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Ulnar variance and the role of joint levelling procedure for Kienböck's disease

Abstract Forty patients with Kienböck's disease were reviewed to determine the relationship between ulnar variance and the development of Kienböck's disease in a Japanese cohort. The joint levelling procedures designed to correct ulnar variance were evaluated in 11 patients after a mean of 9.7 years following surgery. The mean ulnar variance was 0.50 ± 1.67 in patients with Kienböck's disease and 0.56 ± 1.76 in a control group. The onset of wrist symptoms in a younger age group was noticed after sports injuries, whereas older patients had no distinct history of trauma. Joint levelling procedures produced good clinical results, but carpal height ratio, Stahl's index and radioscaphoid angle were not improved, as evidenced radiographically. Our study suggests that in a Japanese cohort ulnar minus variance is not an important factor in the aetiology of Kienböck's disease. Although joint levelling procedures improved the clinical results, they did not reverse lunate collapse or carpal alignment.

Résumé Quarante malades présentant une maladie de Kienböck ont été examinés pour déterminer le rapport entre divergence ulnaire et le développement de cette maladie dans une cohorte japonaise. Les procédures de nivellement conçues pour corriger la divergence ulnaire ont été évaluées chez onze malades après un délai moyen de 9.7 années après la chirurgie. La divergence ulnaire moyenne était de 0.50 ± 1.67 chez les malades avec la maladie de Kienböck et de 0.56 ± 1.76 dans un groupe témoin. Le début des symptômes du poignet dans une plus jeune tranche d'âge a été remarqué après des accidents sportifs, alors que les malades plus agés n'avaient aucu-ne histoire distincte de traumatisme. Les procédures de remises à niveau ont produit de bons résultats cliniques, mais la proportion de la hauteur carpienne, l'index de Ståhl et l'angle radioscaphoidien n'étaient pas amélioré. Notre étude suggère, dans cette cohorte japonaise, que la divergence ulnaire discréte n'est pas un facteur important dans l'étiologie de la maladie de Kienböck. Bien que les procédures de mise à niveau aient amélioré les résultats cliniques, ils n'ont pas rendu réversible l'effondrement lunaire ni le mauvais alignement carpien.

Introduction

The aetiology of Kienböck's disease remains unclear, and the treatment ranges from conservative measures [8, 15] to surgical procedures such as joint levelling by radial shortening or ulnar lengthening [11, 14, 19]. Joint levelling procedures were introduced based on the work of Hulten in 1928 [10]. He reported that 17 of 23 Kienböck's patients had an ulnar shorter than the radius at the wrist by more than 1 mm. It was concluded that compression of the lunate by this anatomic "ulnar minus variant" predisposed to avascular necrosis of the lunate bone. Consequently, joint levelling procedures, designed to correct ulnar minus variant and to unload the lunate, have been reported to achieved good clinical results in the treatment of patients with Kienböck's disease [1].

It was not until recently that the importance of ulnar minus variance has been questioned by several authors [4, 7]. There was a racial difference in ulnar minus variance. Gelberman et al. [9] showed that Kienböck's disease is uncommon in black Americans whose normal ulnar variance (+0.70) is significantly more positive than in whites (+0.27). D'Hoore et al. [7] studied a European population by comparing individuals Kienböck's disease with age-matched control subjects and found no association between ulnar minus variance and Kienböck's disease. Chan et al. [4] reported a predominance of patients who had positive ulnar variance in the Chinese population. Nakamura et al. [12] reported the presence of the

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disease in Japanese patients who had positive ulnar variance. Initially these studies appeared to show complete disagreement with Hulten's theory.

In this study we evaluated the relationship between ulnar variance and the development of Kienböck's disease in the Japanese population and reviewed the causal factors of the disease. We have also presented the long-term clinical and radiological follow-up of patients after joint levelling procedures.

Materials and Methods

Between 1985 and 2002, 40 patients with Kienböck's disease were treated at Yamaguchi University Hospital and Ogori Daiichi General Hospital. There were 20 men and 20 women. Patients were diagnosed to have Kienböck's disease if radiographs showed sclerotic change and fragmentation of the lunate. The average age at the time the diagnosis was confirmed was 46.2 years with range from 18 to 72 years. All patients had unilateral disease. Twelve patients were treated conservatively and 28 underwent surgery, in which 11 received joint levelling procedures (nine radial shortenings and two ulnar lengthenings), nine with limited intercarpal fusion, excision of necrotic lunate and tendon ball replacement, three vascularized bone grafting and five with other salvage procedures.

The onset of wrist symptom was reviewed according to three different aged groups, young (18–30 years), middle aged (31–55) and old (older than 56).

Ulnar variance of the non-affected wrists (healthy side) was measured on standard anteroposterior radiographs at the time of diagnosis with use of the concentric ring method described by Palmer et al. [13]. Roentgenograms were taken with the shoulder abducted 90°, the elbow flexed 90° and the forearm in neutral position. Ulnar variance was measured in 100 control subjects in the same manner. The control group consisted of 50 women and 50 men with a median age of 47.0 (range, 22–76; SD, 16.0) years. They were randomly chosen from general clinic population and had no historical and radiographic evidence of previous injury and arthritis.

The outcome of joint levelling procedures was evaluated both clinically and radiographically. There were seven men and four women, and age at operation averaged 37 (range, 18–59) years. The mean follow-up time after operation was 9.7 (range 5–18) years. Radiographic staging was evaluated by Lichtman's method [11]. Two wrists were diagnosed in stage II, five in stage IIIa (normal radioscaphoid angle) and four in stage III (radioscaphoid angle >60 °). Radial shortening was performed with the dorsal approach. After removal of 2 mm of the radius, a T-plate was used for fixation. The functional outcome was evaluated at the final follow-up by the Mayo modified wrist score [6], which was calculated with pain (25 points), grip strength (25), active range of motion (25) and functional status (25). A radiographic analysis included Lichtman's staging (1977), carpal height ratio as seen on anteroposterior view and Ståhl's index, and radioscaphoid angle on lateral view. Statistical analysis was performed using the Student's t-test, and p-value less than 0.05 was taken to be a significant difference.

Results

The onset of symptoms in the affected wrist varied in the three groups (Table 1). In the young group, four of five patients had a history of sports injury or trauma. Two patients participated in soccer and one in baseball, and one had a traffic accident on a bicycle. In the middle-aged

Table 1 Onset of wrist symptom (n=27)

Onset of wrist symptom	Young (18–30 years)	Middle age (31–55)	Old (more than 56)
Sports injury	3	–	–
Trauma	1	3	–
Heavy labour	–	6	–
No distinct history	1	2	11

Table 2 Results of joint levelling procedure (n=11). NS not significant

Evaluation	Pre-operative	Post-operative	p value
Clinical			
Mayo wrist score	60.5±9.4	72.0±7.7	<0.05
Pain	15.2±1.1	20.0±1.8	NS
Active range of motion	8.2±1.6	15.2±2.7	p<0.01
Grip strength	11.8±4.1	14.9±2.0	p<0.01
Radiological			
Carpal height ratio	48.6±5.3	50.4±3.6	NS
Stahl's index	34.8±8.0	33.8±8.3	NS
Radioscaphoid angle	54.3±9.9	56.1±8.9	NS

group, three of 11 had a trauma history, six performed heavy manual with frequent use of the affected wrist and two had no specific history. In the old group, all nine patients had no distinct history of trauma.

Mean ulnar variance was 0.50±1.67 (range, +3 to −2) and 22% had ulnar minus variance in the Kienböck's disease group. There was no significant difference in age distribution and gender. The mean ulnar variance of 100 control wrists was 0.56±1.76 (range, +6 to −3) and 21% had ulnar minus variance. No significant difference was found between the two groups.

All eleven patients improved subjectively after joint levelling procedures. (Table 2) The mean score for pain and grip strength improved significantly from 15.2±1.1 and 8.2±1.6 pre-operatively to 20.0±1.8 and 15.2±2.7 (p<0.01) post-operatively. The score for active range of motion improve from 11.8±4.1 to 14.9±2.0 but was not significant. Six patients could return to their original full-time jobs without restrictions. The average Mayo modified score significantly improved from 60.5±9.4 pre-operatively to 72.0±7.7 post-operatively (p<0.05).

Radiological staging of the disease did not deteriorate in all of 11 patients at the final follow-up (Table 2). Carpal height ratio changed from 48.6±5.3° pre-operatively to 50.4±3.6° post-operatively, but it was not a significant improvement. Ståhl's index and radioscaphoid angle were also not significantly improved—from 34.8±8.0° to 33.8±8.3° and from 54.3±9.9° to 56.1±8.9°. New bone formation at the lunate fossa of the radius was observed in two patients (Fig. 1a and b).

Fig. 1a–b Five years follow-up of radial shortening in a 24-year-old man. **a** Pre-operative PA view showing Lichtman 3B of Kienböck's disease. **b** New bone formation observed at the lunate fossa of the radius

Discussion

Various algorithms have been proposed for the treatment of Kienböck's disease, usually based on the radiological staging system of Lichtman [11]. The salvage operations involving excision arthroplasty [11] or total fusion are required for patients with stage IV disease. Operative options for stage II–IIb are controversial and can be divided into two categories: decompression of the lunate, which involves joint levelling [14, 19], limited intercarpal fusion and capitate shortening; and the direct revascularization techniques to the necrotic lunate, which involves vascularized bone graft [16] and vascular bundle transfer [18].

Current literature suggests that the association between ulnar variance and Kienböck's disease appears to vary in different regions of the world. Bonzar et al. [3] and Chen et al. [5] confirmed a strong association between ulnar minus variance and Kienböck's disease after correction for the influence of age in both North American and Chinese populations. D'Hoore et al [7] suggested a negative association in European population. In our study, we have shown that the ulnar variance in the Kienböck's disease group was 0.50±1.67, which did not differ significantly from control wrists. Thus, ulnar minus variance may not be a causative factor for the disease in the Japanese population.

It was noteworthy that the onset of wrist symptoms varied with the age of the patient. It is possible that the onset of the symptom is caused by a lunate fracture with a single wrist injury in young patients and pathological stress fracture due to osteoporosis in old patients. In those who perform heavy manual work, the disease may be due to repetitive trauma and a combination of several other risk factors.

If ulnar minus variance was not a causal factor for Kienböck's disease, then operative realignment of the radius and ulna would be unwarranted. Many authors reported satisfactory long-term results following joint levelling procedures [1, 14, 19]. However, it is still unclear whether joint levelling can change the natural course of Kienböck's disease. In a supporting view of joint levelling procedure, Salmon et al. [15] presented that patients treated by radial shortening had better clinical outcome than those managed conservatively. Beckenbaugh et al. [2] and Tajima et al. [17], however, found little difference between the long-term results of patients managed conservatively and operatively. Fujisawa et al. [8] also suggested that Kienböck's disease has the capacity to heal spontaneously in the long run.

We believe that the ideal treatment for Kienböck's disease should be restoration of vascularity and morphology and the carpal relationship of the lunate. Our long-term results suggested that there was no evidence of further carpal collapse following joint levelling, but none of the parameters used to measure carpal collapses were reversed. The good subjective outcome of joint levelling procedures may be attributed to the alteration in pressure and force transmission across the necrotic lunate rather than to the elimination of a causal factor.

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