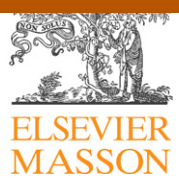
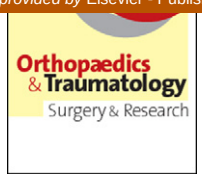


Available online at ScienceDirect
www.sciencedirect.com

Elsevier Masson France
EM|consulte
www.em-consulte.com



WORKSHOPS OF THE SOO (2008 HAVRE). SYMPOSIUM: TOTAL KNEE ARTHROPLASTY

Total knee arthroplasty with limitations of flexion

P. Massin[a,*], C. Lautridou[c], M. Cappelli[b], A. Petit[d], G. Odri[b], F. Ducellier[a], C. Sabatier[c], C. Hulet[c], JP. Canciani[e], J. Letenneur[b], P. Burdin[d], Société d'Orthopédie de l'Ouest (SOO)

[a] *Orthopedic Surgery Department, Teaching Hospital, 4, rue Larrey, 49033 Angers cedex 09, France*
[b] *Orthopedic Surgery Clinic, Hôtel Dieu Teaching Hospital, place Alexis-Ricordeau, 44093 Nantes cedex, France*
[c] *Orthopedic Surgery Department, Teaching Hospital, avenue de la Côte-de-Nacre, 14033 Caen, France*
[d] *Orthopedic Surgery Department, 1, Trousseau Teaching Hospital, 37044 Tours cedex 9, France*
[e] *Saint-Grégoire Hospital, 6, boulevard Boutière, CS 56816, 35768 Saint-Grégoire, France*

KEYWORDS
Total knee arthroplasty;
Stiff knee;
Limitation of flexion

Summary Does total knee arthroplasty (TKA) increase mobility in stiff knees, where flexion is restricted due to degenerative changes associated with osteoarthritis, inflammatory disease, hemophilia, or post-traumatic sequelae also affecting soft tissue? The results of one hundred twenty eight TKA from five specialized centers were retrospectively reviewed. Only knees with pre-operative flexion less than 90° were included. Forty six of these also had severe flexion contracture (>20°). As a result of the arthroplasty, the flexion increased by $23 \pm 17°$ in group 1 (stiff flexion only, 82 cases), and by $17 \pm 15°$ in group 2 (combined stiffness), in which the total range of motion (ROM) increased by $39 \pm 21°$. Improvements in mobility were greater in the cases with severe pre-operative stiffness. One-year functional results did not correlate with final flexion. Flexion at last follow-up did not depend on pre-operative flexion; however, in group 2, final postoperative ROM did correlate with pre-operative ROM. Complications concerned mainly those cases with severe stiffness, in which extensive quadriceps release was performed (two cases of skin necrosis, one infection and one rupture of the patellar tendon), or the patients of group 2 (one skin necrosis, two femoral fractures, one infection and one sciatic nerve palsy). Hemophilia was a factor of poor prognosis. Overall, TKA provided significant flexion gain. It often required tibial tuberosity osteotomy, to improve exposure and prevent injury to the extensor mechanism. Extensive quadriceps release should be reserved to post-traumatic cases with intact skin and no recent infection.

Type of study: level 4 retrospective.

Introduction

The technical problems involved in total knee arthroplasty (TKA) for knee stiffness vary according to the type and degree of stiffness. The management of flexion stiffness (passive flexion deficit) was codified by Robert Judet, without reference to arthroplasty. The surgery he described is

* Corresponding author.
E-mail address: philippe.massin@bch.aphp.fr (P. Massin).

1877-0568/$ - see front matter © 2009 Elsevier Masson SAS. All rights reserved.
doi:10.1016/j.otsr.2009.04.002

very seldom associated to TKA, and numerous complications seem to ensue. The literature on TKA in knee stiffness is sparse, but it is agreed that the degree of pre-operative flexion determines postoperative flexion [1]. The technical problem in severe flexion stiffness lies in the difficulty of exposing the knee [2,3]. The benefit provided by TKA is consensual, but the associated complication rate is high [4—7].

A symposium was held, to collect retrospective data from several centers specializing in this kind of surgery, with a view to specifying the best adapted strategy, analyzing results at 1 year according to pre-operative severity, etiology, history of surgery and specific release techniques associated to conventional surgery.

One hundred and twenty eight consecutive cases of TKA for pre-operative flexion $\leq 90^\circ$ were retrospectively selected in five centers. Results were analyzed in terms of mobility as assessed clinically over the first year of follow-up, whether by goniometry or ''visually''.

Methods

Records for consecutive first-intention TKA for knee stiffness performed between September 2000 and September 2006 in five centers in western France were retrospectively examined. Cases of arthrodesis revision were excluded. A follow-up period of 1 year was required for inclusion, given that mobility remains relatively stable thereafter [8,9].

Mobility was assessed visually at post-operative check-ups, in terms of absolute flexion and of absolute gain. Absolute flexion gain was defined as the difference between pre-operative and last follow-up flexion.

Finally, the range of motion (ROM) between maximum extension and maximum flexion was the main criterion for cases of combined stiffness. Results were therefore expressed in terms of absolute and relative mobility gain, the latter defined as absolute gain relative to pre-operative mobility, and were considered ''excellent'' in case of $<10^\circ$ residual flexion contracture and $>90^\circ$ final flexion, ''good'' in case of 10—15° residual flexion contracture and 70—90° final flexion, ''moderate'' in case of 10—15° residual flexion contracture and 50—70° final flexion, and otherwise ''poor''.

Clinical scoring used a simplified version of the IKS scale. Three functional parameters were regularly to be found in the records: climbing up and down stairs, use of a walking cane, and walking distance. Climbing up and down stairs and walking distance were scored positively out of 50 points and use of a walking cane negatively out of 20 points, the sum of the three giving a total score. Scores of ≥ 90 were considered excellent, 79—89 good, 60—69 moderate and <60 poor. Pain was scored separately, on a 50 point scale.

Group 1 (simple flexion stiffness)

Comprised 82 knees followed up at 6 months, 65 of which were also followed up at 1 year. Table 1 presents demographic data. Twenty-nine knees had been previously operated. Etiologically, there were three main groups, comparable for age: 47 cases of idiopathic osteoarthritis (37 varus, nine valgus and one femoro-patellar), eight of inflammatory arthritis and 22 of post-traumatic arthritis (10 sprain sequelae, and five femoral, four tibial and two patellar malunions). Remaining etiologies included hemophilia ($n = 3$) and bacterial arthritis ($n = 2$). Mean pre-operative flexion was $76 \pm 19^\circ$ (10—90°).

Table 1 Pre-operative data for the two stiffness groups.

	Extension stiffness $n = 82$	Combined stiffness $n = 46$
Age	67 ± 13 years	58 ± 15 years
Sex-ratio	52F/30H	22F/24M
Etiology		
Idiopathic knee osteoarthritis	58%	31%
Inflammatory arthritis	10%	19%
Post-traumatic knee arthritis	26%	16%
Hemophilia	4%	28%
Other	2%	6%
Pre-operative stiffness		
Mild	69%	53%
Moderate	16%	28%
Severe	15%	19%

Specific release surgery was performed in 25 cases. Bone surgery mainly comprised tibial resection, to enlarge the two extension and flexion spaces in case of slight flexion contracture. Increasing the tibial slope with hyper-congruent inserts more specifically enlarged flexion space. In six cases, bone surgery was isolated (three tibial slope enhancements and three tibial resections). There were also nine cases of isolated soft-part surgery: arthrolysis, associated in two cases to quadriceps plasty. Finally, in 10 cases bone surgery was associated to arthrolysis, two of which were part of large-scale quadriceps release, following Judet (nine tibial slope enhancements and one tibial resection).

Pre-operative stiffness was considered mild for flexion $>70^\circ$ (56 patients), moderate where between 50 and 70° (13 patients) and severe where $<50^\circ$ (13 patients). The latter category included the two cases of quadriceps plasty and the two Judet arthrolyses (one for post-traumatic knee arthritis, the other for juvenile arthritis). Bone cut extension did not vary over the three stiffness categories.

Three tibial tuberosity osteotomies were performed to improve access to the knee. Seventy-five patients received posterior-stabilized implants (34 hyper-congruent, 41 with postcam). In only seven patients was the posterior cruciate ligament conserved.

The second, combined stiffness, group

Comprised 46 knees with 6 months' follow-up, including 35 with 1 year's follow-up. Fifteen had been previously operated. There were three main groups of etiology: 14 cases of idiopathic osteoarthritis (seven varus, five valgus and two femoro-patellar), nine of inflammatory arthritis and 13 of hemophilia. Mean age was significantly younger in the latter two groups: 52 years [21—71] versus 68 years [55—81]; $p = 0.001$. Remaining etiologies included seven cases of post-traumatic arthritis, two of bacterial arthritis sequelae

and one condylar necrosis. Mean pre-operative flexion was 77 ± 16° (35—90°), and mean pre-operative flexion contracture 28 ± 10° (20—60°), giving a mean ROM of 49 ± 21° (0—70°). Stiffness was greater in case of inflammatory arthritis and hemophilia than in idiopathic osteoarthritis, in terms of both flexion (73° [40—90°] versus 85° [70—90°]) and flexion contracture (34° [20—60°] versus 24° [20—30°]). Mean ROM in hemophilia (33 ± 20°) was significantly less than in idiopathic osteoarthritis (60 ± 9°, $p = 0.001$), but not significantly different from the ROM found in inflammatory arthritis (47 ± 28°, $p = 0.2$), which in turn did not significantly differ from that found in idiopathic arthritis ($p = 0.1$).

There were four cases of ankylosis, five of severe stiffness (ROM = 10—35°), 13 of moderate stiffness (ROM = 35—50°) and 24 of mild stiffness (ROM = 55—70°).

Soft-tissue release surgery was performed in more than half of the cases overall (19 posterior capsule releases and five arthrolyses). 34 patients required specific bone surgery. Unlike in group 1, distal femoral resection was frequent, to open the extension space and treat the flexion contracture, with 14 distal femoral, eight tibial and 12 associated femorotibial resection extensions. Such bone and ligament surgery was restricted to cases of severe stiffness and ankylosis.

In terms of technique, 20 anterior tibial tuberosity osteotomies were required. All implants were semi-stressed, with posterior stabilization (28 hyper-congruent and 18 with stabilizing camshaft).

Statistical analysis

The impact of pre-operative stiffness severity, etiology, history of surgery, associated release surgery, and condylar offset alteration on post-operative results was studied. Qualitative variables were compared by Chi^2 test (with Yates correction for small sample size): e.g., for the percentage of good, moderate and poor results according to etiology or pre-operative severity. Quantitative values were correlated by Spearman test, given the small sample sizes: e.g., pre- and post-operative mobility, or functional score and ROM at last FU. Finally the Student test for small samples was used to compare mean ROM or ROM gain between two groups (such as with or without history of surgery), or mean age between two etiologies. *P*-values are stated for each comparison; the significance threshold was set at 0.05.

Simple flexion stiffness results

Tables 2 and 3 show results for the two patient groups.

Mean flexion at last follow-up was 99 ± 20° (15—130°). Forty-nine of the 81 knees had recovered good flexion (>100°) (Fig. 1). Nine had just over 90° flexion, while the remaining 21 failed to reach 90°. Achieving these results required six mobilizations under general anesthesia (7%), one of which, performed on postoperative Day 45, was complicated by a patellar tendon rupture.

Mean flexion gain (post-minus pre-operative flexion) was 23 ± 17° (20—85°). Forty patients (50%) gained more than 25° flexion, considered satisfactory. Six of the others showed no flexion gain and six lost flexion, and were considered failures (14.8%). Five of the six with no gain had quite good pre-operative flexion (90°). None underwent specific peroperative release surgery. One case was complicated by skin necrosis. Overall final functional results were considered good in two cases and poor in the others, although none experienced significant pain. The six knees with loss of flexion had no particular etiology, with quite good pre-operative flexion (71—90°) in five cases. Deterioration set in during Week 2 in three of these cases. Only one underwent mobilization under general anesthesia. There were no particular

Table 2 Functional and mobility results for the two stiffness groups.

1 year's FU	Flexion stiffness *n* = 65 (%)	Combined stiffness *n* = 35 (%)
Mobility result		
Excellent	60	45
Good	11	20
Moderate	13	6
Poor	16	29
Functional result		
Excellent	40	37
Good	34	33
Moderate	9	20
Poor	17	10

Table 3 Mean pre-operative mobility and flexion, extension and range of motion gain at last FU for the two stiffness groups.

	Extension stiffness *n* = 82	Combined stiffness *n* = 46
Pre-operative mobility		
Extension	6 ± 6°	28 ± 10°
Flexion	76 ± 19°	77 ± 16°
Mobility gain		
Extension	4 ± 6°	22 ± 11°
Flexion	23 ± 17°	17 ± 15°
ROM	23 ± 19°	39 ± 21°

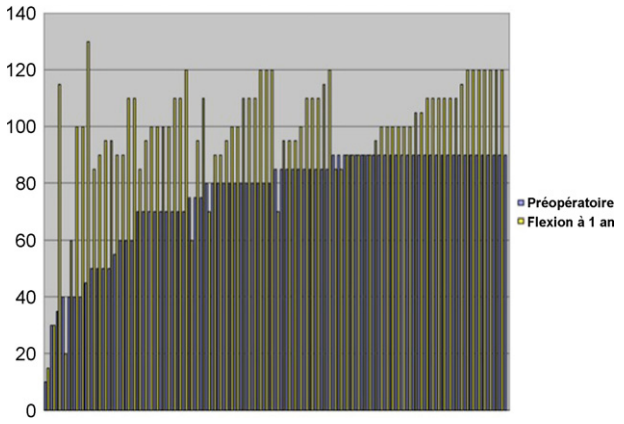


Figure 1 Postoperative flexion according to increasing pre-operative flexion in the flexion stiffness group.

complications during implantation; only one underwent specific release surgery (arthrolysis). Overall final functional results were considered moderate in two cases, poor in two and good in two — all without significant pain.

Final flexion was independent of pre-operative flexion ($p = 0.1$), while gain was greater in severe or moderate than in mild stiffness ($p = 0.001$). That is, the more severe the pre-operative stiffness, the greater the mobility gain.

Etiology (46 cases of idiopathic, 20 of post-traumatic and nine of inflammatory arthritis) did not affect flexion results ($p = 0.25$). Nor did flexion gain correlate with pre-operative malalignment or alteration of posterior condylar offset (r respectively 0.00 and 0.04). Conservation (63 cases) or reduction (nine cases) of patellar thickness did not affect flexion gain ($p = 0.2$). Nor did history of surgery ($p = 0.6$). Complementary extensor system release surgery (basically, arthrolysis) improved flexion by 16° to 22°, but with no significant effect on final flexion ($p = 0.5$); it restored initially more severe cases of stiffness to average final flexion values.

It is noteworthy that the initially mild flexion contracture (mean 6°; range, 0 to 15°) was improved, with a mean residual contracture of 1° (0—15°). In two cases, however, arthroplasty increased the flexion contracture — from 5 to 10° in one case, and from 0 to 15° in the other.

Functional results were excellent in 40% of cases, good in 34%, moderate in 9% and poor in 17%, without correlation with the final degree of flexion ($r = 0.17$, $p = 0.1$).

Complications in this group comprised two cases of skin necrosis, one infection requiring lavage and one secondary quadriceps tendon rupture following mobilization under general anesthesia. Both these major complications concerned quadriceps arthrolysis.

Combined stiffness results

Mean flexion at last follow-up was $96 \pm 18°$ (60—130°). Nineteen of the 46 knees recovered good flexion (>100°) (Fig. 2). Four had just over 90° flexion, while the remaining 23 failed to achieve 90° flexion.

Mean flexion gain was $19 \pm 15°$ (−15—65°). Ten patients gained more than 25° (21%). Two of the remaining knees showed no flexion gain, and three lost flexion (10.8%). Four of these five knees had had quite good pre-operative flexion (90°).

Mean flexion contracture at last follow-up was $7 \pm 8°$ (0—30°). Mean ROM at last follow-up was $89 \pm 16°$ (60—130°).

On our above criteria, there were 10 poor results at 1 year (29%), two moderate (6%), seven good (20%) and 16 excellent (45%). Moderate stiffness gave the best results (significant, at $p = 0.01$). Final and pre-operative range of motion values correlated significantly ($r = 0.43$; $p = 0.02$), unlike pre-operative malalignment ($r = 0.01$; $p = 1$). Hemophilia had a significant negative impact on the final result ($p = 0.001$). Specific osseous and/or ligamentary release surgery had no significant impact on results at 1 year ($p = 0.3$): nor did history of surgery ($p = 0.9$). Tibial slope >5°, however, correlated significantly with final mobility ($p = 0.05$), unlike variation in posterior condylar offset ($p = 0.06$).

Of the 30 patients with complete functional scores at 1 year, the overall final functional result was excellent in 37% of cases, good in 33%, moderate in 20% and poor in 10%. Functional score correlated with neither final flexion, residual flexion contracture nor final ROM ($r = 0.18$, 0.17 and 0.14, respectively; $p > 0.2$). Complications recorded in this group comprised one infection, two fractures and one non-regressive fibular nerve palsy.

Discussion

In case of knee stiffness, TKA is far from guaranteeing correction of stiffness, although this does not necessarily indicate failure. The objective is in fact variable, to be agreed on with the patient ahead of surgery. Priority may be given to pain rather than mobility, especially as functional scores seem not to correlate with the final degree of flexion. If no extensive quadriceps release surgery is undertaken, conventional arthroplasty can still substantially improve flexion, especially in case of severe flexion stiffness, despite the received wisdom that pre- determines post-operative flexion [1,10,11]. When increased knee mobility is sought, specific surgery can improve relative flexion gain, restoring flexion to acceptable values comparable to those of a mildly stiff knee managed without specific release surgery, as reported by Anouchi et al. [12] and Parsley et al. [8]. In the present series, such surgery was often limited to arthrolysis and thoroughly conventional collateral ligament release, yet gave 50% improvement in serious stiffness, with good, very good or excellent results in 50% of cases. The few

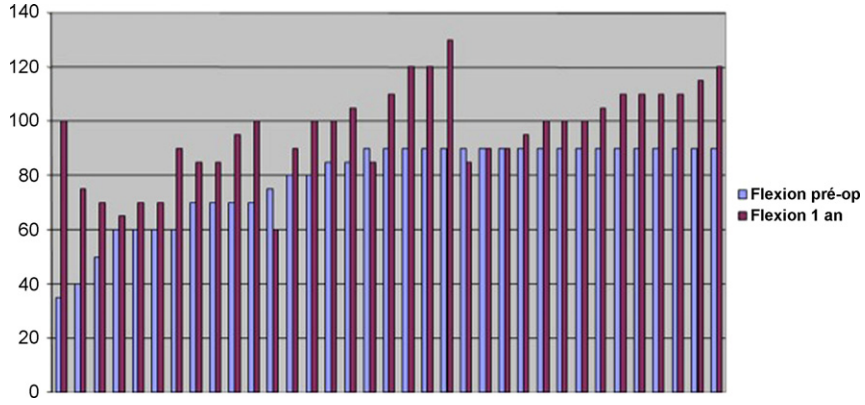


Figure 2 Postoperative flexion according to increasing pre-operative flexion in the combined stiffness group.

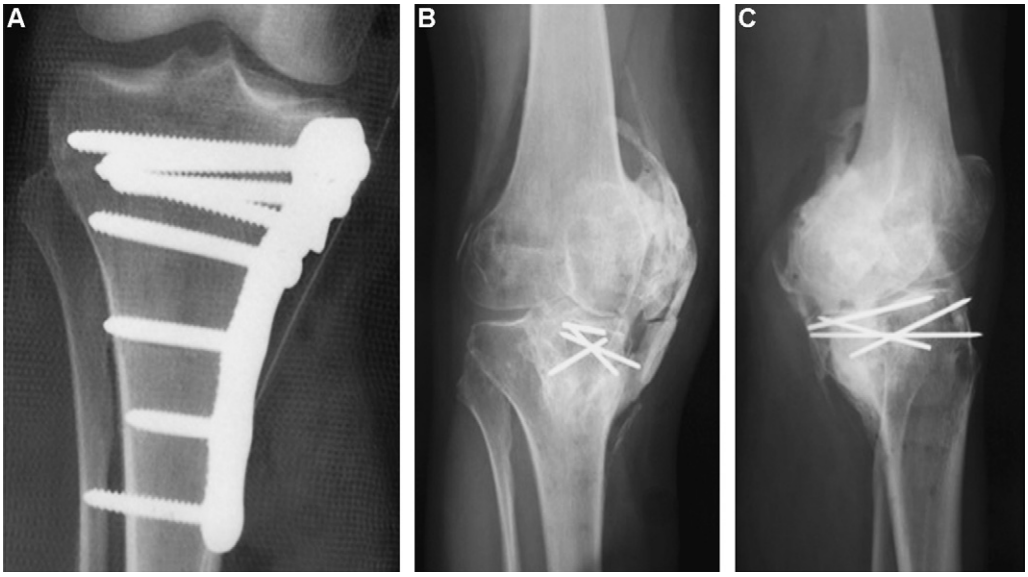


Figure 3 Open osteosynthesis for a medial tibial plate fracture (a) complicated by infection. After removal of material, extension stiffness developed, related to medial collateral ligament ossification (b and c). The patient was pain free, but wished to recover mobility. Joint release required medial collateral ligament resection and hinged implant, in turn requiring ATT osteotomy. Quadriceps release, following Judet, may be performed later, after ATT osteotomy consolidation. (With thanks to Pr Massin for images).

complications were related to recovery of large flexion, the possibility of which is dependent upon cutaneous status and entails a risk of adherent non-extensible scar necrosis. In the present series, only two extensive quadriceps arthrolyses were performed, for severe extension stiffness, and led to infection associated with skin necrosis in one case of post-traumatic osteoarthritis and to extensor system rupture in a case of juvenile polyarthritis. Despite extensor system repair, some 20° active flexion contracture persisted in the latter patient. This raises the question of single-step extensive quadriceps release associated to TKA, and at least points to restrictive conditions: perfect cutaneous status, absence of history of infection, primary quadriceps release to enable knee exposure without risk for the extensor system by tibial tuberosity osteotomy.

The study of combined stiffness showed the negative prognostic impact of hemophilia, associated with seven of the 10 poor results. Although the mean flexion mobility gain was 17° in the combined stiffness group, it was only 11° in case of hemophilia. The mean 19° mobility gain is average for the literature on this etiology, which ranges between 10° for Augereau [13], 23° for Lachiewicz [14] and 28° for Unger [15]. The combined stiffness group included the most severe cases, and notably four ankyloses (two hemophilias and two post-traumatic arthritis sequelae) in flexion (35 to 60°). The mean 63° mobility gain was very significant, at the cost of just one infection complication. In the context of the literature, these results are satisfactory: Kim et al. [5,16] reported a mean 80° gain in mobility for a 59% complication rate, and Naranja et al. [7] a mean 55° gain in mobility for a 57% complication rate (skin necrosis, infection, extensor system rupture, femoral fractures, excessive laxity secondary to extensive release surgery and fibular nerve palsy in case of severe flexion contracture). Special precautions therefore need to be taken, notably with regard to the approach, avoiding excessive patellar tendon traction, which accounts for the large number of tibial tuberosity osteotomies in this group. Quadriceps plasty is another means of obtaining exposure in such tight knees [17]. The flexion space can be enlarged by resection of the posterior condyles, without apparent adverse effects in this population in which flexion remains limited. Increasing the tibial slope beyond 5° seems to improve flexion mobility gain, but cannot be recommended from the present series without longer follow-up.

In conclusion, the approach strategy for stiff knees needs to take account of cutaneous status (preexisting scars to be repaired), of the reducibility of the frontal deformity and of patellar balance. The exposure technique is fairly straightforward, involving subquadricipital arthrolysis, and osteophyte resection to release the condylar passage of the collateral ligaments. In extreme cases of ankylosis, extensive collateral ligament release may be followed by implanting a hinged prosthesis (Fig. 3). The present series almost systematically involved central pivot resection. There are few specific techniques for flexion: the tibial tuberosity should be osteotomized to protect the patellar tendon in case of severe stiffness, if quadriceps arthrolysis has been excluded. (indications for extensive quadriceps release are rare.) A clear contract drawn up with the patient, giving priority to pain relief overt recovery of mobility, seems the least risky. Finally, it is surely primordial to achieve femoro-patellar space balance, although this could not be analyzed in the present retrospective multi-center study.

Conflict of interests

None.

References

[1] Ritter MA, Berend ME, Harty LD, Davis KE, Meding JB, Keating EM. Predicting range of motion after revision total knee arthroplasty: clustering and log-linear regression analyses. J Arthroplasty 2004;19:338—43.

[2] Rajgopal A, Ahuja N, Dolai B. Total knee arthroplasty in stiff and ankylosed knees. J Arthroplasty 2005;20:585—90.

[3] Kelly MA, Clarke HD. Stiffness and ankylosis in primary total knee arthroplasty. Clinical orthopaedics and related research. Clin Orthop Relat Res 2003;416:68—73.

[4] Bae DK, Yoon KH, Kim HS, Song SJ. Total knee arthroplasty in stiff knees after previous infection. J Bone Joint Surg Am 2005;87:333—6.

[5] Kim YH, Kim JS, Cho SH. Total knee arthroplasty after spontaneous osseous ankylosis and takedown of formal knee fusion. J Arthroplasty 2000;15:453—60.

[6] Bhan S, Malhotra R, Kiran EK. Comparison of total knee arthroplasty in stiff and ankylosed knees. Clin Orthop Relat Res 2006;451:87—95.

[7] Naranja Jr RJ, Lotke PA, Pagnano MW, Hanssen AD. Total knee arthroplasty in a previously ankylosed or arthrodesed knee. Clin Orthop Relat Res 1996;331:234—7.

[8] Parsley BS, Engh GA, Dwyer KA. Preoperative flexion. Does it influence postoperative flexion after posterior-cruciate-retaining total knee arthroplasty? Clin Orthop Relat Res 1992;275:204—10.

[9] Shoji H, Solomonow M, Yoshino S, D'Ambrosia R, Dabezies E. Factors affecting postoperative flexion in total knee arthroplasty. Orthopedics 1990;13:643—9.

[10] Gandhi R, de Beer J, Leone J, Petrucelli D, Winemaker M, Adili A. Predictive risk factors for stiff knees in total knee arthroplasty. J Arthroplasty 2006;21:46—52.

[11] Nelson CL, Kim J, Lotke PA. Stiffness after total knee arthroplasty. J Bone Joint Surg Am 2005;1(Suppl Pt 2):264—70.

[12] Anouchi YS, McShane M, Kelly FJr, Elting J, Stielh J. Range of motion in total knee replacement. Clin Orthop Relat Res 1996;331:87—92.

[13] Augereau B, Travers V, Le Balch T, Witvoet J. Total hip and knee arthroplasties in hemophilia. À propos of 27 cases. Rev Chir Orthop Reparatrice Appar Mot 1987;73: 381—94.

[14] Lachiewicz PF, Inglis AE, Insall JN, Sculco TP, Hilgartner MW, Bussel JB. Total knee arthroplasty in hemophilia. J Bone Joint Surg Am 1985;67:1361—6.

[15] Unger AS, Kessler CM, Lewis RJ. Total knee arthroplasty in human immunodeficiency virus-infected hemophiliacs. J Arthroplasty 1995;10:448—52.

[16] Kim J, Nelson CL, Lotke PA. Stiffness after total knee arthroplasty. Prevalence of the complication and outcomes of revision. J Bone Joint Surg Am 2004;86-A(7):: 1479—84.

[17] Aglietti P, Windsor RE, Buzzi R, Insall JN. Arthroplasty for the stiff or ankylosed knee. J Arthroplasty 1989;4:1—5.