Introduction: Individuals with carpal tunnel syndrome (CTS) often complain about loss of manual dexterity, clumsiness and dropping of small objects. Changes in precision pinch posture were shown in subjects with artificial median nerve block [1] and in cervical myelopathy patients [2]. The purpose of this study was to investigate the effect of CTS on the precision pinch variability in individuals with mild to moderate symptom severity. We hypothesized that CTS subjects would show a higher variability of the precision pinch coordination compared to a control group.

Materials and Methods: Sixteen CTS and sixteen age- and gender-matched control subjects participated in this study. The inclusion criteria for the CTS group were: right handedness, right hand affected, a history of paresthesias and pain in the median nerve innervated territory, night awakening, positive provocative tests (Phalen and Hoffmann-Tinel), a positive finding in the electrodiagnostic examination with a distal motor latency of more than 4.6 ms and a sensory latency of more than 3.7 ms. The inclusion criteria for the control group were: right-handedness, gender- and age-matched CTS subjects within ±5 years and no previous history of musculoskeletal disorders in the upper extremity.

A marker-based motion analysis system (VICON 460, Oxford, UK) was used to capture digit motion. Fourteen spherical, light reflective markers (5 mm in diameter) were attached on the dorsal aspect of the hand (Figure 1). Two markers were placed on each phalangeal and metacarpal segment of the index finger and the thumb. A hand-based coordinate system was established. The subject was instructed to perform pinch movement to make contact of the tips as accurately as possible. The task consisted of 15 cycles of precision pinch motion between the index finger and the thumb with eyes closed. Each cycle began at the maximal opening digit posture, followed by the pinch closure at which the digit tips touched each other.

The pinch closure was determined as the moment when the distance between the tip markers of the thumb and index finger is minimal. To quantify the pinch performance, we calculated three variability measures at the pinch closure across 15 cycles. (1) Variability of tip positions: The standard deviation of the tip marker coordinates (X, Y, Z); (2) Variability of joint angles: the standard deviations of the joint angles, including the flexion/extension of the metacarpophalangeal (MCP), proximal interphalangeal (PIP), and distal interphalangeal (DIP) joints of the index finger, and the flexion/extension of the MCP and interphalangeal (IP) joints of the thumb. (3) Variability of the tip distance: the standard deviation of the distance between the tip markers of the thumb and index finger, i.e. tip-to-tip distance.

Results: The CTS subjects performed less consistently the precision pinch movement between the thumb and index finger compared to the control subjects (Figure 2). CTS subjects showed a larger variability of the tip positions at the pinch closure compared to the control subjects. More specifically, the difference in variability was axis-dependent. The variability of the thumb tip along the X-axis for the CTS subjects (4.9 ± 1.8 mm) was significantly higher than that for the control subjects (2.7 ± 0.8 mm) (p < 0.001). Likewise, the variability of the index finger tip along the X-axis for the CTS subjects (3.7 ± 1.5 mm) was significantly higher than that for the control subjects (2.2 ± 0.8 mm) (p < 0.01). However, the variability along the Y- or Z-axis was not significantly different between the two subject groups (p > 0.09). The CTS subjects showed a larger variability of the joint angles compared to the control subjects (p < 0.01). The variability along the X, Y, and Z-axes was 1.5 ± 0.7 mm for the CTS group and 1.0 ± 0.3 mm for the control subjects.

Discussion: We found that CTS subjects had a higher variability of the tip positions, individual joint angles and the tip-to-tip distance compared to gender- and age-matched control subjects. Therefore, we confirmed our hypothesis that CTS causes a degradation of the precision pinch performance. The increased variability may result from disturbed proprioceptive afferents and reduced motor function. The variability associated with the index finger may be explained by the impairment of the first lumbrical muscle. The first lumbrical muscle is endowed with a high number of muscle spindles and plays an important role in coordination of MCP joint flexion and IP joint extension. Higher variability of the tip distance for CTS subjects indicates that CTS impairs not only the function of individual joints or individual digits, but also the thumb-finger coordination. Increase of the variability of tip distance implies a lack of accurate thumb-finger opposition, thus disturbing subsequent grasping and handling of small objects with higher risk of slip and dropping. Our results can help to quantify clumsiness and reduced dexterity in mild to moderate CTS. Kinematic variability for repetitive movements may be a valuable measure to quantify hand dysfunction.