SCIENTIFIC ARTICLE

Measurement of Carpal Alignment Indices Using 3-Dimensional Computed Tomography

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Purpose This study aimed to establish normal values for wrist carpal alignment measured by 3-dimensional computed tomography (CT) and to show the inter- and intraobserver reliability of this measurement compared with simple radiography.

Methods The study utilized 3-dimensional CT and simple radiography of wrist joints in 30 asymptomatic volunteers. The wrist position was standardized using a custom-designed positioning device. Three independent observers measured carpal alignment parameters including distal radius articular angle, radiolunate angle, radioscaphoid angle, radiocapitate angle, radius-third metacarpal angle, scapholunate angle, lunocapitate angle, and lunate-third metacarpal angle.

Results Based on 3-dimensional CT measurement, the mean values of these parameters were: 12.9° ± 1.8° for the distal radius articular angle; 1.2° ± 3.8° for the radiolunate angle; 54.2° ± 5.6° for the radioscaphoid angle; 1.9° ± 2.2° for the radiocapitate angle; −1.0° ± 2.5° for the radius-third metacarpal angle; 52.9° ± 6.9° for the scapholunate angle; 0.7° ± 4.1° for the lunocapitate angle; −2.3° ± 4.6° for the lunate-third metacarpal angle. All parameters showed high inter- and intraobserver reliability in the 2 modalities.

Conclusions The normal values and ranges for carpal alignment angles were evaluated by using 3-dimensional CT. We could obtain high reliability in 3-dimensional CT as well as plain radiograph for the measurement of carpal alignment. *(J Hand Surg Am. 2018;■(■):1.e1-e7. Copyright © 2018 by the American Society for Surgery of the Hand. All rights reserved.)*

Type of study/level of evidence Diagnostic II.

Key words Carpal alignment, 3-dimensional computed tomography, wrist.

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CARPAL INSTABILITY IS THE consequence of biomechanical changes caused by many pathological conditions in the wrist, and it may appear as a form of carpal malalignment in imaging studies. This condition can gradually advance to carpal collapse if not treated.[1,2] Changes in the angle or displacements between carpal bones are usually evaluated with a simple radiograph. Frequently measured parameters include the radiolunate angle, the scapholunate angle, and the lunocapitate angle. However, some researchers have questioned the reliability of alignment measurement using simple radiographs because of inconsistent measurement methods.[3–5] Many studies have evaluated the methods used to make measurements on plain radiographs, in order to improve accuracy.[3,4,6,7] Lateral radiography cannot provide consistent images and it is difficult for an observer to identify reliable bony landmarks owing to overlapping of the carpal bones.[3] Wrist position also affects the spatial relationship between the proximal and the distal rows, making reproducible and reliable measurement difficult.[7] Computed tomography (CT) has been used by many researchers because of its high resolution. Because bony landmarks are easily identified, CT has been commonly utilized to evaluate humpback deformity or height-length ratio in cases of scaphoid fracture, with good reliability.[6,8,9] However, carpal alignment measurement, which usually requires lateral projection images of the wrist, is not easily performed using CT, and there are few reports on its application.

This study aimed to measure carpal alignment using 3-dimensional CT. For this purpose, we used a custom-made device to stabilize the wrist during acquisition of a 3-dimensional CT image in asymptomatic volunteers and processed the 3-dimensional image using a computer program to establish a consistent stereographic baseline in posteroanterior, lateral, and axial rotations. Computer-assisted removal of carpal bones unnecessary for analysis may enable accurate measurement by providing good visualization of a bony landmark, which might otherwise be hindered by overlapping. Through analysis of inter- and intraobserver reliability and comparison of the results with data from simple radiography, we also aimed to determine the reliability of 3-dimensional CT in evaluating carpal alignment compared with plain radiography.

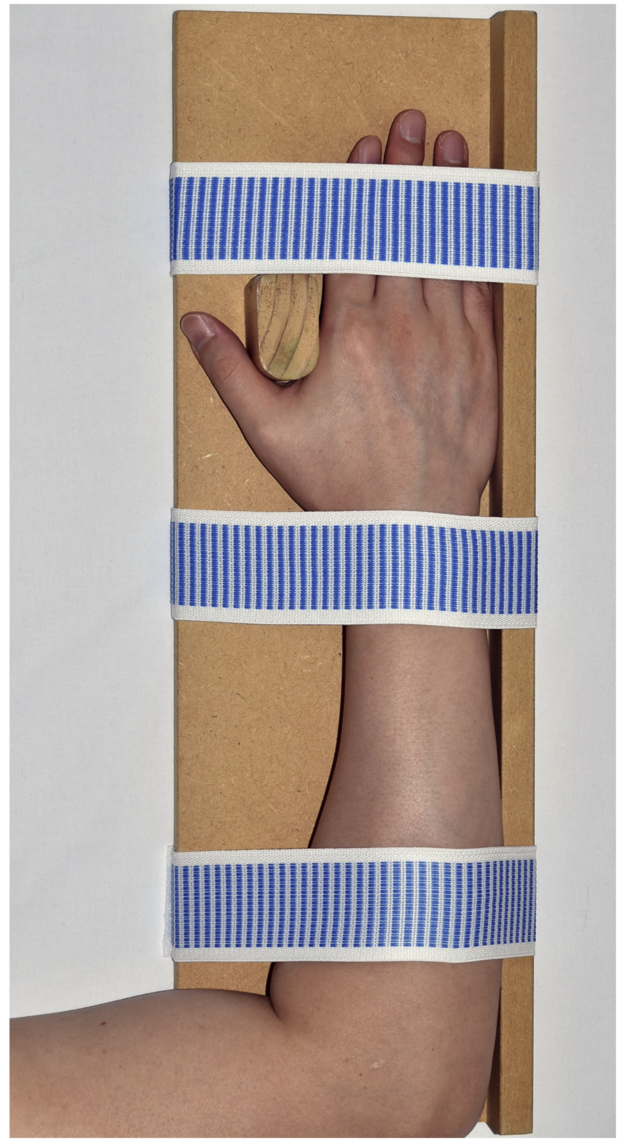

FIGURE 1: Stabilizing device.

MATERIALS AND METHODS

Image analysis including 3-dimensional CT (Lightspeed Ultra 16 computed tomography; GE Medical Systems, Chicago, IL) and simple lateral radiography was applied in 30 volunteers who had no symptoms in their hands, elbows, or wrists and who were considered normal on physical examination. The mean age of the volunteers was 36.2 years, with a range of 21 to 49 years. There were 22 men and 8 women. Volunteers were recruited by a public advertisement in our hospital. Our institutional review board approved this study.

To control the wrist and forearm position and standardize carpal alignment, each volunteer wore a stabilizing device[4,10] to keep the wrist in a zero position,[11] and underwent both lateral radiography and 3-dimensional CT (Fig. 1). Zero position was defined as the wrist in neutral with respect to flexion/extension, radial/ulnar deviation, and rotation (pronation/supination). A simple lateral radiograph was taken, with the patient lying prone and the shoulder abducted 90°, the elbow flexed 90°, and the palm facing down.

Three-dimensional CT scans were performed at 0.625-mm intervals, and 3-dimensional images were reconstructed to include the distal radius, the scaphoid, the lunate, the capitate, and the third metacarpal bone. Digital Imaging and Communications in Medicine was used for further analysis. Computer software programs for medical 3-dimensional imaging (Picture Archiving and