Acta Orthop. Belg., 2015, **81**, 36-40

ORIGINAL STUDY

Association between the capitate-triquetrum distance and carpal collapse in scaphoid nonunion

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The effect of the lunate type on carpal collapse in cases of scaphoid nonunion has not been thoroughly investigated. The purpose of the present study was to determine whether any association exists or not between the capitate-triquetrum distance and occurrence of carpal collapse in cases of scaphoid nonunion. In a retrospective study, 76 patients with scaphoid nonunion formed two groups based on the capitate-triquetrum distance ; forty-three patients with distance of less than 5 mm and 33 patients with distance of 5 mm or more. The two groups were comparable with respect to sex distribution, age, dominant hand involvement, manual labor, nonunion location and time from injury to final x-rays. Six patients (13.9%) in the capitate-triquetrum < 5 mm group and 13 patients (39.4%) in the capitate-triquetrum ≥ 5 mm group had no signs of collapse, with significant difference ($p < 0.05$). Capitate-triquetrum distance could contribute in the decision making process for cases of scaphoid nonunion without straightforward indication for surgical intervention.

Keywords : Lunate type ; scaphoid nonunion ; SNAC wrist.

INTRODUCTION

The minimum distance between the capitate and triquetrum (C-T distance) on a postero-anterior plain radiograph with the wrist in neutral deviation determines lunate type. Type 1 lunate has a single distal facet articulating with the capitate only, while type 2 lunate has also a second, smaller, medial facet articulating with the hamate. C-T distance of 2 mm or less is indicative of type 1 lunate whereas C-T distance of 4 mm or more is indicative of type 2 lunate. Intermediate values cannot reliably determine lunate type (*5*). Lunate type has been associated with dorsal intercalated segment instability (DISI) pattern in cases of scaphoid nonunion (*6*) and scapholunate instability (*14*). In this retrospective study we attempted to categorize patients according to the direct measurement of C-T distance, rather than strictly determine lunate type, and to evaluate the occurrence of signs of carpal collapse in cases of scaphoid nonunion, such as DISI pattern and stages of scaphoid nonunion advanced collapse (SNAC).

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No benefits or funds were received in support of this study. The authors report no conflict of interests.
The study was carried out at the Department of Orthopaedics, Agios Pavlos General Hospital, Thessaloniki, Greece.

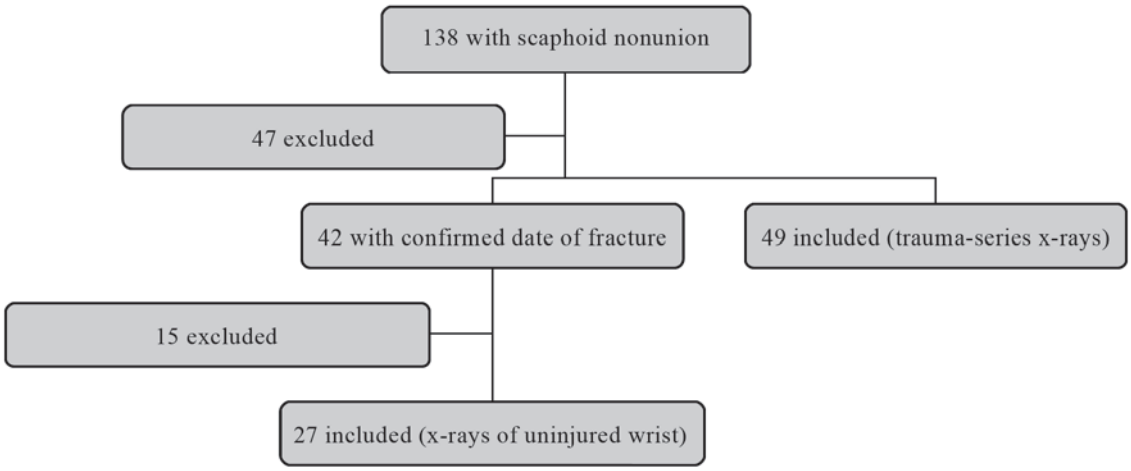

Fig. 1. — Study flow chart

Our purpose was to determine whether any association exists or not between the C-T distance and carpal collapse in cases of scaphoid nonunion.

MATERIALS AND METHODS

From May 1995 to May 2012 we treated 138 patients with scaphoid nonunion. We retrospectively evaluated their plain radiographs and included in the study 49 patients with available trauma series radiographs or MRI revealing the fracture of the scaphoid. We confirmed the date when acute scaphoid fracture had been diagnosed for another 42 patients, based on the old medical records of our or referring hospitals' emergency departments. From these 42 patients, we included 27 patients with available radiographs of the uninjured wrist, in order to assess the C-T distance. Finally, the study population was 76 (49+27) patients. The flow chart of our study population is presented in Figure 1.

An orthopaedic hand surgeon, who had not been involved in treatment, conducted the radiological assessment while blinded to the purpose of the study. He measured the C-T distance on the trauma series x-rays of 49 patients and on the x-rays of the uninjured wrist of 27 patients. A digital caliper (Absolute Digimatic Caliper, Mitutoyo America Corporation, Aurora, IL) was used in order to precisely measure that distance on a postero-anterior plain radiograph with the wrist in neutral. We did not take into account the possible magnification because the focus film distance has been traditionally set at 100cm for all wrist x-rays. The observer also assessed the initial and final x-rays for signs of carpal collapse, considering the preoperative radiographs as the final x-rays. The method of evaluating the various stages of carpal collapse in scaphoid nonunion is presented in table I.

Two study groups were formed based on the C-T distance measurement ; group I (43 patients) with C-T distance of less than 5 mm and group II (33 patients) with C-T distance of 5 mm or more. We chose 5 mm as the cut-off value because it has been suggested in the literature that the biomechanical behavior of the wrist alters significantly as the medial facet of the lunate exceeds 5 mm in width (*20*). We compared the two groups in regard with age, sex, dominant hand involvement, manual labor, nonunion location and time from injury to final x-rays. Finally, we attempted to identify whether any significant difference exists between the two groups or not in regard with the occurrence of carpal collapse.

Statistical analysis was performed with SPSS for Windows (version 13, SPSS, Chicago, IL), with use of the Student's t-test, the Fisher's exact test and the chi-squared test. Significance was defined as $p < 0.05$.

RESULTS

The two groups were comparable with respect to sex distribution, age, dominant hand involvement, manual labor and nonunion location. The mean time from injury to final x-rays was 41.7 months (SD = 33.4) for the C-T < 5 mm group and 38.2 months (SD = 24.7) for the C-T ≥ 5 mm group, with no significant difference between the two groups ($p = 0.40$, student's t-test) (Table II). No patient was found

Table I. — Stages of carpal collapse in scaphoid nonunion (in increased severity)

Stages of carpal collapse	Definition
DISI without arthritis	Capitolunate angle > 15°
SNAC I	Radiostyloid – scaphoid arthritis
SNAC II	+ Scapho – capitate arthritis
SNAC III	+ Capito – lunate arthritis

DISI: Dorsal Intercalated Segment Instability, SNAC: Scaphoid Nonunion Advanced Collapse.

Table II. – Characteristics of the two groups

	C-T < 5 mm	C-T ≥ 5 mm	p value
Patients	43	33	
Mean age (years) ± SD	28,3 ± 6.9	31.2 ± 9.1	p = 0.23
Sex (M/F)	38/5	29/4	p = 0.94
Dominant hand involvement (YES/NO)	29/14	18/15	p = 0.25
Manual labor (YES/NO)	35/8	27/6	p = 0.96
Nonunion location (Waist/Proximal pole)	36/7	28/5	p = 0.89
Time from injury to final x-rays (months ± SD)	41.7 ± 33.4	38.2 ± 24.7	p = 0.40

with physiologically elevated capitolunate angle (> 15º) or any other form of carpal collapse on the initial images (trauma x-ray series or x-rays of the uninjured wrist).

Six patients (13.9%) in the C-T < 5 mm group and 13 patients (39.4%) in the C-T ≥ 5 mm group had no signs of carpal collapse on the final x-rays, with significant difference (p = 0.011, CI = 95%, chi-squared test) (Table III). The radiographs of the remaining patients of each group revealed various stages of carpal collapse with no significant difference between the two groups in regard with the severity of the collapse (p = 0.845, Fisher's exact test) (Table IV, Fig. 2).

DISCUSSION

Many cadaveric studies have documented the existence of two types of lunate in normal wrists. Type 1 lunate has a single distal facet articulating with the capitate, while type 2 lunate has a second, smaller, medial facet articulating with the hamate. The prevalence of each type ranges from 35 to 55% for type 1 and from 45 to 65% for type 2 (*1,17*). The width of the medial facet varies between 1-6 mm (*17*). The minimum distance between the capitate and triquetrum on a postero-anterior plain radiograph with the wrist in neutral deviation determines lunate type (*5*).

The clinical implications of this anatomic variance have been described in the literature. Increased frequency of lunato-hamate impingement (*16*), scapho-trapezium-trapezoid arthrosis (*11*), Kienböck's disease (*12*), chondromalacia of proximal hamate and lunato-hamate arthrosis (*13*) have been attributed to lunate type 2. Moreover, lunate type seems to affect biomechanical behavior of normal wrist. Lunate type 1 frequently coexists with scaphoid type 1 which exhibits a rotational moment around its longitudinal axis and a gliding movement along scaphoid fossa during radial deviation. In contrast, lunate type 2 frequently coexists with scaphoid type 2 which exhibits a rotational moment around its transverse axis and a flexed posture during radial deviation (*19*). This kinematical model has resulted in recognition of two distinct normal wrist patterns, the row wrist pattern (lunate type 1-scaphoid type 1) and the column wrist pattern (lunate type 2-scaphoid type 2). However, a normal wrist could exhibit a biomechanical behavior that is placed between the two extremes (*2,5*).

Natural history studies of scaphoid nonunion have noted that radiographic evidence of wrist

Table III. — Prevalence of carpal collapse in the two groups

	C-T < 5mm	C-T ≥ 5mm	Total
No collapse	6	13	19
Collapse	37	20	57
Total	43	33	76

p = 0.011, chi-squared test.

Table IV. — Prevalence of various stages of carpal collapse in the two groups

	C-T < 5 mm	C-T ≥ 5 mm	Total
DISI without arthritis	21	9	30
SNAC I	10	7	17
SNAC II	2	1	3
SNAC III	4	3	7
Total	37	20	57

p = 0.845, Fisher's exact test.

arthritis occurs in almost 100% of symptomatic patients 5-20 years after the onset of the scaphoid nonunion (*9,10,15*). Although pain and arthritis occur frequently enough for most to recommend surgical intervention, neither pain nor arthritis is the inevitable result of scaphoid nonunion (*3*). Moreover, up to 50% of patients with radiologically abnormal joints may be clinically asymptomatic (*8*).

In 2007, Haase *et al* retrospectively evaluated the radiographs of 45 patients with established scaphoid nonunion. They found that 15 of 21 patients with type 1 lunate had DISI deformity compared to four of 24 patients with a type 2 lunate. They suggested that lunate type 2 is associated with significantly decreased incidence of DISI pattern in cases of established scaphoid nonunion (*6*). More recently, Rhee *et al* concluded that the same is true for scapholunate instability. These authors retrospectively reviewed 58 patients with scapholunate dissociation and found that ten of 25 patients with lunate type 1 had DISI deformity, whereas only five of 33 patients with lunate type 2 had the same deformity (*14*).

Surgery is the mainstay of treatment for most cases of symptomatic scaphoid nonunion. Many reports are encountered in the literature with good or excellent results achieved by various methods of surgical intervention (*4,21*). In younger symptomatic patients, surgical intervention is strongly recommended in order to prevent or at least delay the occurrence of carpal collapse (*10,15*). However, the decision about treatment plan is not so straightforward for mildly symptomatic middle-aged patients who are still able to perform their daily and occupational activities with minimal functional deficit (*3*). Surgery inevitably leads to temporary inability of patients to work which could mean even the loss of employment. The latter can have a significant impact on a patient's life, particularly in countries with an unstable economy. Moreover, there is no guarantee that surgical intervention would be absolutely successful. Any complication can lead to major disappointment as a previously mildly symptomatic wrist becomes severely symptomatic after surgery. For all these reasons, the decision to proceed with surgical treatment can be extremely difficult.

In this study we attempted to evaluate whether the measurement of C-T distance could reliably predict carpal collapse. Significant drawbacks of our study are that we have not correlated the radiographic findings with the clinical examination and that there is an inherent bias in selection of study population, as the majority of our patients had severe enough symptoms to seek medical advice. Another limitation of our study is the radiological assessment by only one observer. Nevertheless, our

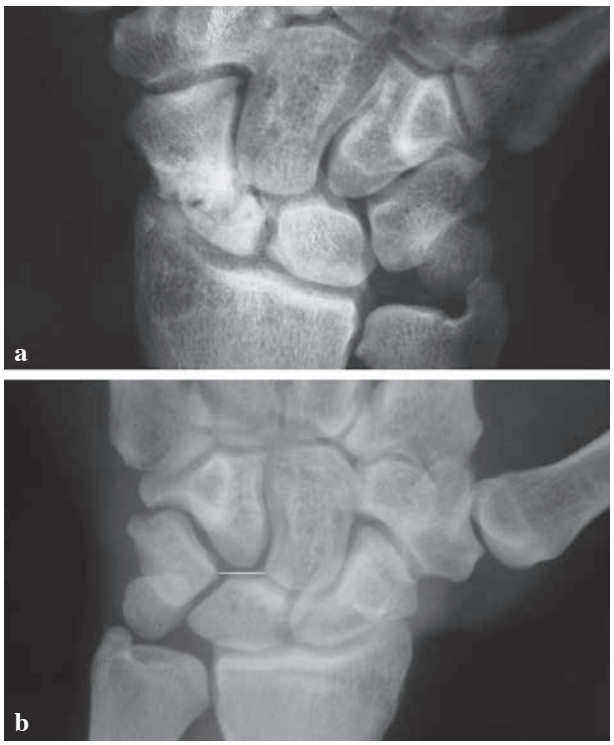

Fig. 2. — 35-year-old male patient. Scaphoid fracture 8.5 years ago. a) Radiostyloid-distal scaphoid arthritis (SNAC I) ; b) Minimum capitate-triquetrum distance of 7.8 mm (white line), measured on the x-ray of the uninjured wrist.

results suggest that C-T distance of 5 mm or more renders the wrist less vulnerable to collapse ($p < 0.05$). Once the collapse occurs, its progression to more severe stages is not influenced by the C-T distance ($p = 0.845$). We believe that our conclusions could contribute to the prediction of carpal collapse and the decision making regarding the treatment plan for patients without straightforward indication for surgical intervention.

REFERENCES

1. **Burgess RC.** Anatomic variations of the midcarpal joint. *J Hand Surg [Am]* 1990 ; 15 : 129-131.
2. **Craigen MA, Stanley JK.** Wrist kinematics. Row, column or both ? *J Hand Surg [Br]* 1995 ; 20 : 165-170.
3. **Düppe H, Johnell O, Lundborg G, Karlsson M, Redlund-Johnell I.** Long-term results of fracture of the scaphoid : a follow-up study of more than thirty years. *J Bone Joint Surg Am* 1994 ; 76 : 249-252.
4. **Fernandez DL.** A technique for anterior wedge-shaped grafts for scaphoid nonunions with carpal instability. *J Hand Surg [Am]* 1984 ; 9 : 733-737.
5. **Galley I, Bain GI, McLean JM.** Influence of lunate type on scaphoid kinematics. *J Hand Surg [Am]* 2007 ; 32 : 842-847.
6. **Haase SC, Berger RA, Shin AY.** Association between lunate morphology and carpal collapse patterns in scaphoid nonunions. *J Hand Surg [Am]* 2007 ; 32 : 1009-1012.
7. **Harrington RH, Lichtman DM, Brockmole DM.** Common pathways of degenerative arthritis of the wrist. *Hand Clin* 1987 ; 3 : 507-527.
8. **Kline NS.** Primer on the rheumatic diseases, IV. *JAMA* 1964 ; 190 : 741-751.
9. **Lindström G, Nyström A.** Natural history of scaphoid non-union, with special reference to "asymptomatic" cases. *J Hand Surg [Br]* 1992 ; 17 : 697-700.
10. **Mack GR, Bosse MJ, Gelberman RH, Yu E.** The natural history of scaphoid non-union. *J Bone Joint Surg Am* 1984 ; 66 : 504-509.
11. **McLean JM, Turner PC, Bain GI *et al.*** An association between lunate morphology and scaphoid-trapezium-trapezoid arthritis. *J Hand Surg Eur Vol* 2009 ; 34 : 778-782.
12. **Nakamura K, Beppu M, Matsushita K, Arai T, Ide T.** Biomechanical analysis of the stress force on midcarpal joint in Kienböck's disease. *Hand Surg* 1997 ; 2 : 101-115.
13. **Nakamura K, Patterson RM, Moritomo H, Viegas SF.** Type I versus type II lunates : Ligament anatomy and presence of arthrosis. *J Hand Surg [Am]* 2001 ; 26 : 428-436.
14. **Rhee PC, Moran SL, Shin AY.** Association between lunate morphology and carpal collapse in cases of scapholunate dissociation. *J Hand Surg [Am]* 2009 ; 34 : 1633-1639.
15. **Ruby LK, Stinson J, Belsky MR.** The natural history of scaphoid non-union : a review of fifty-five cases. *J Bone Joint Surg Am* 1985 ; 67 : 428-432.
16. **Thurston AJ, Stanley JK.** Hamato-lunate impingement : an uncommon cause of ulnar-sided wrist pain. *Arthroscopy* 2000 ; 16 : 540-544.
17. **Viegas SF, Wagner K, Patterson RM, Peterson P.** Medial (hamate) facet of the lunate. *J Hand Surg [Am]* 1990 ; 15 : 564-571.
18. **Watson HK, Weinzweig J, Zepperi J.** The natural progression of scaphoid instability. *Hand Clin* 1997 ; 13 : 39-49.
19. **Watts AC, McLean JM, Fogg Q, Bain GI.** *Scaphoid anatomy*. In : Slutsky DJ, Slade JF III (ed). *The Scaphoid*. Thieme Medical Publishers, New York, 2011, pp 3-10.
20. **Yazaki N, Burns ST, Morris RP *et al.*** Variations of capitate morphology in the wrist. *J Hand Surg [Am]* 2008 ; 33 : 660-666.
21. **Zaidemberg C, Siebert JW, Angrigiani C.** A new vascularized bone graft for scaphoid nonunion. *J Hand Surg [Am]* 1991 ; 16 : 474-478.