

UC Irvine

UC Irvine Previously Published Works

Title

A new diagnostic morphological parameter for the Carpal tunnel syndrome: The palmaris longus tendon cross-sectional area.

Permalink

<https://escholarship.org/uc/item/6xr0v4qs>

Journal

Medicine, 101(40)

Authors

Joo, Young

Moon, JeeYoun

Lee, Yoon

et al.

Publication Date

2022-10-07

DOI

10.1097/MD.00000000000030906

Peer reviewed

A new diagnostic morphological parameter for the Carpal tunnel syndrome

The palmaris longus tendon cross-sectional area

Young Joo, MD, PhD^a, JeeYoun Moon, MD, PhD^b, Yoon Jin Lee, MD^c, Yun-Sic Bang, MD^c, Jungmin Yi, MD^d, Jae Ni Jang, MD^d, Min-Ying Su, PhD^e, Young Uk Kim, MD, PhD^{d,e,*}

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 $2.34 \pm 0.82 \text{ mm}^2$ in the normal group and $3.97 \pm 1.18 \text{ mm}^2$ 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 ulnaris 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.

This research did not receive any specific grant from funding agencies in the public.

The authors have no conflicts of interest to disclose.

The datasets generated during and/or analyzed during the current study are available from the corresponding author on reasonable request.

^a Department of Anesthesiology and Pain Medicine, CHA Ilsan Medical Center, CHA University, Goyang, Republic of Korea, ^b Department of Anesthesiology and Pain Medicine, Seoul National University Hospital, Seoul National University School of Medicine, Seoul, Republic of Korea, ^c Department of Anesthesiology and Pain Medicine, CHA Bundang Medical Center, CHA University, Seongnam, Republic of Korea, ^d Department of Anesthesiology and Pain Medicine, Catholic Kwandong University of Korea College of Medicine, International St. Mary's Hospital, Incheon, Republic of Korea, ^e Department of Radiological Sciences, University of California, Irvine, CA, USA.

* Correspondence: Young Uk Kim, Department of Anesthesiology and Pain Medicine, Catholic Kwandong University of Korea College of Medicine,

International St. Mary's Hospital, Simgokro, 100 Gil 25, Seo-Gu, Incheon City, Republic of Korea (e-mail: uk201@hanmail.net).

Copyright © 2022 the Author(s). Published by Wolters Kluwer Health, Inc. This is an open-access article distributed under the terms of the Creative Commons Attribution-Non Commercial License 4.0 (CCBY-NC), where it is permissible to download, share, remix, transform, and buildup the work provided it is properly cited. The work cannot be used commercially without permission from the journal.

How to cite this article: Joo Y, Moon JY, Lee YJ, Bang Y-S, Yi J, Jang JN, Su M-Y, Kim YU. A new diagnostic morphological parameter for the Carpal tunnel syndrome: The palmaris longus tendon cross-sectional area. *Medicine* 2022;101:40(e30906).

Received: 16 December 2021 / Received in final form: 30 August 2022 / Accepted: 1 September 2022

<http://dx.doi.org/10.1097/MD.000000000030906>

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).

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	<i>P</i> < .001

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

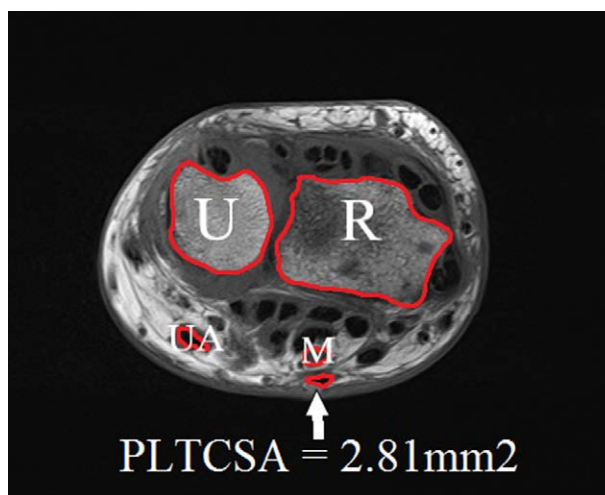


Figure 1. Axial T1 weighted turbo spin echo wrist MR images of the PLTCSA at the pisiform level. M = median nerve, PLTCSA = palmaris longus tendon cross-sectional area, R = radius, U = ulnar, UA = ulnar artery.

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 mm² in the normal group and 3.97 ± 1.18 mm² 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 2.81mm², 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

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.

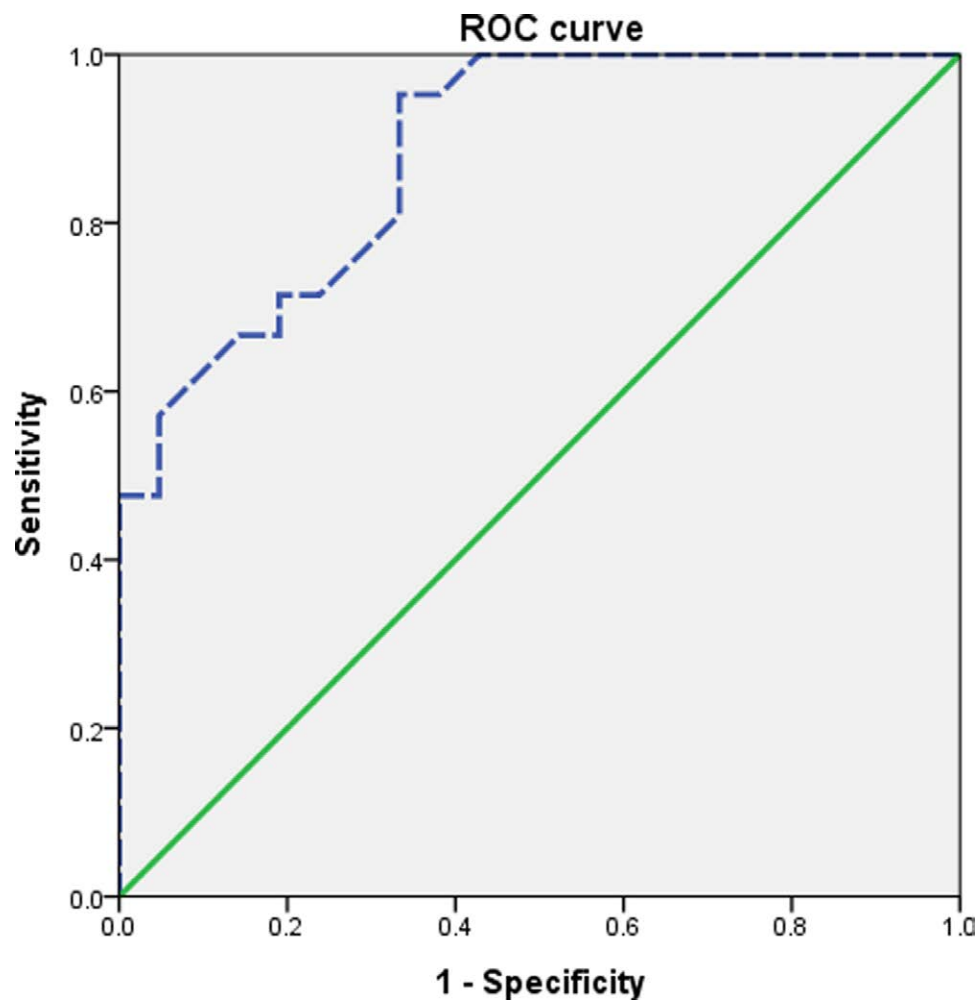


Figure 2. Receiver operating characteristic curve of PLTCSA for prediction of CTS. The most suitable cut off point of PCA was 2.81 mm^2 , with sensitivity of 76.2%, specificity of 71.4% and AUC of 0.88. PLTCSA AUC (95% CI) = 0.88 (0.78-0.98). AUC = area under the curve, CTS = Carpal tunnel syndrome,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

Acknowledgments

All authors thank the International St. Mary's Hospital.

Author contributions

Conceptualization: Young Uk Kim.

Data curation: Young Uk Kim.

Formal analysis: Young Uk Kim.

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.

References

- [1] Egger A, Tosti A. Carpal tunnel syndrome and associated nail changes: review and examples from the author's practice. *J Am Acad Dermatol.* 2020;83:1724–9.
- [2] Genova A, Dix O, Saefan A, et al. Carpal tunnel syndrome: a review of literature. *Cureus.* 2020;12:e7333.
- [3] Grant Y, Freilich S, Horwitz MD, et al. Carpal tunnel syndrome in patients with arteriovenous fistula for haemodialysis: a narrative review of the current literature. *J Vasc Access.* 2021;22:795–800.
- [4] Xie Y, Zhang C, Liang B, et al. Effects of shock wave therapy in patients with carpal tunnel syndrome: a systematic review and meta-analysis. *Disabil Rehabil.* 2020;44:177–88.
- [5] Zyluk A. The role of genetic factors in carpal tunnel syndrome etiology: a review. *Adv Clin Exp Med.* 2020;29:623–8.
- [6] Keith MW, Masear V, Chung K, et al. Diagnosis of carpal tunnel syndrome. *J Am Acad Orthop Surg.* 2009;17:389–96.
- [7] Ikeda M, Okada M, Toyama M, et al. Comparison of median nerve cross-sectional area on 3-T MRI in patients with carpal tunnel syndrome. *Orthopedics.* 2017;40:e77–81.
- [8] Jarvik JG, Yuen E, Kliot M. Diagnosis of carpal tunnel syndrome: electrodiagnostic and MR imaging evaluation. *Neuroimaging Clin N Am.* 2004;14:93–102, viii.
- [9] Kleindienst A, Hamm B, Lanksch WR. Carpal tunnel syndrome: staging of median nerve compression by MR imaging. *J Magn Reson Imag.* 1998;8:1119–25.
- [10] El-Karabaty H, Hetzel A, Galla TJ, et al. The effect of carpal tunnel release on median nerve flattening and nerve conduction. *Electromyogr Clin Neurophysiol.* 2005;45:223–7.
- [11] Buch HA. Palmaris longus tendon assisted temporalis muscle transfer for lagophthalmos. *Indian J Ophthalmol.* 2015;63:464.
- [12] Leslie BM, Osterman AL, Wolfe SW. Inadvertent harvest of the median nerve instead of the palmaris longus tendon. *J Bone Joint Surg Am.* 2017;99:1173–82.
- [13] Sato K, Murakami K, Mimata Y, et al. Superficial Ulnar artery crossing over the palmaris longus tendon at the wrist in a cadaver: a case report. *J Hand Surg Asian Pac Vol.* 2018;23:137–9.
- [14] Park HB, Kim KH, Kim D, et al. A cadaveric study for the volar needle approach to the pronator quadratus using the palmaris longus tendon landmark. *Muscle Nerve.* 2019;60:582–5.
- [15] Shah HR, Hiremath A, Thatte MR. Anomalous palmaris longus tendon causing carpal tunnel syndrome. *Indian J Plast Surg.* 2019;52:360–1.
- [16] Zivkovic S, Gruener G, Arnold M, et al. Quality measures in electrodiagnosis: Carpal tunnel syndrome-an AANEM quality measure set. *Muscle Nerve.* 2020;61:460–5.
- [17] Bodofsky EB, Campellone JV, Wu KD, et al. Age and the severity of carpal tunnel syndrome. *Electromyogr Clin Neurophysiol.* 2004;44:195–9.
- [18] Aroori S, Spence RA. Carpal tunnel syndrome. *Ulster Med J.* 2008;77:6–17.
- [19] Deryani E, Aki S, Muslumanoglu L, Rozanes I. MR imaging and electrophysiological evaluation in carpal tunnel syndrome. *Yonsei Med J.* 2003;44:27–32.
- [20] de Campos CC, Manzano GM, Leopoldino JF, et al. The relationship between symptoms and electrophysiological detected compression of the median nerve at the wrist. *Acta Neurol Scand.* 2004;110:398–402.
- [21] Kocaoglu B, Ulku TK, Gereli A, et al. Palmaris longus tendon graft versus modified Weaver-Dunn procedure via dynamic button system for acromioclavicular joint reconstruction in chronic cases. *J Shoulder Elbow Surg.* 2017;26:1546–52.
- [22] Shearin JW, Walters B, Yang SS. Flexor Carpi radialis to palmaris longus tendon transfer for spontaneous rupture of the Flexor Carpi radialis Tendon - a review of an uncommon finding and surgical technique for operative correction. *J Hand Surg Asian Pac Vol.* 2016;21:417–21.
- [23] Pal JN, Bera AK, Roy AN, et al. Palmaris longus tendon grafting for extensor pollicis longus tendon rupture bScrew tip after 20 years. *J Orthop Case Rep.* 2016;6:25–7.
- [24] Lee S, Cho HR, Yoo JS, et al. The prognostic value of median nerve thickness in diagnosing carpal tunnel syndrome using magnetic resonance imaging: a pilot study. *Korean J Pain.* 2020;33:54–9.
- [25] Abdelbaser I, Mageed NA, Elfayoumy SI, et al. The effect of ultrasound-guided bilateral thoracic retrolaminar block on analgesia after pediatric open cardiac surgery: a randomized controlled double-blind study. *Korean J Anesthesiol.* 2022;75:276–82.
- [26] Baytar MS, Yilmaz C, Karasu D, et al. Comparison of ultrasonography guided serratus anterior plane block and thoracic paravertebral block in video-assisted thoracoscopic surgery: a prospective randomized double-blind study. *Korean J Pain.* 2021;34:234–40.
- [27] Boltuch AD, Marcotte MA, Treat CM, et al. The palmaris longus and its association with carpal tunnel syndrome. *J Wrist Surg.* 2020;9:493–7.
- [28] Frohlich J, Sancheti S. Hydrolocation assisted subclavian venous catheterization [published online ahead of print June 28, 2022]. *Korean J Anesthesiol.* doi: 10.4097/kja.22231.
- [29] Ghai B, Kumar M, Makkar JK, et al. Comparison of ultrasound guided pulsed radiofrequency of genicular nerve with local anesthetic and steroid block for management of osteoarthritis knee pain. *Korean J Pain.* 2022;35:183–90.
- [30] Keese GR, Wongworawat MD, Frykman G. The clinical significance of the palmaris longus tendon in the pathophysiology of carpal tunnel syndrome. *J Hand Surg Br.* 2006;31:657–60.
- [31] Kim SH. Anatomical classification and clinical application of thoracic paraspinous blocks. *Korean J Anesthesiol.* 2022;75:295–306.
- [32] Peksoz U, Yayik AM, Celik EC. Efficacy of ultrasound-guided transversalis fascia plane block in pediatric ureteroneocystostomy surgery. *Korean J Anesthesiol.* 2022;75:188–90.
- [33] Turgut MC, Saglam G, Toy S. Efficacy of extracorporeal shock wave therapy for pillar pain after open carpal tunnel release: a double-blind, randomized, sham-controlled study. *Korean J Pain.* 2021;34:315–21.
- [34] Han DS, Wu WT, Hsu PC, et al. Sarcopenia is associated with increased risks of rotator Cuff Tendon diseases among community-dwelling elders: a cross-sectional quantitative ultrasound study. *Front Med (Lausanne).* 2021;8:630009.
- [35] Chu CA, Chen YJ, Chang KV, et al. Reliability of sonoelastography measurement of tongue muscles and its application on obstructive sleep apnea. *Front Physiol.* 2021;12:654667.