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ORIGINAL STUDY

Radiographic analysis of anatomical risk factors for Kienböck's disease

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The aim of this study was to identify possible anatomical risk factors for Kienböck's disease. We measured on a posteroanterior radiograph of the wrist, in zero-position, the Lunate Diameter and Height, Lunate Tilting Angle, Lunate Uncovering Index, Lunate Fossa Inclination, Radial Inclination and Ulnar Variance. We measured these seven parameters on the unaffected hand in the Kienböck group (N = 54) to avoid the influence of arthritic changes and on the dominant hand in a control group (N = 126). Statistical significant differences were found for a smaller Lunate Diameter and Height, a more radially inclined Lunate Tilting Angle and a flatter Radial Inclination (Student's t-test). This may result in more load transmission onto the lunate, which may lead to avascular necrosis.

INTRODUCTION

The aetiology of Kienböck's disease (*14*) remains unresolved. Since Hulten in 1928 found a correlation with negative ulnar variance, many articles were published on this subject (*3, 7, 9, 11, 13, 15, 16, 26, 27*). Despite the good clinical results achieved with radioulnar joint leveling procedures, there are doubts about the role of a negative ulnar variance in the pathogenesis of Kienböck' disease (*5, 6, 17, 24*). Other anatomical risk factors have been reported (*23,34*). The aim of this survey was to study several radiographic features previously associated with Kienböck's disease.

MATERIALS AND METHODS

The radiographs of the unaffected hand in 54 patients with Kienböck's disease were analysed. This diagnosis was based on typical radiographic findings or MRI. The contralateral hand was used to avoid the influence of arthritic changes : Tsuge and Nakamura (*34*) and Gelberman *et al* (*11*) found no difference between normal left and right wrists. The results were compared with a control group of 126 healthy subjects without a history of trauma or skeletal disease. In the patient group and in this control group the same seven parameters (see below) were measured. The intraobserver variability was studied by performing three measurements on each radiograph. The reproducibility was within 0.5 mm and 1°. A statistical analysis was done with Student's t-test. The level of significance was set at $p < 0.05$.

On standard posteroanterior radiographs in "zero-position" of the ulnar variance (*7*) in unloaded conditions with the shoulder abducted at 90°, the elbow flexed at 90° and the forearm on the X-ray table (*26*), the following parameters were measured.

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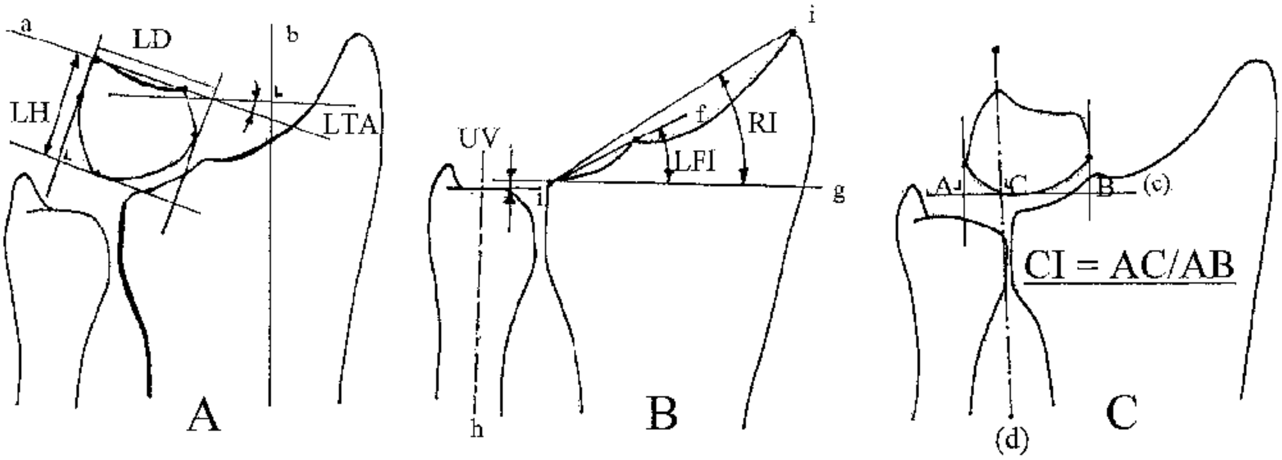

Fig. 1A. — Measurement of lunate diameter (LD) and height (LH) from the baseline of the lunate (a).
Measurement of the lunate tilting angle (LTA) which is the angle between a perpendicular line drawn to the base of the lunate (a) and the axis of the radius (c).
Fig. 1B. — Measurement of the ulnar variance (UV) which is the distance between the most distal part of the ulnar cortical rim and a line drawn from the ulnar side of the articular surface of the distal radius towards the ulna (*11*).
Measurement of the lunate fossa inclination (LFI) which is the angle between the sclerotic line of the lunate fossa of the radius (f) and a line perpendicular (g) to the long axis of the distal ulna (h).
Measurement of the radial inclination (RI) which is the angle between a line from the ulnar side of the carpal surface of the radius to the tip of the radial styloid (i) and a line perpendicular (j) to the axis of the ulna (h).
Fig. 1C. — Measurement of the lunate uncovering index (LCI) which is the index between the uncovered portion of the lunate (AC) on a line perpendicular (d) to the longitudinal axis of the radial side of the DRUJ (e) and the projection of the entire lunate on the same line (AB) (LCI = AC/AB).

– The *lunate diameter* (LD) and *height* (LH) (*34*) : The baseline of the lunate (a) runs from the ulnar tip of the distal facet to the radial tip of the facet (fig 1A). The LD and the LH are measured from this base line.
– *The lunate tilting angle* (*34*) : This is the angle between the perpendicular line drawn to the baseline of the lunate (a) and the axis of the radius (c) (fig 1A).
– *The lunate uncovering index* (*28*) : The index between the uncovered portion of the lunate (AC) on a line perpendicular (d) to the longitudinal axis of the radial side of the distal radioulnar joint DRUJ (e) and the projection of the entire lunate on the same line (AB) (fig 1C).
– *The lunate fossa inclination* (*22, 34*) : The angle between the sclerotic line of the lunate fossa of the radius (f) and a line perpendicular (g) to the long axis of the distal ulna (h) (fig 1B).
– *The radial inclination* : The angle between a line from the ulnar side of the carpal surface of the radius to the tip of the radial styloid (i) and a line perpendicular (j) to the axis of the ulna (h) (fig 1B).
– *The ulnar variance* : A line is drawn from the ulnar side of the articular surface of the distal radius towards the ulna. The variance is the distance between this line and the carpal surface of the ulna (*11*) (fig 1B).

RESULTS

The data are summarised in tables I and II.

There were no statistically significant differences in sex (p = 0.87) or age (p = 0.93) distribution between both groups (table I).

We found a significant difference for a smaller diameter (p = 0.0037) and height (p = 0.04) in the Kienböck group. There was also a flatter radial inclination (p = 0.018) and a more radially inclined lunate tilting angle (p = 0.0036). The lunate uncovering index (p = 0.086) and the lunate fossa inclination (p = 0.439) did not appear to be important factors. The ulnar variance in the Kienböck group compared to the control group was statistically not significant (p = 0,51) (table II), in other words there is no indication that shorter or longer ulnae would

Table I. — Demographic data

	Kienböck group	Control group
N	54	126
Males/Females	31/23	68/58
Mean age (Years)	35	36
Range (Years)	(17 to 58)	(17 to 69)

be seen more frequently in patients with Kienbock's disease compared to an age and sex matched non diseased population.

DISCUSSION

The origin of avascular necrosis of the lunate or Kienböck's disease is not yet elucidated. The vascularity of the lunate bone has been studied previously (*10, 18, 25*). However mechanical predispositions have been postulated by several authors.

Our results, with a smaller lunate diameter and height, a flatter radial inclination and a radially more inclined lunate tilting angle are similar to those reported by Tsuge and Nakamura (*34*). These findings support the overload theory. The lunate makes up part of the proximal row in the central column as described by Taleisnik (*32*). A smaller lunate will support a greater relative load placed on it. Following the studies of Frank (*8*) and Antuna Zapico (*1*) a lunate with a more radially inclined tilting angle is less able to resist axial loading because of its trabecular pattern. It is undergoing more shear stresses than simple compression stresses.

Mirabello *et al* (*23*) reported that a flat distal radius may predispose to Kienböck disease and that there is a correlation between the slope of the distal radial articular surface and the age of onset. We also found a flatter distal radius.

The last argument to support the overload theory would be the good clinical results of surgery changing the load on the lunate (*13, 20, 33*).

Since Hulten (*13*) described negative ulnar variance in Kienböck, this became the main point of discussion. Some authors followed this reasoning (*2, 11, 19, 21, 23, 30*), others opposed it (*3, 5, 6, 7, 9, 15, 16, 17, 24, 26, 27, 34*). First of all measuring ulnar variance needs a standard X-ray technique with standard positioning of the arm because ulnar variance changes with pronation and supination (*7, 15, 24, 29*). Secondly a standard technique of measurement is necessary. Several techniques have been described for measurement of ulnar variance (*11, 15, 26*), with comparable results (*31*). We used 'the project a line technique' of Gelberman *et al* (*11*). Thirdly Nakamura *et al* (*24*) found a significant difference between males and females and an increasing ulnar variance with advancing age. This was also observed by other authors (*4, 6, 9*), therefore a sex/age matched group was used.

So only when fullfilling all these criteria can one evaluate the importance of ulnar variance. No significant difference between the Kienböck and the control group was found. Negative ulnar variance does not appear to be a risk factor for Kienböck's disease (*5, 6, 9,16, 24*). Many studies suggesting such a correlation were not performed in standard conditions (*2, 11, 23*). A Kienböck has never been

Table II. — Results of measurements and statistical analysis

	Kienböck group Mean ± SD	Control group Mean ± SD	p
Lunate diameter (mm)	14.23 ± 1.02	15.43 ± 1.60	0.0037*
Lunate height (mm)	10.08 ± 1.20	11.50 ± 0.70	0.04*
Lunate tilting angle (°)	20.94 ± 4.6	17.68 ± 5.4	0.0036*
Radial inclination (°)	23.72 ± 4.3	25.42 ± 4.8	0.018*
Ulnar variance (mm)	-0.89 ± 0.9	-0.42 ± 1.4	0.51
Lunate fossa inclination (°)	13.81 ± 4.1	13.61 ± 4.4	0.88
Lunate uncovering index (%)	33.65 ± 10.5	39.32 ± 9.3	0.17

* $p < 0.05$ Statistical significance for Student's t-test.

described after a Darrach procedure. The good results of joint leveling procedures may be attributed to the altered pressure and force transmission rather than to the elimination of a risk factor (*5, 6, 12, 20, 33*). Maybe a greater negative ulnar variance is playing a role after the development of Kienböck with more collapse of the lunate if the ulnar compartment is giving less containment.

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