA) was used for statistical analysis and the significance level of $p<0.05$ was considered significant for statistical evaluations.

RESULTS

Preoperative (pre-op) carpal tunnel volumes and median nerve volumes and post-op carpal tunnel volumes and median nerve volumes were significantly different: pre-op CTS volume 569.4±95.71 mm^3 and post-op CTS volume 619.3±99.62 mm^3 ($p<0.0001$). The pre-op volume of the median nerve was 32.51±7.35 mm^3 and the post-op volume of the median nerve was 38.54±8.46 mm^3 ($p<0.0001$). When we compared the two methods in terms of volume increases, a significant difference was found. Pre-op CTS volume with MOCTR was 518±101.7 mm^3 and post-op CTS volume was 566±104.4 mm^3 ($p<0.0001$). Pre-op median nerve volume was 31.28±9.59 mm^3 and post-op median nerve volume was 36.35±10 mm^3 ($p<003$). Pre-op CTS volume with ECTR was 613.2±77.07 mm^3 and post-op CTS volume was 665.6±85.66 mm^3 ($p<0.007$). Pre-op median nerve volume was 31.68±4.70 mm^3 and post-op median nerve volume was 37.94±6.17 mm^3 ($p<0.02$). We compared the techniques pre- and postoperatively in terms of volume changes of carpal tunnel and median nerve. No significant difference was noted in neither carpal tunnel volume nor median volume ($p>0.054$ and $p>0.911$).

DISCUSSION

Based on these studies, the present prospective study sought to determine whether mini-open compared with endoscopic release provides better carpal tunnel volume expansion. Our study shows that the TCL section increases the volume of the carpal tunnel and median nerves significantly, while there is no superiority of the endoscopic technique or mini-open technique as a surgical method.

In CTS, the volume of the flexor tendon synovial membrane increases within the carpal tunnel, and the intracarpal tunnel pressure increases.[11,12] Compression of the median nerve induces disturbance of intraneural blood flow.[13] Experimental models show that nerve compression results in an early reduction in epineural blood flow with resultant perineural edema; eventually, axonal blood flow is affected with a subsequent reduction in intraneural blood flow and associated edema.[14] The standard technique of open carpal tunnel release is effective and safe; endoscopic release was introduced more than two decades ago with the potential advantages of lower morbidity and quicker recovery from surgery.

The literature indicates that the mini-open or endoscopic section of the flexor retinaculum increases the canal volume.[3] Moreover, Richman et al.[8] reported morphologic changes in the carpal canal after TCL release using standard open surgery. The mean volume of the carpal canal was increased 22±14% compared with preoperative values at the eight-month post-op interview.

Kato et al.[15] concluded that their technique for ECTR of the TCL increases the cross-sectional area of the carpal canal. Furthermore, Momose et al.[16] reported that the TCL could not be well delineated, and the carpal tunnel was significantly enlarged both at the hamate and pisiform levels after ECTR. Crnković et al.[17] reported that this volume increase was parallel to electromyography and clinical improvement.

There are some limitations in this study. First, our sample size was small. Second, the scope of the present study was only volumetric comparison; no clinical comparison was performed. From this point of view, and although a power analysis was not performed, our results are still valuable.

In conclusion, our study demonstrates that carpal tunnel and median nerve volume changes can be detected by MRI. However, there is no superiority of the endoscopic technique or mini-open technique as a surgical method. Thus, the surgeon should decide on which method to use considering the advantages and disadvantages previously reported in the literature.

Declaration of conflicting interests

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