

# Double trapezia sign

## A new radiologic sign of scaphoid nonunion

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### Abstract

In scaphoid nonunion, pseudarthrosis and sclerotic change occur at the nonunion site. These changes make a distal fragment look like a trapezium on plain radiographs and we called this phenomenon the double trapezia sign. The purpose of this study was to estimate the diagnostic reliability of the double trapezia sign and its clinical and prognostic implications for the scaphoid nonunion.

A retrospective review of 124 patients who underwent surgical treatment because of scaphoid nonunion between January 2007 and December 2017 was performed. Two hand surgeons and 1 musculoskeletal radiologist reviewed preoperative plain radiographs independently. Each observer evaluated the plain radiographs in 2 separate sessions at least 3 weeks apart to assess intraobserver and interobserver reliabilities of the double trapezia sign. To assess clinical and prognostic implications of the double trapezia sign, the patients were divided into the positive and nonpositive groups, and several variables such as age, sex, duration of nonunion, size of the distal fragment, avascular necrosis (AVN) of the proximal fragment, type of bone graft, healing time, and failure rate were compared between the 2 groups.

The kappa values of intraobserver and interobserver reliabilities were  $>0.8$ , corresponding to almost perfect agreement. There were 58 patients in the positive group and 66 patients in the nonpositive group. The mean duration of nonunion was 38.5 months in the positive group and 12.2 months in the nonpositive group ( $P < .001$ ). The size of distal fragment was 49.6% and 60.9%, respectively ( $P < .001$ ). The AVN of proximal fragment was 24.1% and 54.5%, respectively ( $P = .001$ ). The mean healing time was 4.1 and 6.4 months, respectively ( $P < .001$ ). The failure rate was 13.8% and 27.3%, respectively ( $P = .066$ ).

In conclusion, the double trapezia sign is a valuable radiographic sign of scaphoid nonunion. The double trapezia sign is easily identifiable on plain radiographs and has excellent intra- and interobserver reliabilities. The positive double trapezia sign implies mid-waist nonunion, long duration of nonunion, less possibility of AVN, and favorable postoperative prognosis.

**Abbreviations:** AVN = avascular necrosis, CT = computed tomography, MRI = magnetic resonance imaging, PA = posteroanterior.

**Keywords:** avascular necrosis, double trapezia sign, nonunion, radiographic sign, scaphoid

### 1. Introduction

Scaphoid fracture is the most common carpal fracture, accounting for 60% of fractures in the carpus.<sup>[1]</sup> However, scaphoid

fracture is frequently missed on initial plain radiographs.<sup>[2,3]</sup> When scaphoid fracture is not detected early, heavy biomechanical loading and precarious blood supply usually cause nonunion.<sup>[4-7]</sup> Scaphoid nonunion has a predictable outcome.<sup>[1,8]</sup> The distal scaphoid fragment moves with the distal carpal row and the proximal scaphoid fragment moves together with the lunate. Bone resorption at the fracture site caused by abnormal movement leads to collapse of the scaphoid into flexion, and the lunate becomes extended through the extension force transmitted to the lunate through the lunotriquetral ligament. The consequence of continuous bone resorption and abnormal movement are the humpback deformity of the scaphoid and dorsal intercalated segmental instability deformity of the proximal carpal row. However, these pathologic deformities are frequently unapparent. Moreover, the diagnosis of the scaphoid nonunion itself is not always straightforward as well. The information about the scaphoid nonunion provided by plain radiographs is usually limited. Although several measurement parameters such as scaphoid length, intrascaphoid angle, radiolunate angle, scapholunate angle, and revised carpal height ratio were introduced to evaluate morphologic changes of the scaphoid and carpal alignment, they are annoying to measure and have no prognostic implication. For this reason, more advanced imaging modalities such as computed tomography (CT) and magnetic resonance imaging (MRI) are preferred for detailed evaluation of the scaphoid nonunion.<sup>[9]</sup> However, CT and MRI are not always

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available because of patient and hospital factors. If a distinctive and informative radiographic sign of the scaphoid nonunion exists, it will be helpful for the diagnosis and treatment of the scaphoid nonunion even without the aid of CT or MRI. With a considerable experience of the scaphoid nonunion, our senior author (S-WS) found a noticeable radiographic sign of the scaphoid nonunion, so-called the double trapezia sign. The double trapezia sign refers morphological similarity of a distal scaphoid nonunion fragment to the ipsilateral trapezium. When the double trapezia sign is positive, it looks like there are 2 trapeziums on the wrist posteroanterior (PA) view or scaphoid view plain radiograph (Fig. 1).

The purpose of this study was to estimate the diagnostic reliability of the double trapezia sign and its clinical and prognostic implications for the scaphoid nonunion.

## 2. Materials and methods

### 2.1. Patients and data processing

After approval by the Institutional Review Board (SC18RESI0003), we retrospectively reviewed our electronic medical records and identified 131 patients who underwent

surgical treatment because of scaphoid nonunion between January 2007 and December 2017. The preoperative evaluation included plain radiographs, CT, MRI, and bone scan. The plain radiographs consisted of a wrist PA view, lateral view, scaphoid view, and ulnar deviation view. The CT, MRI, or bone scan was undertaken when the plain radiographs were inconclusive or when avascular necrosis (AVN) of the proximal nonunion fragment was suspected. Nonunion was defined as a persistent fracture gap without any evidence of healing process at least 3 months after the initial trauma.<sup>[10]</sup> The inclusion criterion was a scaphoid nonunion with postoperative follow-up of minimum 1 year. The exclusion criteria were inadequate documentation or imaging, accompanying other pathologic lesions of the involved wrist, previous surgical treatment for the scaphoid nonunion, and any systemic illness that might have an influence on musculoskeletal system. After excluding 5 patients with previous surgery for the scaphoid nonunion and 2 patients with accompanying scapholunate dissociation, 124 patients were enrolled in this study.

Two board-certified attending hand surgeons and 1 board-certified attending musculoskeletal radiologist reviewed preoperative plain radiographs independently. They evaluated presence of the double trapezia sign and size of the distal nonunion



**Figure 1.** Wrist posteroanterior view (A) and scaphoid view (B) plain radiographs showing the positive double trapezia sign. The distal nonunion fragment resembles the trapezium that articulates with the distal nonunion fragment. On the contrary, the double trapezia sign is negative on another wrist posteroanterior view (C) plain radiograph.

fragment. All evaluations were performed using a PACS software (Maroview version 5.4.10.68; Infinitt Healthcare, Seoul, Republic of Korea). The double trapezia sign was regarded as positive when the distal nonunion fragment resembled the ipsilateral trapezium in shape and size on the wrist PA view or scaphoid view plain radiograph (Fig. 1). The lengths of the proximal and distal nonunion fragments were measured on the wrist PA view plain radiograph. They were defined as the distance from the tip of the proximal pole to the center of the distal surface and the distance from the center of the proximal surface to the center of the scaphotrapezium joint, respectively (Fig. 2). The size of the distal nonunion fragment was expressed as a percentage of the length of the distal nonunion fragment. Before evaluation, all observers were provided with a set of written description and figures similar to Figures 1 and 2 explaining the evaluation methods. Each observer evaluated the plain radiographs in 2 separate sessions at least 3 weeks apart to assess intraobserver and interobserver reliabilities of the double trapezia sign. For the size of the distal nonunion fragment, an average value was calculated from all measurements of the 3 observers. The patient list was randomized at both sessions to minimize recall bias and the observers were not informed of the purpose of the study until after their evaluations were completed.

To assess clinical and prognostic implications of the double trapezia sign, the patients were divided into the positive and nonpositive groups, and several variables were compared between the 2 groups. A patient was assigned into the positive group only when all 3 observers classified the patient into the positive double trapezia sign unanimously. On the contrary, a patient was assigned into the nonpositive group when all observers classified the patient into the negative double trapezia sign or when 3 observers' decisions were divergent. The variables included age, sex, duration of nonunion, size of the distal

nonunion fragment, AVN of the proximal nonunion fragment, type of bone graft, time to union, and failure of union. The AVN of the proximal nonunion fragment was confirmed with preoperative MRI showing low signal intensity on T1-weighted image and intraoperative observation. A single surgeon (S-W) performed all the operations. The choice of the surgical procedure was at the surgeon's discretion but vascularized bone graft was more preferred when AVN of the proximal nonunion fragment was confirmed. All patients followed same postoperative care program. Finger motion was encouraged immediately after surgery, and wrist motion was permitted after 8-week cast immobilization. Patients were routinely evaluated in clinic at postoperative 2 weeks, 4 weeks, and then approximately every 4 weeks, as needed until union was confirmed. Union was defined as bridging trabeculae consolidating majority of the nonunion gap on at least 2 different plain radiographs accompanied by the absence of adverse features such as a gap at the graft interface, a shift in the graft, or loosening of the internal fixation.<sup>[11]</sup> Failure to union was defined as a failure to reach 50% bony bridging by postoperative 1 year.<sup>[12]</sup>

## 2.2. Statistical analysis

Continuous variables were expressed as the mean and range, and categorical variables were summarized by the number of patients and percentages. Intraobserver and interobserver reliabilities of the double trapezia sign were determined with use of the multirater kappa measure described by Siegel and Castellan.<sup>[13]</sup> The generated kappa values were interpreted according the guidelines of Landis and Koch.<sup>[14]</sup> A value of 0.01 to 0.20 indicates slight agreement; 0.21 to 0.40, fair agreement; 0.41 to 0.60, moderate agreement; 0.61 to 0.80, substantial agreement; and 0.81 to 0.99, almost perfect agreement. Zero indicates no agreement beyond that expected because of chance alone; -1.00, total disagreement; and +1.00, perfect agreement.<sup>[14]</sup> Comparison of the positive and nonpositive groups was made using the independent *t* test for continuous variables and the chi-square test for categorical variables. A *P* value <.05 was considered statistically significant. SPSS version 21.0 for Windows (SPSS Inc, Chicago, IL) was used for statistical analyses.

## 3. Results

A total of 124 patients were available for this study. There were 26 female and 98 male patients with an average age of 38.5 years (range, 18–58 years). The double trapezia sign was regarded as positive unanimously by 3 observers in 58 patients. The sign was regarded as negative unanimously in 54 patients. On the contrary, 3 observers' decisions were discordant in 12 patients. The kappa values of intraobserver and interobserver reliabilities are summarized in Table 1. The kappa values of intraobserver reliabilities of 3 observers were 0.95, 0.92, and 0.95, respectively. The kappa values of interobserver reliabilities of 2 sessions were 0.83 and 0.86, respectively. According to the guidelines of Landis and Koch,<sup>[14]</sup> the intraobserver and interobserver reliabilities of the double trapezia sign were very high, corresponding to almost perfect agreement.

The patients were divided into the positive and nonpositive groups. Descriptive statistics and comparison of 2 groups are presented in Table 2. In the positive group, there were 9 female and 49 male patients with a mean age of 44.0 years (range, 31–58 years). The mean time interval between initial trauma and



**Figure 2.** On the wrist posteroanterior view plain radiograph, “a” is the length of the distal fragment and “b” is the length of the proximal fragment. The size of the distal fragment is expressed as a percentage of the length of the distal fragment:  $\frac{a}{a+b} \times 100$ .

**Table 1**  
**Intraobserver and interobserver reliabilities of the double trapezia sign.**

	Kappa value (95% CI)
Intraobserver reliability	
Surgeon 1	0.95 (0.93–0.98)
Surgeon 2	0.92 (0.87–0.95)
Radiologist	0.95 (0.93–0.98)
Interobserver reliability	
Session 1	0.83 (0.72–0.95)
Session 2	0.86 (0.75–0.94)

CI = confidence interval.

surgical treatment was 38.5 months (range, 5–242 months). The mean size of the distal nonunion fragments was 49.6% (range, 41.2–60.1%) indicating that most of nonunions occurred at the mid-waist portion of the scaphoid. The AVN of the proximal nonunion fragment was confirmed in 14 patients (24.1%) and they underwent vascularized bone graft. The mean time required for bony union was 4.1 months (range, 3–7 months) and bony union was not achieved in 8 patients (13.8%). In the nonpositive group, there were 17 female and 49 male patients with a mean age of 33.7 years (range, 18–58 years). The mean duration of nonunion was 12.2 months (range, 3–48 months). The mean size of the distal nonunion fragments was 60.9% (range, 34.5%–82.7%) suggesting that many nonunions were located proximally. More than half of the patients (54.5%) accompanied AVN of the proximal nonunion fragment and 32 patients (48.9%) underwent vascularized bone graft. The mean healing time was 6.4 months (range, 4–10 months) and 18 patients (27.3%) failed to gain bony union.

In the nonpositive group, compared with the positive group, patients were younger (44.0 vs 33.7 years,  $P < .001$ ) and the mean duration of nonunion was shorter (38.5 vs 12.2 months,  $P < .001$ ). However, the size of the distal nonunion fragment was bigger (49.6% vs 60.9%,  $P < .001$ ) and more patients accompanied the AVN of the proximal nonunion fragment (24.1% vs 54.5%,  $P = .001$ ). Although more patients undertook vascularized bone graft (24.1% vs 48.9%,  $P = .005$ ), longer time was taken for bony union (4.1 vs 6.4 months,  $P < .001$ ). Moreover, even though there was no statistical significance, the failure rate was almost twice that of the positive group (13.8% vs 27.3%,  $P = .066$ ).

#### 4. Discussion

Our study was designed to compare the positive and nonpositive groups to validate clinical and prognostic implications of the double trapezia sign. Our study revealed that the positive and nonpositive groups were quite dissimilar in many aspects. In the positive group, the location of nonunion was the mid-waist portion, and more than 3 years had passed before the nonunion was found. It seems that many patients had been asymptomatic for a relatively long time. Meanwhile, the AVN of the proximal nonunion fragment was uncommon and the postoperative prognosis was relatively favorable. It took about 4 months on average for bony union and the failure rate was 13.8%. On the contrary, in the nonpositive group, the nonunion site was more proximally located. Although nonunion was diagnosed earlier, more than half of the patients accompanied the AVN of the proximal nonunion fragment and the postoperative prognosis was poor. Even though vascularized bone graft was performed more frequently, the mean time required for bony union was 6.4 months and the failure rate was 27.3%. Considering such definite differences between the 2 groups, the double trapezia sign is not a simple radiographic finding. Rather, it is a pathognomonic sign representing a certain subgroup of scaphoid nonunions. When the double trapezia sign is positive on the plain radiographs, it implies that there is a scaphoid nonunion at the mid-waist portion with low possibility of AVN and in addition, it predicts that postoperative prognosis will be relatively favorable.

The incidence of scaphoid fractures is second to distal radius fractures among fractures involving the wrist.<sup>[2]</sup> Despite its high incidence, unique anatomical geometry and various fracture patterns make it difficult to diagnose scaphoid fracture in the early phase. Up to 40% of acute scaphoid fractures are radiographically occult, even when radiographs are optimally performed and reviewed by a skilled interpreter.<sup>[9]</sup> Furthermore, many people do not feel the need for a medical advice in the acute stage and miss the chance of proper diagnosis. Therefore, a remarkable number of patients visit a hospital after symptomatic scaphoid nonunion develops. From subtle change of intramedullary density with intact outer cartilaginous surface to advanced periscaphoid arthritis with irreversible carpal malalignment, symptomatic scaphoid nonunions represent a wide spectrum of anatomical and radiographic features. Plain radiographs have traditionally been the starting point for imaging evaluation of the hand and wrist.<sup>[9]</sup> However, plain radiographs are of limited value in evaluating scaphoid nonunion because the projection of

**Table 2**  
**Demographic features and clinical characteristics of the positive and nonpositive groups.**

Variables	Positive group (N = 58)	Non-positive group (N = 66)	P
Age, yr (range)	44.0 (31–58)	33.7 (18–58)	<.001
Sex (F:M)	1: 5.4	1: 2.9	.162
Female (%)	9 (15.5%)	17 (25.8%)	
Male (%)	49 (84.5%)	49 (74.2%)	
Duration of nonunion, mo (range)	38.5 (5–242)	12.2 (3–48)	<.001
Size of distal fragment, % (range)	49.6 (41.2–60.1)	60.9 (34.5–82.7)	<.001
AVN of proximal fragment (%)	14 (24.1%)	36 (54.5%)	.001
Type of bone graft (V:N)	1: 3.1	1: 1.1	.005
Vascularized (%)	14 (24.1%)	32 (48.9%)	
Nonvascularized (%)	44 (75.9%)	34 (51.1%)	
Time to union, mo (range)	4.1 (3–7)	6.4 (4–10)	<.001
Failure of union (%)	8 (13.8%)	18 (27.3%)	.066

AVN = avascular necrosis.

overlapping bones hampers obtaining good visualization of the scaphoid morphology. As a result, CT and MRI are frequently selected as supplementary diagnostic tools for accurate diagnosis and preoperative planning. The high degree of resolution and multiplanar capability of CT makes it an ideal modality for preoperative evaluation of bony architecture.<sup>[9]</sup> In addition, 3D-CT-based imaging techniques which has gained greater popularity over the past decade, provide very detailed morphological information.<sup>[15]</sup> On the contrary, MRI has increased accuracy for identifying other accompanying pathologic conditions of the involved wrist and detecting AVN of nonunion fragments.<sup>[16]</sup> Despite such superiorities, however, the execution of MRI or CT largely depends on local availability and patient's economic capacity. Therefore, every effort should be made to get as much information as possible from plain radiographs. In this regard, an easily recognizable unique radiographic sign that has an acceptable consistency for a specific pathologic condition must be a very useful tool for selection of proper surgical treatment and prediction of treatment outcome. About 60% to 80% of scaphoid fractures occur at the waist portion.<sup>[17]</sup> If a scaphoid waist fracture fails to unite, continuous motion between fracture fragments gives rise to pseudarthrosis at the fracture site and fracture surfaces become sclerotic as time goes by.<sup>[18,19]</sup> These changes make a distal nonunion fragment look like a trapezium. The double trapezia sign is positive when a distal nonunion fragment resembles the ipsilateral trapezium on the wrist PA view or scaphoid view plain radiograph. The judgment of the double trapezia sign is intuitive and need not troublesome measurement or comparison. Although the double trapezia sign seems to be somewhat subjective, we investigated intraobserver and interobserver reliabilities of the double trapezia sign with 3 experienced observers and demonstrated excellent reliabilities. As mentioned earlier, the double trapezia sign represents a long-lasting scaphoid nonunion at the mid-waist portion with low possibility of AVN. It also has a prognostic implication for a favorable postoperative outcome. Therefore, we think that the double trapezia sign is a valuable radiographic sign. It provides diagnostic and prognostic information even without the aid of CT or MRI.

Undoubtedly, there are several limitations in the current study. First, this was a retrospective study at the single institution and the number of enrolled patients was relatively small. So, there is a possibility of selection bias. Second, the demographic features of the 2 groups were different with a statistical significance. These differences may have affected the results. Third, surgical techniques were not standardized. This might also have affected our result. However, all surgical procedures were performed by a single experienced surgeon (S-WS) with limited changes of surgical techniques. Fourth, this study did not evaluate functional outcomes. Therefore, our study cannot conclude whether there was any difference in functional outcomes between the 2 groups. Fifth, regression analysis was not performed in this study. Although the positive double trapezia sign was related to favorable prognosis, prognostic implications of the double trapezia sign was not confirmed by regression analysis. Considering above mentioned several limitations, caution is required in interpreting our findings.

## 5. Conclusion

In conclusion, the double trapezia sign is a valuable radiographic sign of the scaphoid nonunion. The double trapezia sign is easily identifiable on plain radiographs and has excellent intraobserver and interobserver reliabilities. The positive double trapezia sign

implies a long-lasting mid-waist scaphoid nonunion, less possibility of AVN of the proximal nonunion fragment, and favorable postoperative prognosis.

## Author contributions

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