Effect Of The Horizontal Extension Technique On The Cross-sectional Area Of The Carpal Tunnel

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Introduction: Any condition that reduces the size of the carpal tunnel or increases the volume of its content will cause carpal tunnel syndrome (CTS). To relieve the pressure on the median nerve, several treatment options, both surgical and conservative, are available. The conservative treatment is a first-line treatment of CTS including manual therapies. Horizontal extension technique (HET) was developed by Shacklock et al (1) based on the clinical neurodynamics. Tensile load is applied parallel to the transversal carpal ligament by manually and the deformation of the carpal tunnel structure is expected by this technique. Although the clinical results have been reported in the CTS patients, it is poorly understood the mechanism of the effectiveness by the HET. The purpose of this study was a comparative measurement of in vivo cross-sections of the carpal tunnel by Magnetic resonance imaging (MRI) by applying HET.

Methods: 12 participants (12 women) without history of wrist disorders were studied. The mean age was 50 years (range, 43-55yrs). The horizontal extension technique (HET) was performed as follows. The therapist approached to the patient’s wrist from the dorsal aspect. Each hand created a gentle pincer action with the index finger (volar) and thumb (dorsal) around the medial and lateral aspects of the wrist complex and metacarpals. The movement was produced by the therapist levering gently over their thumbs and index fingers as an outward wedging action. This movement produced an increase in tension in the transverse carpal ligament by angling the ulnar and radial structures posteriorly around the capitate. This procedure was performed by one therapist. Before taking the MRI image, intraclass correlation coefficients (ICCs) were assessed for the intra-reliability of the pressure force during the HET. The force was measured by load cell (LMA-A100N, KYOWA ELECTRONIC INSTRUMENTS CO., LTD., Tokyo, Japan) during the HET (Figure 1). The mean value of pressure force was calculated by 10 times of the procedure. The pressure force was 40.2N±1.2 in right hand, and 40.3±1.5 in left. The ICCs of this procedure was 0.96. Kinematic MRI of the right wrist was performed with a 0.2-T horizontally open unit (AIRISmate, HITACHI Inc., Sapporo, Japan) in the state of before-HET, during HET, and after HET at 20 minutes intervals. During the HET, the therapist was continually applying the pressure in the whole scan time. T1-weighted axial image was used in this study (GE methods, FOV 130mm, TR 400ms, TE 25, Thickness 4.0mm, Interval 4.5mm, Scan time 5:07). The carpal tunnel measurement by cross sectional images was assessed by the method of Mesgarzadeh et al. (2) The distance between the trapezium and hamate hook (TH) was calculated, and the perpendicular distance (PD) was also calculated as lowered from the top of the transversal carpal ligament (TCL) in TH (Figure 2). The Bowin Ratio (BR) was calculated with PD/TH. Cross-sectional areas (CSA) were calculated at the level between the trapezium and hamate hook. When the TCL was considered as an arc, the center of a circle was calculated by PD and TH, and the radius (R) and central angle (θ) were also calculated. The length of arc (LTCL) was equal to R times θ (LTCL=Rθ). Results were expressed as a mean ± standard deviation (SD). One way- repeated analysis of variance with post-hoc Tukey comparisons were used to determine the influence of HET. All significance levels were set as α=0.05. This study was approved by our institutional review board (IRB).

Results: The rate of the cross sectional changing was 100% (beforeHET), 106%(during HET), and 102% (after HET), and the rate was significantly increased during HET (p<0.05). (Figure 3) In the before HET, the mean values of TH, PD, and BR were 21.03mm, 2.02mm, 0.096, respectively. (Table 1) In the during HET, the mean values of TH, PD, and BR altered to 22.1mm, 1.51mm, and 0.068, respectively. (Table 1) In the after HET, the mean values of TH, PD, and BR altered to 21.60mm, 1.66mm, and 0.076, respectively. (Table 1) The TH, PD, and BR were significantly increased during HET compared to before HET (P<0.05). (Figure 3)

Discussion: Our results demonstrated the significant increase in TH and decrease in PD and BR during HET. It has been known that the structure of the carpal tunnel had flexibility by manual procedure. It has been reported that the expansibility of the transversal carpal ligament was found from 0.9 to 2.9mm during HET(3). Therefore, the increased TH and deceased PD and BR during HET implied that the TCL might be expanded by the HET. Moreover, Berquist et al. described that the BR of the CTS patients was twice larger than that of the healthy subjects. (4) In our study, the BR was also decreased in the HET compared to pre and post HET, suggesting that the HET helps the carpal tunnel to function more normally.

Significance: The cross sectional area in the carpal tunnel was increased during the horizontal extension technique (HET), suggesting that the HET might affect the flexibility of the carpal tunnel structure. The HET might help the carpal tunnel to function more normally.
Acknowledgments: This study was funded by Shinoro Orthopedic Hospital and Sapporo Medical University.


Figure 1. Horizontal extension technique (HET). Before taking the MRI image, intraclass correlation coefficients (ICCs) were assessed for the intra-reliability of the pressure force during the HET. The force was measured by load cell during the HET. The pressure force was 40.2N±1.2 in right hand, and 40.3±1.5 in left. The ICCs of this procedure was 0.96.
Figure 2. Cross-section at the distal of carpal tunnel.

H: hamate, T:trapezium

TH: Distance between trapezium and hamate

PD: Perpendicular distance lowered from the top of the transversal carpal ligament in TH
<table>
<thead>
<tr>
<th></th>
<th>Before-HET</th>
<th>During-HET</th>
<th>After-HET</th>
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<tbody>
<tr>
<td>TH(mm)</td>
<td>21.20 (0.70)</td>
<td>22.20mm (0.81)</td>
<td>21.60mm (0.72)</td>
</tr>
<tr>
<td>PD(mm)</td>
<td>1.89 (0.50)</td>
<td>1.34mm (0.50)</td>
<td>1.66mm (0.50)</td>
</tr>
<tr>
<td>BR</td>
<td>0.088(0.022)</td>
<td>0.060(0.022)</td>
<td>0.076(0.023)</td>
</tr>
<tr>
<td>CSA(mm²)</td>
<td>193.8 (7.4)</td>
<td>205.7 (7.9)</td>
<td>198.9 (6.7)</td>
</tr>
<tr>
<td>LTCL(mm)</td>
<td>21.68(0.61)</td>
<td>22.45(0.73)</td>
<td>22.01(0.79)</td>
</tr>
</tbody>
</table>

TH: Distance between the trapezium and hamate hook
PD: Perpendicular distance as lowered from the top of the transversal carpal ligament in TH. BR: Bowing Ratio as PD/TH.
CSA: Cross-sectional areas
LTCL: Length of the transversal carpal ligament
HET: Horizontal extension technique
Figure 3. Statistically data of TH, PD, BR, and CSA between the before-HET, during-HET, and after-HET.

TH: Distance between the trapezium and hamate hook
PD: Perpendicular distance as lowered from the top of the transversal carpal ligament in TH.
BR: Bowing Ratio as PD/TH.
CSA: Cross-sectional areas
HET: Horizontal extension technique
LTCL: Length of the transversal carpal ligament

Figure 4. MRI image in pre-HET and in HET.