Noninvasive assessment for carpal tunnel pressure using ultrasound elastography

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Introduction

Carpal tunnel syndrome (CTS) is one of the most common musculoskeletal disorders. Disease condition in most of CTS results in tunnel pressure elevated. Therefore, carpal tunnel pressure (CTP) is clinically considered an important key factor in evaluating CTS. However, conventional methods of directly measuring CTP in the clinical practice have been invasive1-4. We have previously derived a proportional relationship between the tunnel pressure and shear wave speed in an in-vivo study using an ideal model5. The objective of this study was to study the relationship between the CTP and shear wave speed propagating in flexor tendon using ultrasound surface wave elastography (USWE) based on cadaveric model.

Methods

A total of 10 fresh frozen human cadaveric forearm hands were used (six men and four women, and three right and seven left hands, aged 40–80 years). Exclusion criteria included a history of prior carpal tunnel release, medical diseases such as metabolic disorders and major trauma to the ipsilateral wrist. Each cadaveric hand was set up as follow (Fig.1. 2.). Carpal tunnel area was defined 6 cm distal from the first wrist flexion crease. 12 Fr Foley catheter was inserted into the carpal tunnel and was set below the tendons to control the CTP by inflating or deflating the balloon with saline. The external fixator was installed straddling the wrist joint to fix and to keep wrist angle in neutral supinated position. The flexor tendons were exposed proximal to the edge of secured area and 50g weights were connected to median nerve and individual tendons except 3rd FDS to apply tension to maintain a physical load during all tests. Weights of 50, 200, 500, 1,000and 1,500 g were hung on the 3rd FDS to create different tendon tension conditions. A diagnostic pressure catheter system was also inserted into the carpal tunnel and was kept away from median nerve and 3rd FDS to measure real time CTP. The ultrasound probe was longitudinally positioned over the carpal tunnel with half of the contact surface on the intra carpal tunnel area and the other half on the outer carpal tunnel area to detect the wave propagation(Fig.3).

Shear wave was generated by function generator onto the 3rd FDS through the skin and wave speeds were simultaneously measured at two areas(intra and outer the carpal tunnel) and calculated by ultrasound system. Measurements were performed and recorded three times at each condition and mean values and standard deviation were calculated.

Mean values of intra carpal tunnel SWS (i-SWS), outer carpal tunnel SWS (o-SWS) and the difference of i-SWS and o-SWS (d-SWS) at multiple tensions and pressures were compared using a two-way ANOVA with critical p value = 0.05. Furthermore, a post hoc Bonferroni test with α = 0.05 was conducted to investigate the effect of tendon tension or carpal tunnel pressure on the SWS, respectively.

Results

Graphs of the result are shown in Fig.4.

• i-SWS and d-SWS significantly increased linearly with carpal tunnel pressure (p=0.000).
• o-SWS remained approximately constant with both tendon tension and carpal tunnel pressure.
• i-SWS was not affected by tendon tension (p=0.222) and there was no interaction between tendon tension and carpal tunnel pressure (p=0.207).

Discussion

• SWS propagating in the 3rd FDS tendon changed sensitively with proportional relationship only within the carpal tunnel region, while SWS outside the carpal tunnel remained consistent.

• These results indicate that it would be possible to deduce the CTP by measuring SWS propagating in the 3rd FDS which should be served as a pressure gauge for evaluation of CTP.

• These findings show surface wave elastography is useful to indirectly estimate carpal tunnel pressure.

• As limitations, the experimental setting did not necessarily reproduce the clinical condition and also did not necessarily reflect the actual pathological process.

Conclusion

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References