

Effects of simple section of transverse carpal ligament on intercarpal stability in carpal tunnel surgery

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Abstract

The aim was to evaluate effects of simple section of transverse carpal ligament on intercarpal stability by radiological parameters in patients with carpal tunnel syndrome those are refractory to conservative treatment. Patients with suspected diagnosis of carpal tunnel syndrome upon medical history and physical examination underwent neurodiagnostic tests (EMG). All 47 subjects, comprising 39 female and 8 male patients, were operated, followed, and assessed by the same surgical team between January 2014 and May 2015 after written informed consent was obtained. Wrist range of motion and general physical examination findings were recorded at both preoperatively and postoperative week 8. Besides, conventional MRI were obtained at the same time points. Trapeziohamate distance, scaphopisiform distance, scapholunate angle, and carpal angle were measured preoperatively and at 12thweek postoperatively. The mean age of the subjects was 49(range: 36-65).Mean preoperative trapeziohamate distance was measured as 25.2 mm (range:20-33), while postoperative trapeziohamate distance was 26.4 mm (range:22-34), ($p=0.031$). Mean preoperative scaphopisiform distance was 32 mm (range:23-34), as compared to postoperative scaphopisiform distance being 33.6 mm (range:24- 36) ($p=0.001$). While mean scapholunate angle was 44°(range: 36-60) preoperatively, it was measured as 45.1° (range: 33-60) in the postoperative period ($p=0.001$). Both preoperative and postoperative mean carpal angles was 127° (range 118-134 and 119-134, respectively). Simple section of transverse carpal ligament is associated with a significant increase in carpal arch distance. We consider that whether or not increases in intercarpal distances may lead to a degenerative process at the wrist in future warrants further research.

Keywords: Instability; carpal tunnel syndrome; magnetic resonance imaging; carpal bones

Introduction

Carpal tunnel syndrome is known to be most common peripheral entrapment neuropathy [1]. Increased pressure within the carpal tunnel and mechanical compression impair median nerve functions [2,3]. Anatomical, physiological, and behavioral characteristics are among the major factors in development of symptoms, which may account for its predominant incidence in workers [4]. Research showed that intracarpal pressure has been somewhat higher in patients with carpal tunnel syndrome compared to healthy population [5,6]. Conservative approaches include mobilization of carpal tunnel by myofascial manipulations, carpal traction, splinting, corticosteroid injections [7-9]. If patients do not respond to conservative modalities, open or endoscopic surgery is the preferred choice. Surgical treatment aims at decompression of median nerve by decreasing the pressure within carpal tunnel secondary to cutting and de-tensioning of the flexor retinaculum and transverse carpal ligament [10-12]. Surgical procedure provides symptom relief in 70% to 90% of patients [13-16].

Several studies described some anthropometric criteria that may have a role in the development of the disease. Size and shape of the carpal tunnel might have unfavorable effects on median nerve. Diminution of cross-sectional area of the carpal tunnel and narrowing of the space elevates hydrostatic pressure within the tunnel and leads to mechanical compression [17].

Biomechanics of the carpal tunnel is very important for better understanding of the underlying mechanism of the diseases, and hence for subsequent treatment planning. Therefore, many studies have been performed about biomechanics of the carpal tunnel [18,19]. Carpal tunnel consists of many bony structures and transverse carpal ligament. Carpal bones are connected to each other with intercarpal ligaments and constitute medial, lateral, and dorsal borders of the tunnel. Transverse ligament, forming the base of the tunnel, attaches to hamate and pisiform bones on medial aspect and to scaphoid and trapezium bones on lateral aspect [20]. However, specific anatomical structure and distribution of the transverse carpal ligament has not been clearly elucidated yet. Recent studies for this purpose deal with three dimensional CT scanning and computerized analyses of the images obtained [21,22].

In a cadaver study, TCL was shown to attach to the trapezium and tubercle of the scaphoid at radial side, and

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to the hook of hamate and pisiform bone at ulnar side. Based on its attachment to carpal bones and orientation, TCL is divided into three components; (i) the part between the trapezium and the hook of hamate (THL), (ii) the part between the trapezium and pisiform bone (TPL), and (iii) the part between the scaphoid and pisiform bone (SPL) [23]. Releasing of carpal tunnel possesses some potentially biomechanical and morphological complications. Insufficient release, median or ulnar nerve injury or neuropraxia, accidental penetration to Guyon's canal, digital nerve injury, and ulnar artery or superficial palmar arch injury were reported [24]. Additionally, many biomechanical alterations have been shown postoperatively. Pillar pain was reported to be 6-36% in clinical studies [25,26]. Open or endoscopic releasing of transverse carpal ligament leads to enlargement of carpal arch and increase of carpal tunnel width, which in turn was shown to likely cause to pillar pain and some alterations in other intercarpal joints [19,27-30]. Pillar pain, developed as of 3rd month postoperatively, is characterized by pain in thenar and hypothenar eminence or pain and tenderness at radial or ulnar side [31]. The pain was revealed to originate from pisotriquetral joint secondary to increased forces onto the joint upon displacement of the pisiform after relaxation of TCL [29]. However, recent studies showed that pillar pain may be related with alterations in muscular, ligamentous, neurogenic, edematous structures, or carpal arch architecture [31]. TCL has three main functions, namely anchorage of thenar and hypothenar muscle groups, transverse stabilization of the wrist, and pulley function for flexor tendons [29,30]. Nevertheless, main transverse stabilizer of the wrist was reported be the capitolunate ligament [32].

Concordance of carpal bones to each other is very critical within the wrist joint. Any discordance may lead to uneven distribution of the loads onto the wrist and eventual development of arthritis. Studies published in the literature did not demonstrate any degenerative arthritis postoperatively, yet reported progression of pisotriquetral degenerative arthritis existing prior to the surgery [29].

The aim of the study was to evaluate effects of simple section of transverse carpal ligament on intercarpal stability by radiological parameters in patients those are refractory to conservative treatment.

Materials and Method

This prospective study was approved by ethics committee and performed in accordance to Helsinki Declaration. Patients with suspected diagnosis of carpal tunnel syndrome upon medical history and physical examination underwent neurodiagnostic tests (EMG). All 47 subjects, comprising 39 female and 8 male patients, were operated, followed, and assessed by the same surgical team between January 2014 and May 2015 after written informed consent was obtained. The study included >18 year-old patients

with carpal tunnel syndrome diagnosis as documented by clinical and EMG findings, where non-responsiveness to conservative treatment is present and surgery is indicated. Exclusion criteria included previous surgery at hand and wrist region, comorbidities (e.g. diabetes mellitus, inflammatory arthritis, gout arthritis, and pregnancy), traumatic sequelae at the wrist, congenital deformity of the wrist, concomitant use of anticoagulant agent, and hemodialysis. All patients were monitored and operated by the same surgical team under local anesthesia and sedation. Standard incision was made parallel and just ulnar to the thenar crease. Superficial palmar fascia was opened. The TCL was longitudinally divided at its distal segment using a blade and small blunt-end scissors under direct visualization. The distal segment of the median nerve was then exposed. The carpal tunnel retinaculotome was then directed proximally to divide the remaining TCL and the distal antebrachial fascia. Finally, neurolysis of median nerve was applied. Wrist range of motion and general physical examination findings were recorded at both preoperatively and postoperative week 8. Besides, conventional MRI with the Achieva 1.5T system (Philips Healthcare, Andover, MA, USA) were obtained at the same time points. Images were acquired in a way that the patient was in prone position, the arm was extended on the head with pronated forearm, the wrist was in neutral position, and the digits were extended. Trapeziohamate distance (THD), scaphopisiform distance (SPD), scapholunate angle (SLA), and carpal angle (CA) were measured preoperatively and at 12th week postoperatively. THD was standardized as the distance between the hook of the hamate and ulnar side of the trapezium, visualized at the axial plane on MRI scans (Figure 1).

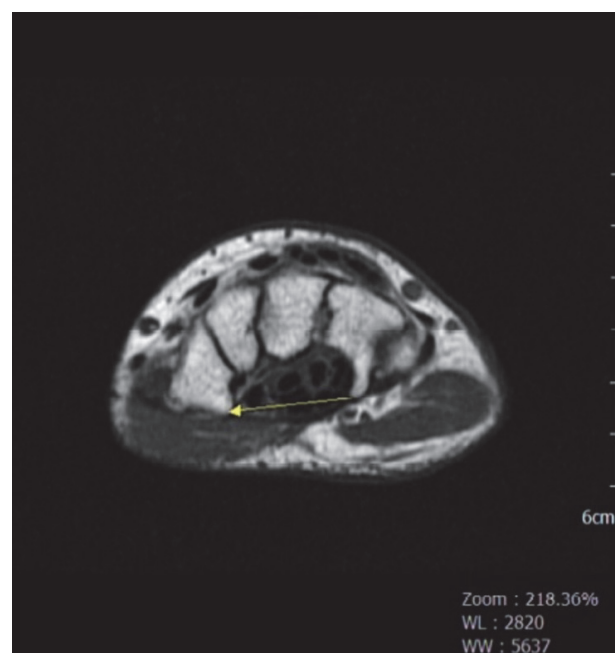


Figure 1. Trapeziohamate distance visualized on the axial plane of MRI scan.

SPD was standardized as the distance between the lateral border of the pisiform bone and ulnar border of the scaphoid bone measured after both pisiform and scaphoid bones were visualized at the same plane in axial T1W MRI scans (Figure 2). SLA was the angle between long axes of the scaphoid and lunate bone in sagittal planes of the wrist (Figure 3). CA was measured as the angle between the line crossing proximal joint surfaces of the scaphoid and lunate bone and the line crossing proximal to the lunate and triquetral bones at coronal planes (Figure 4). All images were evaluated by a single radiologist and an orthopedist. Correlation coefficients for the measurements were 0.96, 0.91, 0.99, 0.99 and 0.90 for THD, SPD, SLA, and CA, respectively.

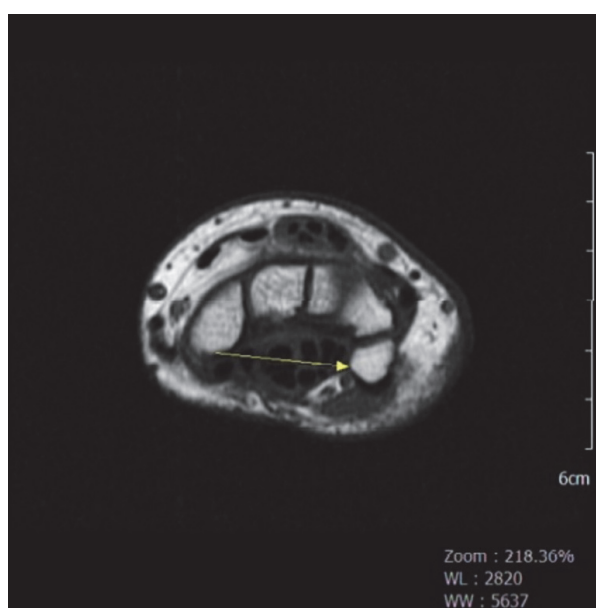


Figure 2. Scaphopisiform distance visualized on axial MRI scan.

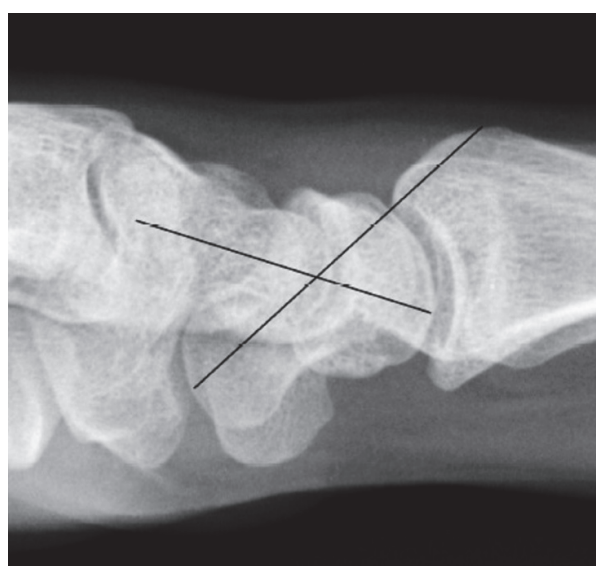


Figure 3. Measurement of scapholunate angle



Figure 4. Measurement of carpal angle on coronal MRI planes.

Results were grouped as preoperative and postoperative. After check of distribution of the data by Kolmogorov-Smirnov test, paired t-test was used for preoperative and postoperative results. P values <0.05 was considered as statistically significant. Data were analyzed by SPSS Version 20 software.

Results

The mean age of the subjects was 49 (range: 36-65). Chief complaint was pain and weakness in 37 patients and paresthesia in the remaining 10 patients. EMG showed moderate-severe CTS in 38 patients and severe CTS in 9 patients. Phalen's test was positive in 35 patients, while Durkan's test was positive in 28 patients. Two patients had thenar atrophy. Dominant extremity was affected in 34 of 47 patients.

Mean preoperative trapezohamate distance was measured as 25.2 mm (range: 20-33), while postoperative trapezohamate distance was 26.4 mm (range: 22-34), ($p=0.031$). Mean preoperative scaphopisiform distance was 32 mm (range: 23-34), as compared to postoperative scaphopisiform distance being 33.6 mm (range: 24-36), ($p=0.001$). While mean scapholunate angle was 44.0 (range: 36-60) preoperatively, it was measured as 45.10 (range: 33-60) in the postoperative period ($p=0.001$). Both preoperative and postoperative mean carpal angles was 127.0 (range 118-134 and 119-134, respectively) ($p=0.323$). These results were separately compared in terms of preoperative and postoperative measurements. Statistically significant increases were shown in trapezohamate and scaphopisiform distances and scapholunate angle, yet carpal angle comparison did not reveal any significant difference. Two patients had ongoing pain and paresthesia despite the intervention. Range of motion of patients was normal at both preoperative and postoperative periods.

Discussion

This study was performed to examine the effects on carpal stability after simple section of transverse carpal ligament, which is the standard technique in the treatment of carpal

tunnel syndrome. Transverse carpal ligament constitutes volar side of the carpal tunnel. By attaching to the pisiform, the hook of the hamate, the scaphoid, and the trapezoid, TCL contributes to the formation of the carpal arch and concavity [32]. Yet, anatomic distribution of TCL remains to be clearly elucidated [33]. Flattening of carpal arch and increase of carpal distance was reported when this ligament was cut [27]. A study assessing trapeziohamate distance before and after TCL was cut demonstrated that this distance decreased during flexion and extension before the intervention, whereas increased by 11% after the intervention [18]. Improvement at trapeziohamate distance was also confirmed by our study showing a significant increase. Cobb et al. reported mean width of the carpal tunnel as 20 ± 1.2 mm at the level of trapezium and hook of the hamate, and 25 ± 1.2 mm between pisiform and scaphoid hiatus, showing a gradual narrowing the tunnel distally [34]. These are consistent with our findings where we detected similar narrowing of the tunnel diameter towards distal parts. Indeed, this may lead to insufficient release of TCL distally or inadequate decompression, posing clinically and functionally unsuccessful therapeutic outcomes.

Gartsman et al. in a study where they performed open carpal tunnel surgery, compared postoperative wrist PA graphs of the patients with that of unaffected sides of the same subjects. They defined carpal arch measuring the distance between the trapezium and the hook of the hamate, where wrist was at 500 of extension. While there was no difference in range of motion of the joint postoperatively, 47 of 50 patients revealed enlargement in the carpal arch [35]. This broadening, measured as 2.9 mm, can be regarded as relatively huge, which may be related to fact that the wrist was evaluated at 500 of extension in this study contrary to the assessment of the wrist in MRI or CT scan in neutral position.

In a study in 1985, Roger et al. evaluated their patients preoperatively, at 1st, and 3rd month postoperatively via CT scans and found that carpal tunnel volume increased after the surgery. However, they showed that this increase was not accompanying any change in anatomical bone alignment, implying that it is associated with an increase in carpal convexity rather than carpal arch enlargement [36].

Aslani et al. compared outcomes of open and endoscopic carpal tunnel surgery in 2012, where they used CT images for radiological assessments. Both groups were found to have increments in pisoscaphoid and trapeziohamate distances, with no significant difference between these two groups. Mean distance between pisiform and scaphoid bones increased from 21.5 mm preoperatively to 22.1 mm after open surgery [37]. Schmitt et al. showed enlargement in the canal often occurred in the area between pisiform and scaphoid hiatus [38]. In our study, mean increase in the distance between scaphoid and pisiform was calculated as 0.8 mm. Published studies revealed that enlargement of the

carpal arch over 20% caused a 25% decrease in grip strength. Nevertheless, this excessive enlargement did not lead to any postoperative wrist pain [35].

MR imaging is also very frequently used for the evaluation of carpal arch. No significant difference was found between carpal tunnel volume measured in cadavers and that measured by MRI. MRI is a reliable method for assessment of the carpal tunnel volume and its content [39]. We also used MRI in order to avoid radiation exposure and ethical problems. Kato et al., in the study they performed to investigate morphological changes in carpal tunnel after endoscopic carpal tunnel surgery, divided carpal tunnel into palmar and dorsal parts according to trapeziohamate line. They showed that postoperative enlargement mainly occurred in palmar part [40].

A biomechanical and anatomic study of Brooks et al. in 2003 did not demonstrate such a meaningful effect of complete release of transverse carpal ligament on the carpal biomechanics and morphology. They detected a small increment in carpal arch, yet considering it within acceptable ranges. They thought that main problem after this operation was related to loss of pulley function and deterioration of excursion and stabilization of flexor tendon. They questioned whether or not TCL repair or limitation of excision of TCL after carpal tunnel surgery may prevent potential outcomes such as postoperative weakness and pillar pain [32].

Conclusion

Anatomical structure of the transverse carpal ligament, a major part of the morphological structure of carpal tunnel, has not been clearly elucidated yet. Decreasing the pressure within the tunnel is still most recognized principle in the surgical management of carpal tunnel syndrome. We aimed to detect whether this surgical intervention had a negative effect on carpal stability or not.

Clinical and radiological findings of our study reveal that although simple cutting of carpal ligament has satisfactory clinical outcomes in the management of carpal tunnel syndrome, it is associated with a significant increase in carpal arch distance. We consider that whether or not increases in intercarpal distances may lead to a degenerative process at the wrist in future warrants further research.

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