SCIENTIFIC ARTICLE

Estimating Scaphoid Lengths Using Anatomical Measurements in the Wrist

Paul W. L. ten Berg, MD,* Johannes G. G. Dobbe, PhD,† Geert Meermans, MD,‡
Simon D. Strackee, MD, PhD,* Frederik Verstreken, MD,§ Geert J. Streekstra, PhD†||

Purpose In reconstructive surgery of scaphoid nonunions with humpback deformity, some surgeons recommend restoration of the normal scaphoid length whereas others overexpand the normal length to ensure carpal realignment and prevent late collapse. To be able to define overexpansion and investigate which levels of overexpansion yield optimal clinical results, a precise method for estimating the original scaphoid length is required. The purpose of this anatomic study was to investigate the precision of estimating normal scaphoid lengths based on intact adjacent bone dimensions, compared with using the contralateral scaphoid length.

Methods From bilateral computed tomographic scans of 28 healthy wrist pairs, 3-dimensional virtual bone models were created. The left and right scaphoid lengths were determined at the central axis. The capitate length at the central axis and the distal radius width served to derive an ipsilateral scaphoid length estimate. Estimation precision for individual cases was based on the 95% range ($\pm 1.96 \times$ SD) of the observed differences between the actual and estimated lengths.

Results On average, the capitate length was 10% smaller than the scaphoid length; the radius width was 9% larger. Consequently, we averaged the capitate length and radius width for ipsilateral estimations. The average difference between the scaphoid length and the latter ipsilateral estimate was 0.1 mm. The average contralateral scaphoid length difference was also 0.1 mm. Estimation precisions, however, were ± 2.2 and ± 1.4 mm, respectively.

Conclusions Scaphoid length estimation based on the contralateral scaphoid is more precise than the estimating scaphoid length using the ipsilateral radius and capitate.

Clinical relevance Scaphoid overexpansion can be ensured if the restored length is at least 1.4 mm longer than the contralateral length. This may be valuable information when establishing a target length for reconstruction and investigating the consequences of scaphoid overexpansion on clinical function, such as range of motion, which are currently unknown. *(J Hand Surg Am. 2016;41(9):e279–e284. Copyright © 2016 by the American Society for Surgery of the Hand. All rights reserved.)*

Key words Scaphoid nonunion, scaphoid, nonunion, reconstruction, anatomy.

Online Only

*From the *Department of Plastic, Reconstructive, and Hand Surgery; the †Department of Biomedical Engineering and Physics; and the ||Department of Radiology, Academic Medical Center, University of Amsterdam, Amsterdam; the ‡Department of Orthopaedics, Lievensberg Hospital, Bergen Op Zoom, The Netherlands; and the §Department of Orthopaedics, Monica Hospital, Antwerp, Belgium.*

Received for publication October 30, 2015; accepted in revised form July 2, 2016.

P.W.B. received a PhD grant (2014) from the Academic Medical Center (Amsterdam, The Netherlands) supporting this research. The rest of the authors declare that they have no relevant conflicts.

Corresponding author: Paul W. L. ten Berg, MD, Department of Plastic, Reconstructive, and Hand Surgery, Academic Medical Center, University of Amsterdam, Room G4-226, Meibergdreef 9, 1105 AZ Amsterdam, The Netherlands; e-mail: paultenberg@hotmail.com.

0363-5023/16/4109-0015$36.00/0
http://dx.doi.org/10.1016/j.jhsa.2016.07.053

Nonunion is a serious complication of a scaphoid fracture.[1,2] An unstable scaphoid waist nonunion is associated with a flexion deformity—a so-called humpback deformity—and bone loss around the fracture site. The distal scaphoid fragment rotates volarly and the proximal fragment rotates dorsally with the lunate, resulting in a dorsal intercalated segment instability (DISI) deformity.

An open volar approach with wedge-shaped corticocancellous grafting is a common treatment option to reconstruct a scaphoid nonunion with a humpback deformity.[3] With this approach, often the focus is on correcting the carpal malalignment by realigning the dorsally tilted lunate to its neutral position by restoring the scaphoid length. Restoration of the scaphoid length reestablishes the strut function of the radial column of the carpus and tension to the palmar radiocarpal ligaments.[4] Tomaino et al[5] proposed transfixing the lunate to the radius in neutral position, opening the nonunion site, and inserting the graft, resulting in restoration of both the lunate alignment and scaphoid length.

To ensure restoration of carpal alignment and prevent late carpal collapse, the surgeon may use a nonanatomically sized graft to overexpand the normal scaphoid length—so-called overstuffing.[4] In this respect, Eggli et al[4] and Capito and Higgens[6] showed adequate correction of DISI deformity and preservation of carpal alignment after an overexpansion of 2 to 4 mm. An additional advantage of overstuffing is an increase in graft stability by optimizing ligamentous tension.[3,7] The consequences of overexpansion for clinical function, such as range of motion, or the development of local changes of osteoarthritis are not yet clear.[6] To be able to define overexpansion objectively and investigate which level of overexpansion yields optimal clinical results without impairing wrist motion, a precise method for estimating the original scaphoid length is required.

A standard approach to estimating normal scaphoid dimensions is to use the contralateral healthy scaphoid as reference. Although there seems to be a high level of bilateral shape symmetry in general,[8–11] there are still anatomic variations and individual left-to-right differences.[12–15] This may introduce uncertainty in estimating the normal scaphoid length and consequently defining scaphoid lengths associated with overexpansion for a given case. We hypothesized that estimating the scaphoid length using adjacent intact bone dimensions could be a useful alternative and might result in more precise estimations than when using the contralateral scaphoid. Therefore, the purpose of this anatomic study was to investigate the precision of scaphoid length estimations based on intact adjacent bone dimensions compared with using the contralateral scaphoid as a length estimator.

MATERIALS AND METHODS

Data acquisition

A total of 28 healthy volunteers participated in this study (14 women and 14 men; average age 26 years; range, 21–40 years), which is comparable to samples sizes of other previously published anatomic scaphoid studies.[10,11,16] The subjects had no history of wrist injury or other musculoskeletal disorders. A high-resolution computed tomography (CT) scan (Philips Brilliance 64 CT scanner, Amsterdam, The Netherlands) was made of both wrists of each individual using a standard wrist protocol. This study was approved by our Human Research Committee. Informed consent of each individual was obtained before participation.

Anatomic measurements

Measurements in 3-dimensional virtual models of the ipsilateral capitate length, ipsilateral distal radius width, and contralateral scaphoid length served as estimators for normal scaphoid length. The capitate and distal radii were chosen because of their close morphologic relations with the scaphoid.[17–19] First, 3-dimensional surface models were obtained from the scaphoid, capitate, and distal radius by image segmentation, using custom software.[20] In total, 168 bone models were derived (3 bones $\times$ 2 wrists $\times$ 28 volunteers). Next, for each scaphoid and capitate model the central length was quantified in an automated fashion. This length, which was defined by the best-fitting line through all the points describing the 3-dimensional model, is referred to as the central axis (Fig. 1).[21] Regarding the distal radius measurements, the coronal width was quantified based on the distance between the tip of the radial styloid[22] and a point halfway across the ulnar aspect of the lunate fossa, from dorsal to volar[23] (Fig. 1). To this end, the tip of the radial styloid and the ulnar aspect were manually selected. Measurements were performed in commercially available 3-dimensional architecture software (Rhinoceros, version 5.0; McNeel North America, Seattle, WA).

Statistical analyses

Statistical analyses of the measurements included the Shapiro–Wilks W test as a measure of normality, and determining the mean and SD for normally distributed data. First, the ipsilateral radius width and the ipsilateral