

Macroscopic and histological assessments of the cruciate ligaments in arthrosis of the knee

Jerome Allain, Daniel Goutallier and Marie Catherine Voisin

Service de Chirurgie Orthopédique, Hôpital Henri Mondor, 51 Av. du Marechal de Lattre de Tassigny, FR-94010 Creteil cedex, France.
E-mail: Jalortho@aol.com
Submitted 00-05-12. Accepted 00-11-16

ABSTRACT – We examined the macroscopic appearance of both cruciate ligaments in 52 knees during knee replacement. It was classified as normal, abnormal or ruptured. The ligaments were also evaluated histologically: stage 0 (normal), stage 1 (degeneration of < 1/3 of the collagen fibers), stage 2 (degeneration of 1/3–2/3) and stage 3 (> 2/3).

17 anterior cruciate ligaments (ACL) were normal, 14 were abnormal and 21 ruptured. All the posterior cruciate ligaments (PCL) were normal. 14 ACL were stage 0, 6 stage 1, 8 stage 2 and 24 were stage 3. 22 PCL were stage 0, 14 stage 1, 13 stage 2 and 3 were stage 3. When the ACL was abnormal or ruptured, the PCL was stage 0 only in one fourth of the cases.

The long-term results of TKR retaining the PCL should be better if the ligament is strong. The intraoperative assessment of the macroscopic appearance of the ACL reflects the histological state of the PCL.

■

There is still a controversy as regards the retention of the posterior cruciate ligament (PCL) during a total knee replacement (TKR) (Freeman and Railton 1988, Howard et al. 1994). Clinical and radiological studies have stressed the superiority of one or the other of the approaches with varying results (Becker et al. 1991, Shoji et al. 1994, Cash et al. 1996). Many factors can explain the difficulty of comparing these alternatives. Some authors have studied the kinematics of operated knees in relation to the retention or not of PCL (Allain et al. 1997, Andriacchi et al. 1982), but other parameters can affect the results. The existence of histological damage of cruciate ligaments in arthrosis, previously reported by Kleinbart et al. (1996), can

make their retention dubious when performing a TKR. We did macroscopic and microscopic examinations of the cruciate ligaments, when performing a TKR to determine the incidence of degeneration of the ligaments and specify in which cases the PCL could be retained.

Patients and methods

45 patients (30 women) operated on with a postero-stabilized TKR because of arthrosis were included. 7 patients operated on bilaterally were included twice except for the statistical analysis. Their average age was 76 (64–84) years. None had a history of knee trauma or previous surgery.

The macroscopic appearance during surgery in both cruciate ligaments was evaluated and classified in 3 stages: normal, abnormal (thinner than normal and sclerotic) or ruptured (complete disappearance of the ligament, which is destroyed, or persistence of only a few fibers). Both cruciate ligaments were removed in one piece with the tibial plateau, fixed in 10% formalin and decalcified in 10% acid nitric solution for histological study (Figure 1). The histological findings in both cruciate ligaments were divided into 4 stages, according to the degeneration of the collagen on longitudinal sections, stained with hematoxylin and eosin (Figures 2, 3 and 4) (stage 0: normal, stage 1: degenerative lesions of collagen fibers in less than one third of the ligament thickness, stage 2: degenerative lesions of collagen fibers between one third and two thirds of the ligament thickness, stage 3: degenerative lesions of collagen fibers in more than two thirds of the ligament thickness).

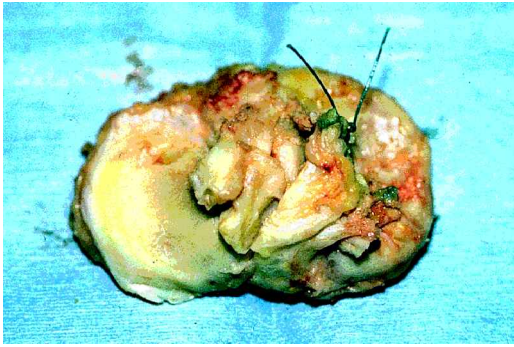


Figure 1. Intraoperative resection of the cruciate ligaments with the tibial plateau.

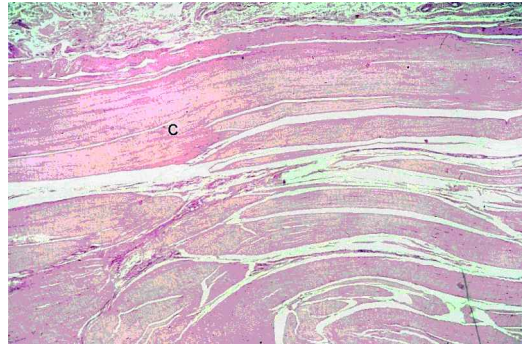


Figure 2. Photomicrograph of the anterior cruciate ligament biopsy. Normal ligament (stage 0) with no collagen fibers damage (hematoxylin and eosin $\times 100$). C – collagen fibers.

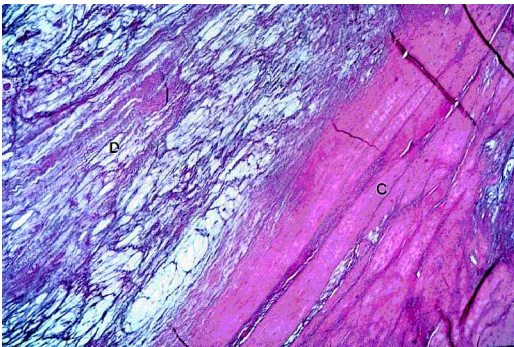


Figure 3. Photomicrograph of the anterior cruciate ligament biopsy. Degenerative lesions of collagen fibers (D) between one third and two thirds of the ligament thickness (stage II) (H&E $\times 100$). C – collagen fibers.



Figure 4. Photomicrograph of the anterior cruciate ligament biopsy. Degenerative lesions (D) of the ligament with disappearance of all the collagen fibers (stage III) (H&E $\times 100$).

The chi-square test was used for the statistical analysis. A p-value < 0.05 was considered significant. The 7 patients operated on bilaterally were included only once in the statistical analysis.

Results

The macroscopic appearance of the ACL was normal in 17 cases, thin and sclerotic in 14 cases and ruptured in 21. The appearance of the PCL was normal in all. Histologically, stage 3 lesions were commoner among ACL (Table 1).

Among the 17 macroscopically normal ACL, 14 were also histologically normal. The 3 remaining ones had minor lesions. The 52 macroscopically normal PCL were histologically healthy in 22 cases. The 30 remaining cases had stage 1 or 2 lesions in 27.

When the ACL was macroscopically normal (17 knees), the PCL was histologically healthy in 13 knees. In the remaining 4, the degeneration never involved more than 1/3 of its thickness. However, when the ACL was macroscopically abnormal (14 knees) or ruptured (21 knees), the PCL was histologically abnormal in 26 (Table 2). Among these 26 cases of histological abnormality in PCL, damage to the ligament involved more than 1/3 of its thick-

Table 1. Histological findings in both cruciate ligaments

Stage	ACL	PCL
0	14	22
1	6	14
2	8	13
3	24	3
Total	52	52

Table 2. Histological findings in the posterior cruciate ligament in relation to the macroscopic aspect of the anterior cruciate ligament

ACL macroscopic findings	PCL histological findings	
	Stage	Cases
Normal: 17	0	13
	1	4
Abnormal: 14	0	5
	1	4
	2	5
Ruptured: 21	0	4
	1	6
	2	8
	3	3

ness in 16 cases. There was a correlation between the histological findings in the PCL and the appearance of the ACL ($p = 0.001$).

Discussion

During a TKR, the mechanical function of cruciate ligaments should be preserved. This role can be ensured by the ligament itself when it is retained (Ewald et al. 1984, Andriacchi and Galante 1988) or else it can be entrusted to the implant, a posterostabilized prosthesis (Insall et al. 1982, Scott and Rubinstein 1986, Freeman and Railton 1988). PCL mechanical abnormalities after TKR can contribute to implant loosening (Lew and Lewis 1982, Andriacchi and Galante 1988). Fontanesi et al. (1991) reported a functional PCL in two thirds of a selected group of 31 patients operated on with a PCL-retaining PCA-prosthesis after at least 18 months. When the frontal preoperative deformation was $> 10^\circ$ of varus or valgus, this rate fell to half. Kleinbart et al. (1996) found that there was a correlation between degeneration of the PCL and arthrosis of the knee, but not with normal ageing.

The good results after a PCL-retaining knee replacement, despite the fact that many posterior ligaments have no function, can be explained by the design of the implant and by the finding that the ligament plays a secondary role when the implant is loaded (Shoemaker et al. 1982) or by improved proprioception with a retained ligament (Kennedy et al. 1982).

It is reasonable to assume that if a PCL-retaining knee replacement were to be reserved for patients with a normal posterior ligament, the results would improve. Our study confirms the observation by Noyes et al. (1974) that the macroscopic assessment of a ligament is unreliable for determining the histological and mechanical characteristics. Our study confirms the fact that the PCL in gonarthrosis is degenerated and insufficient in some cases (Kleinbart et al. 1996, Fontanesi et al. 1991), but it shows that the macroscopic appearance of shows the ACL can be used to evaluate the posterior ligament.

Allain J, Pidet O, Diop A, Simondi M, Goutallier D. Comparaison de la cinématique des prothèses totales de genou postéro-stabilisées ou conservant les deux ligaments croisés par le système optoélectronique Vicon. *Rev Chir Orthop (Suppl II)* 1997; 83: 29-30.

Andriacchi T P, Galante J O. Retention of the posterior cruciate in total knee arthroplasty. *J Arthroplasty (Suppl 3)* 1988: 13-9.

Andriacchi T P, Galante J O, Fermier R W. The influence of total knee replacement design on walking and stair-climbing. *J Bone Joint Surg (Am)* 1982; 64: 1328-35.

Becker M W, Insall J N, Faris P M. Bilateral total knee arthroplasty. One cruciate retaining and one cruciate substituting. *Clin Orthop* 1991; 271: 122-4.

Cash R M, Gonzalez M H, Garst J, Barmada R, Stern S H. Proprioception after arthroplasty: role of the posterior cruciate ligament. *Clin Orthop* 1996; 331: 172-8.

Ewald F C, Jacobs M A, Miegel R E, Wolker P S, Poss R, Sledge C B. Kinematic total knee replacement. *J Bone Joint Surg (Am)* 1984; 66: 1032-40.

Fontanesi G, Rotini R, Pignedoli P, Giancetti F. Retention of the posterior cruciate ligament in total knee arthroplasty. *Ital J Orthop Traumatol* 1991; 17: 65-71.

Freeman M A R, Railton G T. Should the posterior cruciate ligament be retained or resected in condylar non-meniscal knee arthroplasty? The case for resection. *J Arthroplasty (Suppl 3)* 1988: 3-12.

Howard S, Hirsch M D, Lake D et al. Cruciate ligament in total knee arthroplasty: save, sacrifice or substitute? Presented at the American Academy of Orthopaedic Surgeons Annual Meeting, San Francisco, CA, February 1994.

Insall J N, Lachiewicz P F, Burnstein A M. The posterior stabilized condylar prosthesis: a modification of the total condylar design. Two- to four-year clinical experience. *J Bone Joint Surg (Am)* 1982; 64: 1317-23.

Kennedy J C, Alexander I J, Hayes K C. Nerve supply of the human knee and its functional significance. *Am J Sports Med* 1982; 10: 329-35.

Kleinbart F A, Bryk E, Evangelista J, Scott W N, Vigorita V J. Histologic comparison of posterior cruciate ligaments from arthritic and age-matched knee specimens. *J Arthroplasty* 1996; 11: 726-31.

- Lew W D, Lewis J L. The effect of knee-prosthesis geometry on cruciate ligament mechanics during flexion. *J Bone Joint Surg (Am)* 1982; 64: 734-9.
- Noyes F R, DeLucas J L, Torvik P J. Biomechanics of anterior cruciate ligament failure: An analysis of strain-rate sensitivity and mechanisms of failure in primates. *J Bone Joint Surg (Am)* 1974; 56: 236-53.
- Scott N W, Rubinstein M. Posterior stabilized knee arthroplasty: six-year experience. *Clin Orthop* 1986; 205: 138-45.
- Shoemaker S C, Markolf K L, Finerman G A M. In vitro stability of the implanted total condylar prosthesis: effects of joint load and of the posterior cruciate ligament. *J Bone Joint Surg (Am)* 1982; 64: 1201-13.
- Shoji H, Wolf A, Packard S, Yoshino S. Cruciate retained and excised total knee arthroplasty. A comparative study in patients with bilateral total knee arthroplasty. *Clin Orthop* 1994; 305: 218-22.