Acta Medica Okayama

Volume 49, *Issue* 6 1995 *Article* 4

DECEMBER 1995

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Abstract

This study was conducted to retrospectively analyzed the outcome of 192 total knee arthroplasties in 132 patients with rheumatoid arthritis (118 women, 14 men). The Okayama Mark II prosthesis, which requires the posterior cruciate ligament (PCL) to be resected, was used in 83 knees (group I), the Mark II prosthesis, which allows the PCL to be retained, was used in 68 knees (group II), and the new Okayama PCL-R prosthesis, which also allows the PCL to be retained, was used in 41 (group III). According to the Japanese Orthopaedic Association knee scoring system, the clinical outcome of groups I, II and III at 1 year after the operation were 64.9, 71.2 and 72.3 points, respectively, and the average flexion angles in each group at 1 year were 78.4, 92.6 and 101.3 degrees. Postoperative flexion in groups III was significantly greater than in groups I and II. These results suggest that postoperative flexion is greater when the posterior cruciate ligament is retained.

KEYWORDS: total knee arthroplasty, posterior cruciate ligament, PCL resection, PCL retention

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*PMID: 8770238 [PubMed - indexed for MEDLINE]

Acta Med Okayama 1995;49 (6): 295-300

Relationship Between Retention of the Posterior Cruciate Ligament and Postoperative Flexion in Total Knee Arthroplasty

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This study was conducted to retrospectively analyzed the outcome of 192 total knee arthroplasties in 132 patients with rheumatoid arthritis (118 women, 14 men). The Okayama Mark II prosthesis, which requires the posterior cruciate ligament (PCL) to be resected, was used in 83 knees (group I), the Mark II prosthesis, which allows the PCL to be retained, was used in 68 knees (group II), and the new Okayama PCL-R prosthesis, which also allows the PCL to be retained, was used in 41 (group III). According to the Japanese Orthopaedic Association knee scoring system, the clinical outcome of groups I, II and III at 1 year after the operation were 64.9, 71.2 and 72.3 points, respectively, and the average flexion angles in each group at 1 year were 78.4, 92.6 and 101.3 degrees. Postoperative flexion in groups III was significantly greater than in groups I and II. These results suggest that postoperative flexion is greater when the posterior cruciate ligament is retained.

key words: total knee arthroplasty, posterior cruciate ligament, PCL resection, PCL retention

In recent years, surface replacement types of prostheses have been widely used in total knee arthroplasty (TKA) in the treatment of patients with osteoarthritis (OA) and rheumatoid arthritis (RA). However, there are many issues which remain controversial including whether to use cemented or cementless prostheses, the best method for replacement of the patella, and whether or not to preserve the posterior cruciate ligament (PCL) (1, 2). Among these problems the role of PCL has long been debated.

We have previously reported that a sufficient angle of flexion might be achieved after PCL retention with the Okayama Mark II, even though the PCL was sacrificed in the original operative procedure (3). Therefore, in 1989, we changed the design of the Mark II to allow preservation of the PCL and also to achieve stronger fixation at the time of operation (Okayama PCL-R). The purpose of the present study was to compare the functional results of three groups: those in which the PCL was resected using the Okayama Mark II (group I), those in which the PCL was preserved using the same prosthesis (group II), and those in which the Okayama PCL-R prosthesis was used (group III).

Patients and Methods

A total of 192 knees of 132 patients with RA, including 175 knees of 118 women and 17 knees of 14 men were studied. All were patients admitted to our department between 1976 and 1992. The prostheses used were the Okayama Mark II and the Okayama PCL-R. The Okayama Mark II (Mizuho Co., Japan), a cementless press-fit type, has been used clinically since 1975 (4). The articular surface of the tibial plate made from ultra-high molecular weight polyethylene (UHMWPE) was concave in the Mark II type. In contrast, the Okayama PCL-R prosthesis has a tibial plate with a flat posterior part, to allow the greater knee flexion. Moreover, two stems with a wavy surface were made to fix the tibial plate firmly. To fix the femoral shell firmly, we developed a new design. The inner surface of the anterior and posterior walls had a wavy surface, as did the two stems (Fig. 1A, 1B). With the Mark II prosthesis, the procedure does not require bone cement, however, we have the option of using bone cement in cases of marked osteoporosis.

The 192 knees were divided into three groups:

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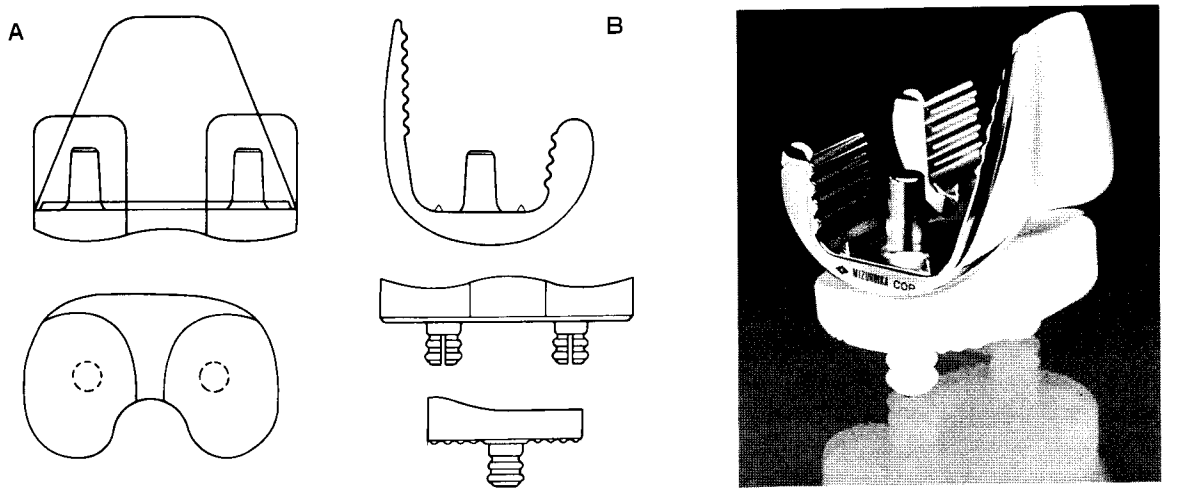

Fig. 1 Okayama posterior cruciate ligament (PCL)-R type. **A:** Design of Okayama PCL-R; **B:** Prosthesis of Okayama PCL-R.

Table 1 Patients studied

Group	No. of knees	Age at operation (years)	Duration from onset (years)
I	83	53.1 ± 11.1	18.9 ± 11.6
II	68	57.3 ± 12.3	16.0 ± 8.9
III	41	60.4 ± 9.3	16.4 ± 11.5

Group I: Okayama Mark II by PCL-resection,
Group II: Okayama Mark II by PCL-retention,
Group III: Okayama PCL-R (new PCL-retention type)

Okayama Mark II with PCL resection (group I, n = 83), Okayama Mark II with PCL retention (group II, n = 68) and Okayama PCL-R (group III, n = 41). The average age at operation was 53.1 years in group I, 57.3 years in group II and 60.4 years in group III, and the duration from onset per group was 18.9, 16.0 and 16.4 years, respectively (Table 1). In each group, we analyzed the clinical outcome and range of motion preoperatively, at discharge (about 1 month after operation) and at 1 year after the operation. The Japanese Orthopaedic Association (JOA) knee scoring system was used for the clinical evaluation (Table 2). Loosening was studied radiologically at 1 year after the operation.

Statistical analysis was performed using Student's t-test, and $P < 0.05$ was considered significant.

Results

The average clinical scores (Table 3 and Fig. 2) were recorded before surgery, at discharge and 1 year after the operation. The average clinical scores at discharge in each group had improved significantly compared with the preoperative scores ($P < 0.01$) from 29.3 points to 64.0 in group I, 30.7 to 66.2 in group II and 35.0 to 65.3 in group III. At 1 year after the operation, the scores of groups II and III were 71.2 and 72.3 points, respectively. They were significantly ($P < 0.01$) better than that of group I.

The average angle of extension and flexion is shown in Table 4. At discharge, the average angle of extension had improved markedly in all groups (Fig. 3), and the angle improved slightly more at 1 year after operation in group III. The flexion angles were 84.1° in group I, 91.2° in group II, 95.4° in group III at discharge. They were approximately 20° smaller than before the operation (Fig. 4). One year after the operation, the angle decreased

Table 2 Japanese Orthopaedic Association Knee Score (JOA score)

Pain (40 points)	
None	40
Frequent pain on motion	30
Persistent pain on motion	20
Pain restricts or prevents motion	10
Severe persistent pain	0
Range of motion (12 points)	
Ability to sit at Japanese style	12
Ability to sit sideways and cross legged or to flex to 110 degrees or more	9
Ability to flex to 75 degrees or more	6
Ability to flex to 35 degrees or more	3
Severe contracture when bending less than 35 degrees or ankylosis	0
Strength of quadriceps muscle (20 points)	
Manual muscle testing 5	20
Manual muscle testing 4 and 3	10
Manual muscle testing 2, 1 and 0	0
Ability to walk and its extent (20 points)	
No difficulty	20
Slight difficulty	10
Moderate limitation or inability to walk	0
Ascending and descending stairs (8 points)	
No difficulty	8
No limitation with use of handrails	6
Step by step ambulation	4
Step by step ambulation with handrails	2
Inability to ascend or descend	0
Total score (100 points)	

Table 3 Clinical knee score (JOA) of 3 groups

Group	Knee score (points)		
	Preoperation	At discharge	One year after op.
I	29.3 ± 8.5	64.0 ± 8.5	64.9 ± 12.0
II	30.7 ± 8.1	66.2 ± 8.1	71.2 ± 10.1
III	35.0 ± 10.5	65.3 ± 12.2	72.3 ± 11.5

Groups are the same as those in Table 1.

Table 4 Degrees of average flexion and extension

	Preoperation	At discharge	One year after op.
Extension			
Group			
I	−29.3 ± 21.7	−3.4 ± 5.7	−3.9 ± 6.7
II	−17.1 ± 15.6	−2.1 ± 4.1	−2.5 ± 4.7
III	−18.5 ± 15.7	−2.6 ± 4.7	−1.4 ± 4.0
Flexion			
Group			
I	103.8 ± 26.9	84.1 ± 17.4	78.4 ± 22.3
II	114.3 ± 18.4	91.2 ± 14.5	92.6 ± 15.5
III	114.6 ± 20.6	95.4 ± 8.5	101.3 ± 12.4

Groups are the same as those in Table 1.

slightly to 78.4° in group I, while increased to 92.6° and 101.3° in group II and III, respectively. A comparison of the flexion angles confirmed that group III showed a significantly ($P < 0.01$) larger angle than groups I and II at 1 year after the operation. Radiologically detectable loosening was not found in all groups at 1 year after the operation.

Discussion

The PCL, an important ligament for knee function, provides posterior stability and prevents posterior sagging. This ligament is essential for a feeling of stability during the ascent and descent of stairs.

The PCL was resected in the early techniques of TKA, including procedures like Freeman, the original Okayama Mark II (4) or Total Condylar types. Conversely, the PCL was preserved in the Kinematic posterior cruciate model and PCA types.

Some argue that resection of the PCL facilitates correction of deformity and better fixation (5) and the prosthesis itself provides anterior-posterior stability. Hirsch *et al.* (6) stated that preserving the PCL does not consistently lead to improved functional results. Becker *et al.* (7) described that no differences were found between the PCL-sacrificed and-retained groups.

However, the proponents of PCL preservation state that it enhances posterior stability, allows more flexion by femoral roll-back, and absorbs shearing forces which would otherwise be absorbed at the tibia plate-bone inter-

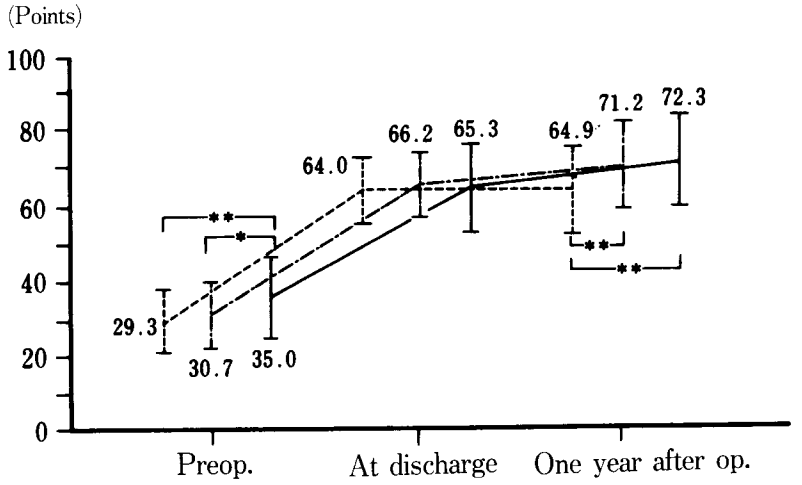

Fig. 2 Clinical knee score (JOA score), average points. The average clinical scores at discharge in each group had improved significantly compared with the preoperative scores. At one year after the operation, the scores of groups II and III were significantly ($P < 0.01$) better than that of group I. (------ GroupI, — · — · — GroupII, —— GroupIII, ** $P < 0.01$, * $P < 0.05$)

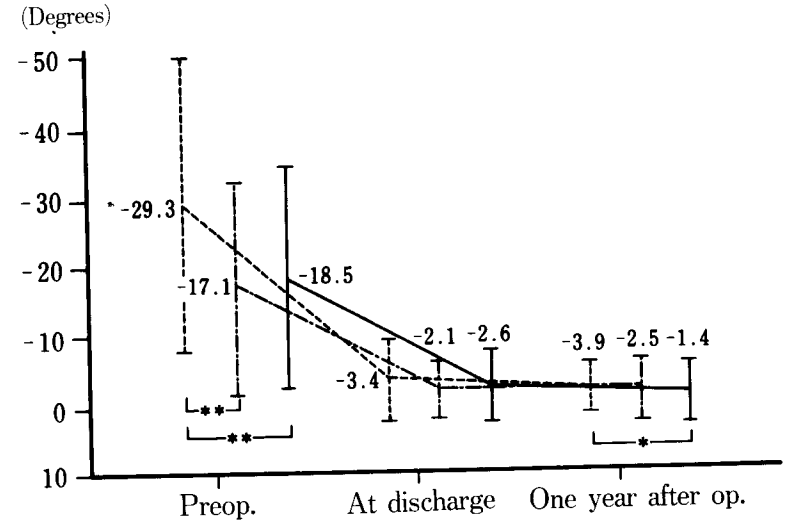

Fig. 3 Average degrees of extension. The average angle of extension at discharge had improved markedly in each group. (------ GroupI, — · — · — GroupII, —— GroupIII, ** $P < 0.01$, * $P < 0.05$)

face (8). Kurosawa (9) showed biomechanically that PCL resection significantly increases perpendicular shear stress and moments at the interosseous interface of the tibial component. It was emphasized that these factors are the main reasons for the loosening of the prosthesis. Yasuda and Sasaki (10) reported that, in tibia replacements with the PCL-retention type, transmitted load is observed over the whole area under the tibia plateau and posterior cortex, and the sum of moments is significantly smaller than that in the PCL-resection type. Thus, he concluded

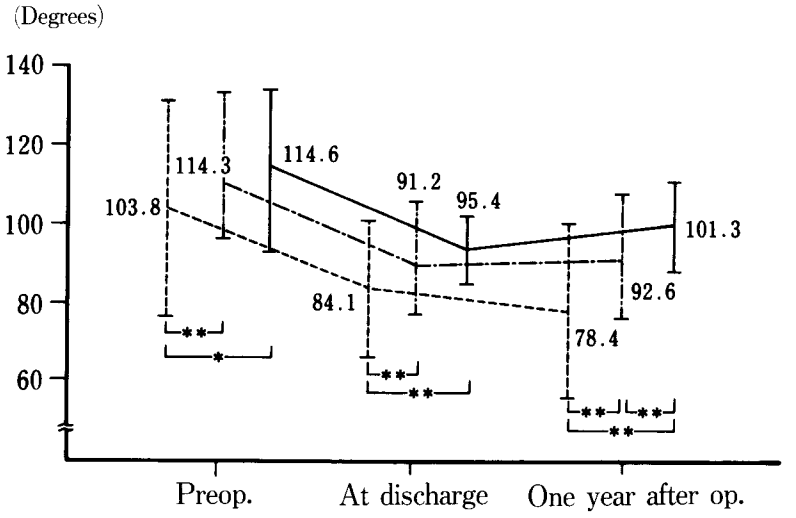

Fig. 4 Average degrees of flexion. The flexion angles in each group were approximately 20° smaller than before the operation. A comparison of the flexion angles confirmed that group III showed a significantly ($P < 0.01$) larger angle than groups I and II at one year after the operation. (------ GroupI, — · — · — GroupII, —— GroupIII, ** $P < 0.01$, * $P < 0.05$)

that the PCL should be preserved whenever possible to prevent loosening.

Regarding the flexion angle, larger angles were achieved by femoral roll-back. The tibiofemoral contact shifts 10 mm from full extension to flexion by roll-back (11) and this 10-mm shift is suggested to represent a 40 % change in the quadriceps mechanisms lever arm (12) and makes to stair climbing easier. Also, the results of several studies have shown better stair climbing ability in patients with intact posterior cruciate ligaments following knee arthroplasty (13).

Based upon electromyographic studies of TKA, Dorr *et al.* (1) observed less abnormal knee joint muscle activity, and they concluded that PCL-retention was prolonged the durability of the prosthesis.

Whether or not the PCL should be preserved in TKA is still controversial.

The original Okayama Mark II procedure provided satisfactory results (14), but radiological loosening was observed in 30 % of the cases after more than five years. After ten years, the loosening increased and approximately 10 % of them were required revision (15). Therefore, we redesigned the Okayama Mark II to improve fixation and to gain larger flexion angle by preserving the PCL. This resigned Mark II has been used since 1989.

In this study, the JOA scores at 1 year after the operation were significantly better ($P < 0.01$) in patients with PCL retention than with PCL resection using the same prosthesis (Okayama Mark II). In addition, we achieved even better results by the Okayama University PCL-R procedure than by the Mark II procedure with PCL retention.

Also, the flexion angle was larger with PCL retention, and the new Okayama PCL-R procedure provided significantly ($P < 0.01$) larger flexion angles.

Therefore, we conclude that the PCL should be preserved in TKA whenever possible because of its important role in knee function, especially with regard to the flexion angle.

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Received August 3, 1995; accepted September 25, 1995.