Quantitative Evaluation of Finger Flexor Tendon Gliding Sounds of Healthy Volunteers Using a Digital Stethoscope

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INTRODUCTION: Quantitative in vivo evaluation of tendon gliding dynamics using imaging modalities remains challenging. Our recent study demonstrated that the flexor tendon gliding sounds at the wrist differ between the thumb and index finger [1]. In the present study, tendon gliding sounds from the index, middle, and ring fingers were recorded, and their acoustic characteristics were quantitatively compared.

METHODS: Fifteen healthy volunteers (8 men and 7 women) participated in this study. The index, middle, and ring fingers of both hands were evaluated. Tendon gliding sounds were recorded using a digital stethoscope (Nexteto, ShareMedical) placed on the palmar aspect of the metacarpophalangeal joint of each finger (Figure 1). With the adjacent fingers held in extension, participants performed active flexion and extension in synchrony with a metronome set at 60 beats per minute. The recorded sounds were converted to WAV files using Audacity (Muse Group) and analyzed with the Librosa audio processing library in Python (Figure 2). Acoustic parameters—average frequency, central frequency, spectral centroid, spectral flatness, and zero-crossing rates—were calculated. Statistical analysis was performed using the one-way analysis of variance followed by Tukey's post hoc test. Results are shown in the Table1.

RESULTS SECTION: The average values of each acoustic parameter for the index, middle, and ring fingers were as follows: average frequency (Hz), 192.5 ± 44.9, 176.8 ± 23.1, 172.7 ± 26.9; central frequency (Hz), 179.2 ± 49.6, 156.7 ± 23.9, 154.4 ± 29.4; spectral centroid, 192.5 ± 44.9, 176.8 ± 23.1, 172.7 ± 26.9; spectral flatness, $1.97 \times 10^{-5} \pm 4.54 \times 10^{-5}$, $6.82 \times 10^{-5} \pm 1.21 \times 10^{-4}$, $2.51 \times 10^{-5} \pm 3.77 \times 10^{-5}$; and zero-crossing rate, 0.012 ± 0.004, 0.011 ± 0.002, 0.011 ± 0.002, respectively. The three finger groups exhibited significant differences in the average frequency, central frequency, spectral centroid, and spectral flatness ($p < 0.05$). Post hoc comparisons revealed significant differences in the average frequency, central frequency, spectral centroid, and spectral flatness between the index and middle fingers and in the central frequency between the index and ring fingers.

DISCUSSION: The results revealed that the acoustic characteristics of tendon gliding sounds differ among fingers. In particular, the acoustic properties of the flexor tendon in the index finger were different from those of the middle and ring fingers. The tendon gliding sound analysis may serve as a novel diagnostic and therapeutic assessment tool for tendinopathy.

SIGNIFICANCE/CLINICAL RELEVANCE: Quantitative evaluation of tendon gliding sounds was performed using a digital stethoscope. The acoustic properties of flexor tendons vary among fingers.

REFERENCES:
[1] Nakabayashi D, et al. Quantitative Evaluation of Tendon Gliding Sounds and Their Classification Using Deep Learning Models. Cureus. 2025 Apr 6;17(4):e81790.

IMAGES AND TABLES:
Figure.1 Recording flexor tendon gliding sounds using a digital stethoscope.
Figure.2 The tendon gliding sounds (A) and Spectrograms of each finger. B: index finger. C: middle finger. D: ring finger.
Table.1 Results of the one-way analysis of variance and Tukey's post hoc test of each parameter.

Figure. 1

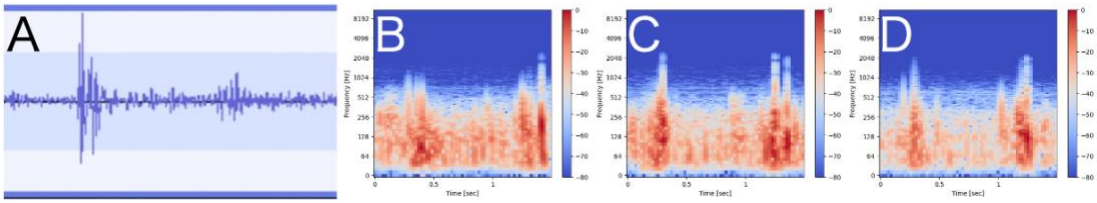

Figure. 2

	index (n = 30)	middle (n = 30)	ring (n = 30)	P value
Average frequency (Hz)	192.5 ± 44.9	172.7 ± 26.9	176.8 ± 23.1	0.034
Central frequency (Hz)	179.2 ± 49.6	156.7 ± 23.9	154.4 ± 29.4	0.008
Spectral centroid	192.5 ± 44.9	172.7 ± 26.9	176.8 ± 23.1	0.034
Spectral flatness	1.97e-05 ± 4.54e-05	6.82e-05 ± 1.21e-04	2.51e-05 ± 3.77e-05	0.020
Zero-crossing rate	0.012 ± 0.004	0.011 ± 0.002	0.011 ± 0.002	0.149

Average frequency (Hz)	P value	Central frequency (Hz)	P value	Spectral centroid	P value	Spectral flatness	P value
Ⅱ-Ⅲ	0.036	Ⅱ-Ⅲ	0.018	Ⅱ-Ⅲ	0.036	Ⅱ-Ⅲ	0.028
Ⅱ-Ⅳ	0.129	Ⅱ-Ⅳ	0.046	Ⅱ-Ⅳ	0.129	Ⅱ-Ⅳ	0.956
Ⅲ-Ⅳ	0.869	Ⅲ-Ⅳ	0.958	Ⅲ-Ⅳ	0.869	Ⅲ-Ⅳ	0.054

Table. 1