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Title	Does correction of carpal malalignment influence the union rate of scaphoid nonunion surgery?
Туре	Article
URL	https://clok.uclan.ac.uk/id/eprint/49843/
DOI	https://doi.org/10.1177/17531934231212979
Date	2023
Citation	McLaughlin, Kealan, Jabbar, Faizan A. A., Kelly, Luke J., Jovanovic, Iva, Gray, Matthew P., Charalambous, Charalambos P. and Harrison, John W. K. (2023) Does correction of carpal malalignment influence the union rate of scaphoid nonunion surgery? Journal of Hand Surgery (European Volume). ISSN 1753- 1934
Creators	McLaughlin, Kealan, Jabbar, Faizan A. A., Kelly, Luke J., Jovanovic, Iva, Gray, Matthew P., Charalambous, Charalambos P. and Harrison, John W. K.

It is advisable to refer to the publisher's version if you intend to cite from the work. https://doi.org/10.1177/17531934231212979

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TITLE

- 2 Does Correction of Carpal Malalignment Influence the Union Rate of Scaphoid Nonunion
- 3 Surgery?

ABSTRACT

5	The aim of this retrospective study was to assess the relation between carpal malalignment
6	correction and radiological union rates in surgery for scaphoid nonunions. Fifty-nine
7	scaphoid waist fracture nonunions treated with open reduction and palmar tricortical
8	autograft were divided according to their pre- and post-surgery scapholunate (SL) and
9	radiolunate (RL) angles. We found that carpal malalignment failed to correct in 32 out of 59
10	cases (54.2%) despite meticulous surgical technique and placement of an appropriately
11	sized wedge-shaped graft. Forty-three fractures (72.9 %) united at a mean of 4.47 months
12	(range 3–11). Twenty-one of the 27 fractures with post-operative SL and RL angles within
13	the normal range united, whereas 22 of the 32 remaining fractures which failed to achieve
14	post-operative angles within the normal range went on to union. The post-operative SL and
15	RL angles were not related to union. Our findings suggest that in scaphoid fracture
16	nonunion surgery, carpal malalignment may not be corrected in a substantial proportion of
17	patients, but such correction may not be essential for bony union. Our findings also show
18	that there is no marked collapse of the scaphoid graft in the early post-operative period.
19	Level of evidence: IV.

INTRODUCTION

23	Scaphoid fractures are the most common fracture of the carpus with an estimated incidence
24	of 1.47 fractures per 100,000 person-years (Van Tassel et al., 2010). Between 60% and 69%
25	of fractures occur through the middle third of the scaphoid (Jørgsholm et al., 2020). The
26	overall risk of developing a scaphoid nonunion is between 2% and 5% (Jørgsholm et al.,
27	2020).

In scaphoid waist fractures, palmar angulation and shortening of the scaphoid may occur, 28 which is considered to be due to the action of opposing forces from the lunate and scapho-29 lunate ligaments (Berdia and Wolfe, 2001; Fisk, 1970). Consequently, the nonunited 30 31 scaphoid may be flexed (a 'humpback deformity') with an associated carpal malalignment 32 and a dorsal intercalated segment instability (DISI) deformity. Studies have suggested the DISI deformity may be a risk factor for nonunion and may also compromise clinical 33 34 outcomes. Hence, one of the surgical goals in the treatment of scaphoid nonunion is to correct any carpal malalignment, aiming to increase the likelihood of achieving bony union 35 36 and to improve clinical outcomes (Mack et al., 1984; Ruby and Leslie, 1987; Szabo and 37 Manske, 1988).

Biomechanical studies in cadaveric specimens have suggested that accurate correction of scaphoid angulation can result in restoration of normal carpal alignment and wrist movements (Burgess, 1987). In assessing carpal alignment, studies have suggested high interobserver reliability with measurement of the scapholunate (SL) and radiolunate (RL) angles. Surgeons measure these angles for preoperative planning to decide on factors such as surgical approach and the type of graft to be used, and intra-operatively to quantify the degree of deformity correction (Roh et al., 2014).

45 Several bone grafting techniques have been described to deal with a scaphoid nonunion 46 with a flexion deformity such as the Russe cancellous graft and anterior wedge-shaped 47 corticocancellous graft (Cooney et al., 1988; Fernandez, 1984; Russe, 1960). In addition to achieving a bony union, the graft aims to correct the scaphoid flexion deformity, and to 48 secondarily correct the kinetics of the proximal carpal row to restore normal carpal 49 alignment and height. A wedge-shaped tricortical bone graft inserted palmarly is a widely 50 used technique. Nonetheless, there is limited evidence on the ability of this technique to 51 52 correct carpal malalignment.

53 The aim of this study was to determine the ability of the palmar wedge-shaped cortico-54 cancellous graft to restore normal carpal indices and explore whether the correction of 55 carpal malalignment may influence the union rate of scaphoid nonunion surgery.

METHODS

57	This study was performed at a National Health Service (NHS) Trust in the United Kingdom
58	and had approval by the audit department of our institution (Ref. 1636). The study was
59	performed in line with the World Medical Association Declaration of Helsinki. As data
60	utilised were anonymous and part of routine clinical care, no specific consent was sought
61	from patients.
62	A consecutive series of 59 patients undergoing surgery for a scaphoid waist fracture
63	nonunion between 2011 and 2019 was studied. Patients with proximal pole nonunions were
64	excluded. All cases were treated by the most senior author using a palmar tricortical wedge
65	graft.
66	
67	Surgical technique
68	Under general anaesthetic and through a palmar approach to the scaphoid, the nonunion
69	site was confirmed using image intensifier. The nonunion was then excised back to bleeding
70	bone. The wrist was extended and supinated, and the nonunion site opened using a laminar
71	spreader. Measurement of the gap to allow an appropriately sized bone graft was then
72	made aiming to correct any scaphoid flexion deformity. A tricortical graft of the same
73	dimensions was harvested from the ipsilateral iliac crest and inserted into the scaphoid
74	defect. A cannulated headless compression screw (Acutrak 2, Acumed, Oregon, USA) was
75	inserted either through a distal entry point (where possible as this avoided a further dorsal
76	skin incision), or a proximal entry point (to allow a more central placement of the screw
77	along the axis of the scaphoid). In all cases, the patients had pre-operative radiographs and
78	had RL and SL angles calculated to assist in surgical planning. Intra-operatively, any change

to carpal alignment was assessed following fixation of the graft using image intensifierimages.

81

99

82 Radiological assessment

Prior to surgery, a scaphoid series of four radiographic images were performed to confirm 83 the nonunion, assess the degree of scaphoid flexion, the presence of scaphoid cysts, and the 84 85 size of the proximal pole bone fragment, to aid surgical planning. Forty-seven patients had a pre-surgery CT scan to confirm the nonunion if this was in doubt and to aid surgical 86 87 planning. Post-surgery scaphoid series radiographs were obtained at six weeks and three 88 months to assess for bony union. We defined bony union radiologically using the method of Dias (2001), with evidence of bridging callus, filling in of any lucency at nonunion site, and 89 no evidence of metalwork loosening. Nonunion was defined by persisting lucency, 90 91 displacement of bony fragments or loosening of metalwork. A CT scan was performed if 92 there was any doubt regarding bony union on plain radiographs at three months. Twenty-93 four out of 59 patients had a post-operative CT scan to confirm bony union. 94 The angles were measured retrospectively by two independent orthopaedic registrars 95 separate to the treating team. The SL and RL angles were measured from a true lateral view 96 of the wrist pre-operatively, intraoperatively using image intensifier, and postoperatively 97 from the final set of radiographs, usually at three months, using a standard technique (Roh 98 et al., 2014). For the SL angle, a line was firstly drawn intersecting the palmar aspects of the

100 line intersecting the palmar and dorsal prominence of the lunate (L). The angle produced

distal and proximal poles of the scaphoid (S). A second line was drawn perpendicular to a

101 between these two lines was measured as the SL angle (Figure 1). The RL angle was

measured between a line is firstly drawn along the longitudinal axis of the radius (R) and a
 second line drawn perpendicular to a line intersecting the palmar and dorsal prominence of
 the lunate (L). The measurements from the pre- and post-surgery radiographs were taken
 on two separate occasions, two months apart, by a different observer on each occasion.

106

107 Statistical analysis

108 Raw angle values were utilised for analysis. In addition, angle values were described as 109 within normal range (SL \leq 60° and RL \leq 15°) or outside normal range. Consistency in the raw value measurements (pre- and postoperative readings) obtained on the two separate 110 111 occasions was assessed using the intraclass correlation coefficient. Reproducibility of the 112 two measurements was also assessed according to whether the two measurements fell within the same range (normal versus higher than normal) using Cohen's kappa. There are 113 114 no absolute definitions of interpreting kappa but there are suggested guidelines by Altman. 115 These reproducibility calculations were performed in R (R Core Team, 2021; Team, 2021) using the irr package (Gamer et al., 2019). Each pair of angle measurements was averaged 116 117 for subsequent analyses. Consistency of a single set of intra-operative SL and RL readings on 118 57 of the 59 patients were compared to their post-operative counterparts by computing the correlation of the raw measurements. Two of the 59 patients had no lateral intraoperative 119 120 view available.

Cases were divided into two groups according to their pre- and post-surgery SL and RL
 angles and whether these angles were corrected to within normal range. Union rates were
 determined for each of these demographics. Union counts between these groups were

- 124 compared using logistic regression and a chi-squared test in R after adjusting for age and
- 125 smoking status. Statistical significance was established at the 5% level.

RESULTS

127	The SL and RL radiological angles on pre- and post-surgical fixation imaging of the 59
128	patients were analysed. High reproducibility of the radiological angles was seen with both
129	the intraclass correlation coefficient (pre-surgery SL: 0.86, <i>p</i> < 0.001; post-surgery SL 0.85, <i>p</i>
130	< 0.001; pre-surgery RL 0.94, <i>p</i> < 0.001; post-surgery RL 0.94, <i>p</i> < 0.001) and Cohen's kappa
131	(pre-surgery SL: 0.76, <i>p</i> < 0.001; post-surgery SL 0.79, <i>p</i> < 0.001; pre-surgery RL 0.82, <i>p</i> <
132	0.001; post-surgery RL 0.81, $p < 0.001$). Consistency of a single set of intra-operative SL and
133	RL readings on 57 of the patients were compared to the three month postoperative imaging
134	by computing the correlation of the raw measurements (SL 0.982 and RL 0.992). Two
135	patients were excluded as no lateral intensifier view was available. We also tabulated
136	whether both intra- and postoperative measurements fell within the same normal ranges:
137	the classifications were identical for RL but two patients had conflicting SL readings. As there
138	was little discrepancy in the intra- and post-operative measurements, we used the post-
139	operative readings for the statistical analyses as the images were of superior quality.
140	Mean follow up for the analysed cases was 4.47 months (range 3–11 months). The patient
141	demographics split by union and nonunion are shown in Table 1 .
142	Of the 59 patients, 43 achieved union (72.9%). Twenty-one of the 27 fractures which had
143	both post-operative SL and RL angles within the normal range achieved union, whereas 22
144	of the 32 remaining fractures which did not have post-operative angles within the normal
145	range achieved union.

To assess the relationship between SL and RL angles with union, we compared three nested logistic regression models via chi-squared tests. In model 1, we regressed union on age and a binary indicator for smoking status; model 2 expanded model 1 to include whether binary

indicators for pre-operative SL and RL angles were on their respective normal ranges; and 149 150 model 3 expanded model 2 to include binary indicators for post-operative SL and RL readings on their normal ranges. Hosmer-Lemeshow tests for goodness-of-fit of the logistic 151 regression models 1, 2 and 3 returned p-values of 0.48, 0.16 and 0.90 respectively. To assess 152 the utility of pre-operative normal ranges in predicting union in addition to age and smoking 153 status, we performed a χ^2 test comparing model 2 to model 1 and obtained a *p*-value of 154 0.4583. To assess the utility of post-operative normal readings in addition to the other 155 covariates, the *p*-value for the χ^2 test comparing model 3 to model 2 was 0.9813. Table 2 156 reports the analysis of deviance table and Table 3 reports confidence intervals for the 157 parameters in model 3. 158

Eight patients in this series had a secondary procedure. Seven patients who failed to unite went on to a partial (four corner) wrist fusion, and one patient who united had removal of the headless bone screw due to screw prominence.

DISCUSSION

163	In our series, 21 out of the 27 patients who had both postoperative SL and RL angles within
164	the normal range achieved union, whereas 22 of the 32 remaining patients who did not
165	have postoperative angles within the normal range achieved union. Union rates were similar
166	in the corrected and non-corrected groups. Although malalignment correction is not
167	achieved in a substantial proportion of cases in our study, we did not find significant
168	evidence to reject the hypothesis that such correction is essential for union.
169	In view of the anatomy of the scaphoid and the challenge of three-dimensional
170	interpretation on plain radiographs of the carpus, carpal alignment indices have been
171	developed to define scaphoid fracture deformity. Previous evaluation of the reliability and
172	validity of alignment measurements on plain radiographs showed that the SL and RL angles
173	had the highest interobserver reliability which was comparative to computer tomography-
174	assessed measurements. In view of this, these indices may be used in preoperative planning
175	and to quantify deformity correction. Using these parameters, we found that the use of a
176	palmar tricortical graft failed to correct carpal malalignment in 32 out of 59 of cases. This
177	occurred despite a meticulous surgical technique and placement of an appropriately sized
178	wedge-shaped corticocancellous graft. These findings suggest that correction of carpal
179	malalignment may not be achieved simply by correcting the scaphoid flexion deformity. This
180	may be due to other factors including chronic shortening of extrinsic carpal ligaments.
181	The aim to correct the SL and RL angles is largely based on previous studies showing an
182	association between the development of a scaphoid nonunion and carpal instability
183	(Linscheid et al., 1972; Mack et al., 1984). Earlier studies suggested by using the Russe
184	technique with an anterior inlay bone grafting technique and K-wire fixation, the carpal

malalignment could be improved, and this increased the chance of achieving a scaphoid
union (Cooney et al., 1980). The present use of corticocancellous wedge-shaped grafts is
thought to allow a more precise correction of any scaphoid flexion deformity (Capito and
Higgins, 2013; Cooney et al., 1988; Fernandez, 1984; Watanabe, 2011).

189 Our results are in accord with previous reports which also demonstrated the challenges of 190 anterior wedge-shaped corticocancellous grafts in correcting carpal malalignment. A palmar corticocancellous graft may not correct the deformity if undersized (Capito and Higgins, 191 192 2013). We aimed to place the largest possible palmar graft and used direct measurement of the defect after debridement of the nonunion to determine the correct graft size. Care was 193 taken to avoid the use of an oversized graft as it may lead to 'overstuffing' of the wrist joint 194 195 (Capito and Higgins, 2013). We used a meticulous technique and assessed the intracarpal 196 angles intraoperatively using image intensifier; however, we frequently noted the preoperative carpal malalignment had not corrected. It is thought even when an 197 198 appropriately sized graft is used and the deformity is initially corrected, subsequent graft resorption and collapse of the scaphoid construct may cause recurrence of the deformity 199 200 (Chacha, 1984). In our series, we compared the SL and RL angles measured intra-operatively and at three months post-operatively and found a high degree of correlation. This suggests 201 in our series there was no marked collapse of the scaphoid in the early post-operative 202 period to three months. 203

In a series of eight patients with scaphoid malunion or nonunion, Nakamura et al. (1987)
applied an anterior wedge-shaped bone graft and internal fixation using a Herbert screw.
They noted an improvement in the RL and SL angles in all cases and all cases united.
However, in two cases the improvement of alignment indices was less than 10° and it was

208 thus concluded that this technique may not reliably correct carpal malalignment. In their 209 series of 6 patients, Tomaino et al. (2000) went further and stated that the commonly used 210 technique of palmar wedge grafting does not ensure restoration of neutral lunate 211 alignment. Hence, in their series, they intraoperatively flexed the wrist to reduce the extended lunate and correct any DISI deformity. The lunate was then temporarily held 212 213 reduced with a radiolunate K-wire while the scaphoid nonunion was excised and the bone 214 graft placed. This was a small series of patients but all patients healed with correction of RL 215 and SL angles. However, this modified technique may not be commonly used in routine 216 scaphoid nonunion surgery.

217 Previous studies suggest that deformity correction in scaphoid nonunion or in symptomatic malunion may restore normal kinetic forces across the wrist leading to improved clinical 218 219 outcomes with regards to pain and range of motion (Amadio et al., 1989; Capito and 220 Higgins, 2013; Tsuyuguchi et al., 1995) as well as a reduced rate of arthritis development. 221 Amadio et al. (1989) looked at scaphoid malunion in 46 patients. They defined a malunion as 222 a lateral intrascaphoid angle (LISA) of >36°. They showed that, at a mean follow up of 63 months, 54% of patients with >45° of LISA developed post traumatic arthritis compared to 223 224 22% of patients with normal indices. However, a clear relation between clinical outcomes 225 and restoration of radiocarpal indices has not been consistently shown by others. Inoue et al. (1997) presented a retrospective review of 160 cases of scaphoid nonunion, treated with 226 227 a compression screw and palmar bone graft technique. They concluded that the 228 contributing factors in association with failure to unite were avascular necrosis of the proximal fragment, fracture fragment instability, prolonged delay in surgery, and fracture 229 site location. They did not find any association of a residual scaphoid flexion deformity with 230 231 an unsatisfactory outcome in terms of pain, function, range of movement and grip strength.

Several other studies have also suggested no long-term sequelae including any increased
risk of arthritis in patients who heal with a malunion of the scaphoid (Forward et al., 2009;
Jiranek et al., 1992; Lee et al., 2015).

235 Limitations of our study include the retrospective assessment of our cases. Therefore, we had to use plain radiographs which are less accurate both for confirming bony union and for 236 237 measurement of intra-carpal angles to assess carpal alignment. A CT scan was only performed postoperatively when indicated if there was doubt regarding bony union. Bony 238 239 union was assessed by the treating team which may have introduced bias, but we note all 240 postoperative imaging was subsequently reported by a consultant radiologist. Forty-seven patients had a pre-surgery CT and 24 had a post-surgery CT. We did assess the 241 reproducibility of the radiological angles in the results and found a high degree when 242 243 measured on three separate occasions. A further limitation is that this is a radiological study and does not refer to the clinical and functional outcomes. Studies have shown the clinical 244 245 outcome may be variable despite bony union even when carpal malalignment is corrected. 246 However, the aims of operative treatment are to achieve bony union and to correct any carpal malalignment, and this study focusses on the technical aspects of the operative 247 treatment, that is, the relation between carpal malalignment correction and union rates. 248

- 249 This study suggests that carpal malalignment correction is not achieved in a substantial
- 250 proportion of patients when using a palmar tricortical graft, but such correction is not
- 251 essential for union. More important may be excision of the nonunion site back to bleeding
- bone, insertion of an 'appropriately' sized structural bone graft, and internal fixation to
- achieve a stable bone-graft-bone construct.

254 REFERENCES 255 256 Amadio PC, Berquist TH, Smith DK, Ilstrup DM, Cooney WP, Linscheid RL. Scaphoid 257 malunion. J Hand Surg Am. 1989, 14: 679-87. Berdia S, Wolfe SW. Effects of scaphoid fractures on the biomechanics of the wrist. Hand 258 259 Clin. 2001, 17: 533-40, vii-viii. Burgess RC. The effect of a simulated scaphoid malunion on wrist motion. J Hand Surg Am. 260 261 1987, 12: 774-6. 262 Capito AE, Higgins JP. Scaphoid overstuffing: The effects of the dimensions of scaphoid reconstruction on scapholunate alignment. J Hand Surg Am. 2013, 38: 2419-25. 263 264 Chacha PB. Int Orthop. Vascularised pedicular bone grafts. 1984;8(2):117-38. Cooney WP, Dobyns JH, Linscheid RL. Fractures of the scaphoid: A rational approach to 265 management. Clin Orthop Relat Res. 1980: 90-7. 266 Cooney WP, Linscheid RL, Dobyns JH, Wood MB. Scaphoid nonunion: Role of anterior 267 268 interpositional bone grafts. J Hand Surg Am. 1988, 13: 635-50. Dias JJ. Definition of union after acute fracture and surgery for fracture nonunion of the 269 scaphoid. J Hand Surg Br. 2001, 26: 321-5. 270 271 Fernandez DL. A technique for anterior wedge-shaped grafts for scaphoid nonunions with 272 carpal instability. J Hand Surg Am. 1984, 9: 733-7. 273 Fisk GR. Carpal instability and the fractured scaphoid. Ann R Coll Surg Engl. 1970, 46: 63-76. Forward DP, Singh HP, Dawson S, Davis TR. The clinical outcome of scaphoid fracture 274 malunion at 1 year. J Hand Surg Eur Vol. 2009, 34: 40-6. 275 Gamer M, Lemon J, Fellows I, Singh P. Irr: various coefficients of interrater reliability and 276 277 agreement. In: 0.84.1 Edn. 2019.

- 278 Inoue G, Shionoya K, Kuwahata Y. Herbert screw fixation for scaphoid nonunions. An
- analysis of factors influencing outcome. Clin Orthop Relat Res. 1997: 99-106.

280 Jiranek WA, Ruby LK, Millender LB, Bankoff MS, Newberg AH. Long-term results after russe

- bone-grafting: The effect of malunion of the scaphoid. J Bone Joint Surg Am. 1992, 74: 1217-
- 282 28.
- Jørgsholm P, Ossowski D, Thomsen N, Björkman A. Epidemiology of scaphoid fractures and
- non-unions: A systematic review. Handchir Mikrochir Plast Chir. 2020, 52: 374-81.
- Lee CH, Lee KH, Lee BG, Kim DY, Choi WS. Clinical outcome of scaphoid malunion as a result
- of scaphoid fracture nonunion surgical treatment: A 5-year minimum follow-up study.
- 287 Orthop Traumatol Surg Res. 2015, 101: 359-63.
- Linscheid RL, Dobyns JH, Beabout JW, Bryan RS. Traumatic instability of the wrist. Diagnosis,
- classification, and pathomechanics. J Bone Joint Surg Am. 1972, 54: 1612-32.
- 290 Mack GR, Bosse MJ, Gelberman RH, Yu E. The natural history of scaphoid non-union. J Bone
- 291 Joint Surg Am. 1984, 66: 504-9.
- 292 Nakamura R, Hori M, Horii E, Miura T. Reduction of the scaphoid fracture with disi
- alignment. J Hand Surg Am. 1987, 12: 1000-5.
- 294 R Core Team. R: A language and environment for statistical computing. In: 2021.
- 295 Roh YH, Noh JH, Lee BK et al. Reliability and validity of carpal alignment measurements in
- evaluating deformities of scaphoid fractures. Arch Orthop Trauma Surg. 2014, 134: 887-93.
- 297 Ruby LK, Leslie BM. Wrist arthritis associated with scaphoid nonunion. Hand Clin. 1987, 3:
- 298 529-39.
- 299 Russe O. Fracture of the carpal navicular. Diagnosis, non-operative treatment, and operative

300 treatment. J Bone Joint Surg Am. 1960, 42-A: 759-68.

301 Szabo RM, Manske D. Displaced fractures of the scaphoid. Clin Orthop Relat Res. 1988: 30-8.

- Team RC. R: A language and environment for statistical computing. In: 2021.
- 303 Tomaino MM, King J, Pizillo M. Correction of lunate malalignment when bone grafting
- 304 scaphoid nonunion with humpback deformity: Rationale and results of a technique
- 305 revisited. J Hand Surg Am. 2000, 25: 322-9.
- 306 Tsuyuguchi Y, Murase T, Hidaka N, Ohno H, Kawai H. Anterior wedge-shaped bone graft for
- 307 old scaphoid fractures or non-unions. An analysis of relevant carpal alignment. J Hand Surg
- 308 Br. 1995, 20: 194-200.
- 309 Van Tassel DC, Owens BD, Wolf JM. Incidence estimates and demographics of scaphoid
- fracture in the u.S. Population. J Hand Surg Am. 2010, 35: 1242-5.
- 311 Watanabe K. Analysis of carpal malalignment caused by scaphoid nonunion and evaluation
- of corrective bone graft on carpal alignment. J Hand Surg Am. 2011, 36: 10-6.

314	FIGURE LEGENDS
315	Figure 1. (a) and (b)Pre-operative imaging including postero anterior and lateral views
316	showing scaphoid nonunion. (c) Scapholunate angle measured between a line drawn
317	intersecting the palmar aspects of the distal and proximal poles of the scaphoid (S) and a second line
318	drawn perpendicular to a line intersecting the palmar and dorsal prominence of the lunate (L). (d)
319	Radiolunate angle measured between a line drawn along the longitudinal axis of the radius (R) and a
320	second line drawn perpendicular to a line intersecting the palmar and dorsal prominence of the
321	lunate (L).