Observational Study

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A new diagnostic morphological parameter for the Carpal tunnel syndrome

The palmaris longus tendon cross-sectional area

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Abstract Carpal tunnel syndrome (CTS) is correlated with increased intracarpal canal pressure (ICP). The effect of palmaris longus tendon (PLT) loading on ICP is documented in previous researches. PLT loading induces the greatest absolute increase in ICP. Therefore, to analyze the connection between the PLT and CTS, we newly made the measurement of the PLT cross-sectional area (PLTCSA). We assumed that PLTCSA is a reliable diagnostic parameter in the CTS. PLTCSA measurement data were acquired from 21 patients with CTS, and from 21 normal subjects who underwent wrist magnetic resonance imaging (W-MRI). We measured the PLTCSA at the level of pisiform on W-MRI. The PLTCSA was measured on the outlining of PLT. The two different cutoff values in the analysis were determined using receiver operating characteristic (ROC) analysis. The mean PLTCSA was $2.34 \pm 0.82\,mm^2$ in the normal group and $3.97 \pm 1.18\,mm^2$ in the CTS group. ROC curve analysis concluded that the best cutoff point for the PLTCSA was $2.81\,mm^2$, with 76.2% sensitivity, 71.4% specificity, and area under the curve of 0.88 (95% CI, 0.78-0.98). PLTCSA is a sensitive, new, objective morphological parameter for evaluating CTS.

Abbreviations: AUC = area under the curve, CTS = carpal tunnel syndrome, ICP = intracarpal canal pressure, PLT = palmaris longus tendon, PLTCSA = palmaris longus tendon cross-sectional area, ROC = receiver operating characteristic, W-MRI = wrist magnetic resonance imaging.

Keywords: anatomy, area, Carpal tunnel syndrome, cross-sectional, diagnosis, new, palmaris longus tendon

1. Introduction

Carpal tunnel syndrome (CTS), the most common peripheral neuropathy in upper extremity.[1–3] On the basis of nerve conduction studies and clinical evaluations, it has been approximated that 1 in every 5 subjects who complain of symptoms such as pain, tingling sensations, numbness in the hands could have CTS. The most characteristic biomechanical and histological finding is the thickening of the subsynovial connective tissue.[4,5] The CTS diagnosis is based upon physical tests, clinical symptoms, ultrasonography (US) and electrodiagnostic studies.[6] Recently, wrist magnetic resonance images (W-MRI) has been demonstrated as a reasonable diagnostic modality for the CTS diagnosis.[7–9] W-MRI can clearly distinguish the anatomy of peripheral nerve along with the pathological change related to mechanical compression and are noninvasive. The increased intracarpal canal pressure (ICP), the medial nerve flattening within the carpal tunnel (CT), bowing of the flexor retinaculum, and swelling of the median nerve in the distal and proximal CT are important anatomical location of the CT anatomy.[10] Palmaris longus tendon (PLT) loading in wrist movement also induces the greatest increase in ICP.[11–13] The PLT originates from the humerus medial epicondyle as do the flexor carpi radialis muscle, the flexor carpi ulanris muscle, and the flexor digitorum superficialis muscle (FDSM). The PLT is located just above the FDSM and just under the fascia of the forearm, the subcutaneous fat.[14,15]

Therefore, to assess the relationship between the PLT and CTS, we newly made the measurement of the palmaris longus tendon cross-sectional area (PLTCSA). Moreover, no previous researches have assessed the clinical best cut off value of PLTCSA. In this article, we have compared the accuracy of PLTCSA and for the CTS diagnosis using W-MRI. We assumed that PLTCSA is an important diagnostic parameter in the CTS.

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2. Methods

The data were retrospectively collected over a period from April 2014 to August 2018 in international St. Mary`s Hospital. The Catholic Kwandong University, Incheon, Korea, Institutional Review Board (IRB) checked and approved this clinical research. (IRB number: IS18RISI0013). The CTS were confirmed by 2 experienced neuroradiologists. The CTS group included 21 patients (9 males and 12 females) with an average age of 44.09 ± 13.22 years (range, 25-69 years).

The inclusion criteria

1) positive modified Phalen test;
2) W-MR image taken within 1 year;
3) confirmation by a nerve conduction examination according to the American Academy of Neurology standards.[16]

The exclusion criteria

1) double crush syndrome;
2) wrist fracture;
3) history of wrist infection;
4) history of any wrist surgery;
5) chronic renal failure.
6) tumors in the CT;

To compare the PLTCSA between the patients with or without CTS, we enrolled control individuals who underwent W-MRI without CTS. The normal group consisted of 21 patients (9 males and 12 females) with a mean age of 43.19 ± 13.27 years (range, 28-79 years) (Table 1). The PLTCSA in the healthy group were similarly assessed at the level of pisiform (Table 1).

2.1. MRI scanning protocol

W-MRI was performed on 3T Avanto (Siemens Healthcare Medical, Germany) with Philips Achieva 3 T scanners. Scan sequence: turbo spin echo (TSE) T1-weighted images in transverse view, TR 893 ms, TE 13 ms, 120 × 120 mm FOV, layer thickness 3.0 mm and Matrix 512 × 333.

2.2. Image analysis

The PLTCSA was measured on the most hypertrophied outlining of the PLT through the cross-sectional area at the pisiform level (Fig. 1).

2.3. Statistical analyses

Unpaired Student *t* tests were used to compare the differences in demographic data. The two different cutoff values in the analysis were determined using ROC analysis. A *P*-value below .05 was regarded significant. Statistical analysis was made with SPSS for Windows computer package version 22 (IBM SPSS Inc., Chicago, IL). Data were expressed as mean and standard deviation (SD).

Table 1

Comparison of the characteristics of control and CTS group.

Variable	Control group n = 21	CTS group n = 21	Statistical significance
Gender (male/female)	9/12	9/12	NS
Age (yrs)	43.19 ± 13.27	44.09 ± 13.22	NS
PLTCSA (mm^2)	2.34 ± 0.82	3.97 ± 1.18	P < .001

CTS = Carpal tunnel syndrome, PLTCSA = palmaris longus tendon cross-sectional area, NS = not statistically significant (*P* > .05).

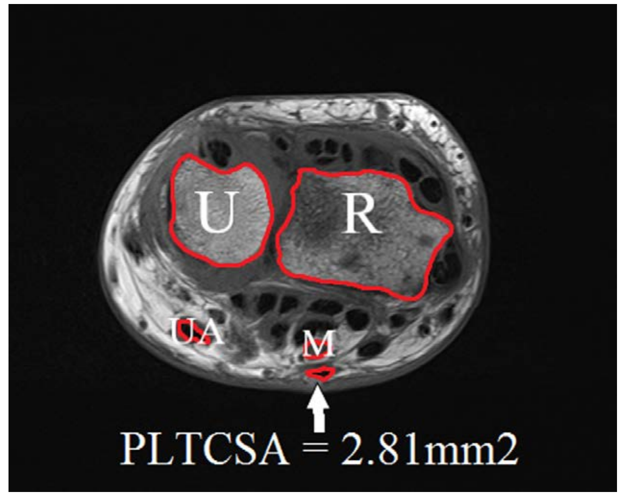

Figure 1. Axial T1 weighted turbo spin echo wrist MR images of the PLTCSA at the pisiform level. M = median nerve, PLTCSA = palmaris longus tendon cross-sectional area, R = radius, U = ulnar, UA = ulnar artery.

3. Results

There are no statistically significant differences between the both groups in the demographic data (Table 1). The average PLTCSA was 2.34 ± 0.82 mm^2 in the normal group and 3.97 ± 1.18 mm^2 in the CTS group. CTS patients had significantly higher PLTCSA (P < .001) (Table 1). Based on the chosen cutoff values in the ROC analysis, the optimal cutoff point for the PLTCSA was 2.81mm^2, with 76.2% sensitivity, 71.4% specificity, and AUC of 0.88 (95% CI, 0.78-0.98) (Table 2, Fig. 2).

4. Discussion

CTS is a debilitating entrapment disease of the hand and wrist. Women are 3 times more likely to have CTS than men, and the prevalence and severity have been documented to increase with aging process.[16,17] The most common symptoms of CTS are pain, numbness, and paresthesia in the index, middle, thumb and radial half of the fourth finger that is worst at night. Wrist extension and flexion increase pressure in the CT, and wrist flexion during sleep may worsen symptoms such that CTS patients awake with numbness and burning to the hand.[18–20]

CTS is also correlated with increased ICP. The CT is open both distally and proximally, however despite this mechanism; it maintains a distinct tissue fluid pressure due to its fibrous borders. The pressure in the CT of a normal individual ranges from 2.5 to 13 mm Hg. A decrease in the cross-sectional area of the CT can lead to an elevation in pressure that becomes critical above 20-30 mm Hg. At this point, axoplasmic flow and epineural blood flow is impeded, and nerve edema, dysfunction, and scarring can result. The effect of PLT loading on ICP is documented in previous researches. PLT loading in wrist extension

Table 2

Specificity and sensitivity of each cutoff point of the PLTCSA.

PLTCSA (mm^2)	Sensitivity (%)	Specificity (%)
1.12	100	9.5
2.55	95.2	61.9
2.59	90.5	66.7
2.81[a]	76.2	71.4
3.42	66.7	85.7
3.75	47.6	95.2

PLTCSA = palmaris longus tendon cross-sectional area.
aThe most suitable cutoff point on the receiver operating characteristic (ROC) curve.

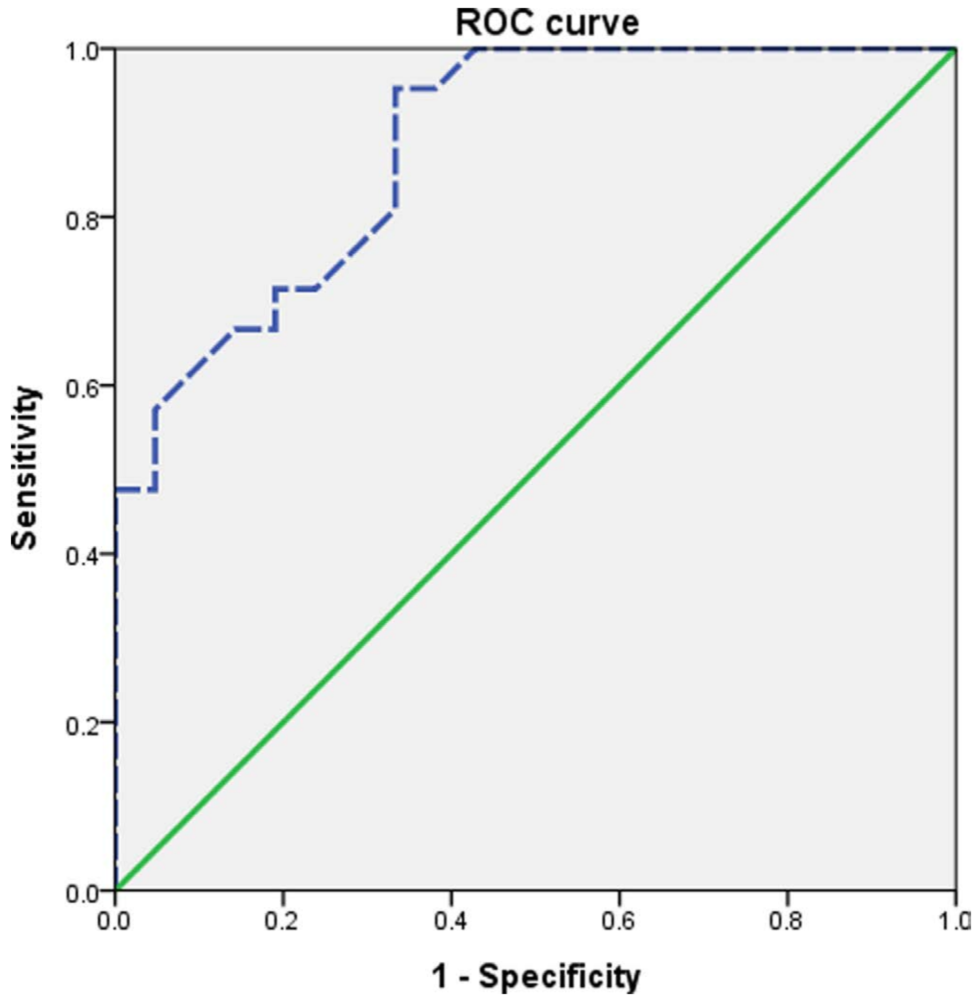

Figure 2. Receiver operating characteristic curve of PLTCSA for prediction of CTS. The most suitable cut off point of PCA was 2.81 mm^2, with sensitivity of 76.2%, specificity of 71.4% and AUC of 0.88. PLTCSA AUC (95% CI) = 0.88 (0.78-0.98). AUC = area under the curve, CTS = Carpal tunnel syndrome, PLTCSA = palmaris longus tendon cross-sectional area.

induces the greatest absolute increase in ICP.[11,21–23] However, the PLT is not yet a proven independent risk factor for the development of CTS. Furthermore, its clinical applications are unknown. Therefore, to assess the relationship between the PLT hypertrophy and CTS, we measured the PLTCSA. The PLTCSA has not been analyzed for its associations with CTS. We assumed that PLTCSA is a new important, sensitive morphologic parameter in CTS diagnosis.

Eventually, this present study results demonstrated the relationship between PLTCSA and CTS. CTS group had significantly higher PLTCSA than healthy group. In this research, the most suitable cutoff value for PLTCSA was 2.81 mm^2, with 76.2% sensitivity, 71.4% specificity, and AUC of 0.88 (95% CI, 0.78-0.98). In the results, we have demonstrated a significant correlation between the PLTCSA and CTS; and PLTCSA was identified as an objective, new measurement parameter. We hope that PLTCSA could be a clear, and precise morphological image analysis to assess CTS.

In the study, PLTCSA was measured from T1W transverse TSE W-MR images. None of the previous studies have demonstrated a clinical correlation between CTS and PLTCSA as a morphologic parameter on W-MRI. W-MRI has been recently reported to be advantageous than electrophysiological exam. W-MRI can visualize high resolution of wrist morphological structures and represents an effective morphological structure for median nerve, visualization of carpal bones, ligaments, tendons, and muscles. Several previous researches have used W-MRI for the evaluation of CTS and have reported characteristic W-MRI image analysis in CTS patients.[24] Deryani et al have insisted that W-MRI can be very useful for the diagnosis of CTS.[19] Because, W-MRI shows detailed anatomical structures that correlate with electrophysiological consequences. Kleindienst et al have concluded that W-MRI can demonstrates severity of nerve compression.[9]

The current study has multiple limitations. First, there can be some biases associated with measurement of the PLTCSA on W-MRI. Even though we found a good quality of morphologic measurement in the T1W transverse W-MR images that best showed the PLT at the pisiform level, the measurement of PLTCSA in the single image could be inhomogeneous because of the different cutting angle in W-MR images resulting from individual anatomic variation. Second, there are several different levels to analyze the PLT using W-MRI such as the body of the scaphoid, hook of the hamate, distal radioulnar joint, and tubercle of the scaphoid. Even though, analysis at the pisiform level is an accurate and reliable for diagnosis, the data might still be biased. Third, CTS has several causes, including the soft tissues, transcarpal ligament, and median nerve flattening; however, we only focused on the PLT only. Fourth, there are several alternative imaging diagnostic tools to evaluate PLT, such as ultrasound imaging test. An ultrasound examination uses sound waves to create real-time pictures[25–35]; however, this study analyzed only the measurement of the PLT on W-MRI.

5. Conclusion

This is the first study to demonstrate the correlation between PLTCSA and CTS. PLTCSA is proposed as a simple and reliable diagnostic image parameter with high sensitivity for the assessment of CTS.

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Author contributions

Conceptualization: Young Uk Kim.
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Funding acquisition: Young Uk Kim.
Investigation: Young Uk Kim.
Methodology: Young Uk Kim.
Writing – review & editing: Young Joo, Jee Youn Moon, Yoon Jin Lee, Yun-Sic Bang, Jungmin Yi, Jae Ni Jang, Min-Ying Su.

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