

Clinical and radiological long-term outcome after posterior cruciate ligament reconstruction and nonanatomical popliteus bypass

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Abstract

Purpose The purpose of this study was to analyse the long-term outcome of patients treated for combined posterior cruciate ligament (PCL) and posterolateral corner injuries by combined PCL reconstruction and popliteus bypass according to Mueller or refixation of the popliteus tendon.

Methods Sixteen patients treated by combined PCL reconstruction and popliteus bypass according to Mueller ($n=7$) or refixation of the popliteus tendon ($n=9$) were included. A mean follow-up of $24\pm$ three years was performed using the International Knee Documentation Committee (IKDC) 2000, Lysholm, Tegner and the Knee Injury and Osteoarthritis Outcome (KOOS) scores. Bilateral stress radiographs were performed. The degree of osteoarthritis was assessed using Kellgren Lawrence score. Pearson correlations of predictive factors for worse outcome were performed ($p<0.05$).

Results Categorically, total IKDC 2000 was B (nearly normal) in five (31 %), C (abnormal) in seven (44 %) and D (severely abnormal) in four (25 %) patients. Lysholm score was 68 ± 22 ; KOOS symptom score was 40 ± 13 , KOOS pain 26 ± 24 , KOOS activity 18 ± 18 , KOOS sport 51 ± 32 and KOOS LQ 44 ± 26 . Median Tegner score decreased from pre-injury 7 (range 4–10) to 4 (range 2–10) at follow-up.

Kellgren Lawrence score showed minimal osteoarthritis in seven (44 %), moderate osteoarthritis in seven (44 %) and severe osteoarthritis in one (12 %) patient.

Conclusions The challenging group of patients treated by PCL reconstruction and popliteus bypass according to Mueller et al. or popliteus refixation showed only moderate clinical and radiological long-term outcome without statistical difference, even if patient age at surgery and the long-term follow-up is acknowledged. Anatomical posterolateral corner reconstruction techniques should be preferred.

Keywords Posterior cruciate ligament reconstruction · Popliteus bypass · Popliteus tendon refixation · Outcome

Introduction

Posterior cruciate ligament (PCL) injuries are frequently combined with posterolateral corner (PLC) injuries [1–3]. The incidence of acute PCL injuries varies between 3.4 % and 20 % [4], and the incidence of isolated PLC injuries is less frequent [2, 5–7]. Despite improved diagnostic possibilities, these injuries are still often missed [8–11]. When missed, these injuries in particular are known to lead to development of early osteoarthritis (OA), most likely in the medial tibiofemoral and patellofemoral joints [12]. This finding has been explained by constant overloading of the patellofemoral and medial tibiofemoral joints (reversed Maquet effect) [4, 13]. It is also known that missed lesions of peripheral structures, such as the PLC, can cause instability and then lead to a subsequent early failure of PCL reconstruction [1, 14, 15]. This being emphasised, a variety of repair and reconstruction techniques, both nonanatomical and anatomical, have been reported over recent decades [14, 16–21]. Nonanatomical techniques, such as Clancy, Hughston/Jacobson and Mueller [14, 18, 21] were used initially. Increasingly, anatomical

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reconstruction techniques, such as Chang, Larson, LaPrade and Miyatake [16, 17, 19, 20] are used.

One nonanatomical technique used in the early days of reconstructive knee surgery is the popliteus bypass according to Mueller. In this technique, a 1-cm-wide strip of the iliotibial tract is harvested, shuttled through a tibial tunnel and attached on the former femoral attachment of the popliteus tendon (Fig. 1) [21]. To date, there are no reported studies investigating the long-term outcome after combined PCL reconstruction and popliteal bypass or popliteal tendon repair.

The primary purpose of our study was to analyse the long-term outcome of patients treated for combined PCL and PLC injuries using combined PCL reconstruction and popliteus bypass according to Mueller or combined PCL reconstruction and refixation of the popliteus tendon.

Methods

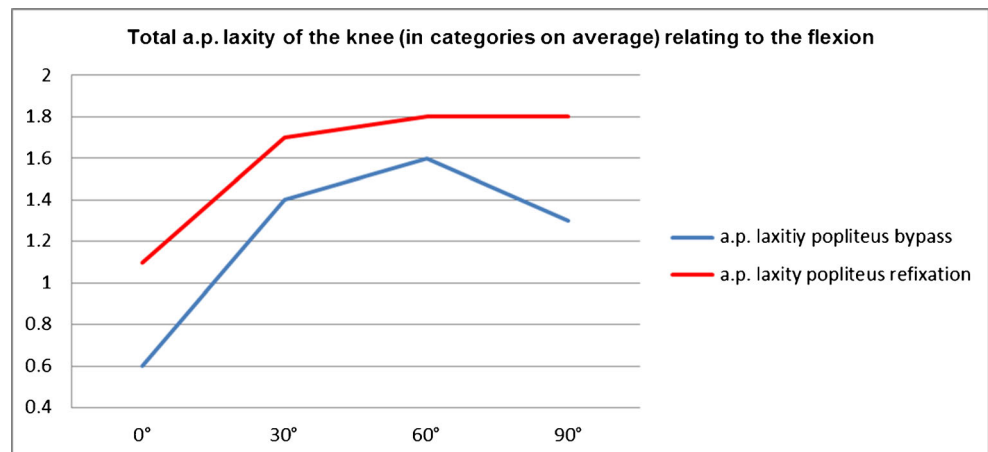
A review of the medical records in the Bruderholz Hospital archives was performed. All patients who underwent a PCL reconstruction and an additional reconstruction of the PLC (popliteus bypass according to Mueller or refixation) between 1981 and 1992 were followed up for a minimum of 18 years. During this period, 47 patients were treated; 22 could not be located, one died and seven refused to participate. One patient with a knee reconstruction sustained a periprosthetic femoral fracture before the follow-up and refused to be included. Ultimately, 16 patients (male:female=11:5, mean age 32 ± 14 years, weight 80 ± 16 kg, and height 175 ± 9 cm at surgery) were included. All patients underwent an open PCL reconstruction using ipsilateral quadriceps tendon autograft. Of those 16 patients, nine (mean age at surgery 41 ± 14 years, mean follow-up $21\pm$ two years) were treated with a popliteus tendon refixation and seven (mean age at surgery $22\pm$ three years, mean follow-up $27\pm$ two years) with the popliteus bypass.

Follow-up was carried out $23\pm$ three [mean \pm standard deviation (SD)] years after surgery, including bilateral, standardised, weight-bearing radiographs [anteroposterior (AP), lateral, Rosenberg views [22]]. In addition, bilateral anterior and posterior stress radiographs (in 30° and 90° flexion [2]) and varus stress radiographs were performed. Analysis of the AP stress radiographs was done according to Stäubli [23]. The extent of knee OA was graded according to the Kellgren–Lawrence OA score (0 normal; grade 1 suspected; grade 2 minimal; grade 3 moderate, grade 4 severe). All measurements were made using the Picture Archiving and Communications System (PACS) (Phillips Easy Vision, The Netherlands). Informed consent was obtained from all patients, and the study was approved by the local ethics committee (EK 295/09).

For clinical outcome assessment, we used the International Knee Documentation Committee (IKDC 2000) Standard Evaluation Form, the Lysholm score, the Tegner score and the Knee Injury and Osteoarthritis Outcome Score (KOOS). Clinical examination was carried out according to the IKDC 2000 form. In addition, anterior and posterior KT-1000 arthrometer measurements (Medmetric, San Diego, CA, USA) were performed with the knee in 25° of flexion.

Statistical analysis was performed by a professional statistician using SPSS 17.0 (SPSS, Chicago, IL, USA). Continuous variables were described using mean, SD and range. Categorical variables were tabulated as absolute and relative frequencies. For statistical analysis, two groups were investigated (group 1, bypass; group 2, refixation). There were no statistical differences between patients in both groups. Traffic accidents were the main reason for injury in both groups (ten of 16; 62.5 %), followed by injuries while doing sports activities (five of 16, 31.3 %). A two-tailed Pearson's correlation was used to compute associations between variables. For all analyses, $p < 0.05$ was considered statistically significant and $p < 0.1$ as a tendency.

Fig. 1 Popliteus bypass according to Mueller



Results

Total IKDC 2000, IKDC 2000 for subcategories ligament and function, and Lysholm, Tegner and KOOS scores are presented in Table 1.

The side-to-side differences of anterior KT-1000 arthrometer measurements 134 N were 5.2 ± 4 mm and of posterior KT-1000 arthrometer measurements were 1.6 ± 1.5 mm. A trend to a higher difference in anterior and posterior translation was recognised in group 1 compared with group 2, although these differences were not significant due to the small number of patients. The Kellgren–Lawrence score showed minimal OA in seven (44 %), moderate OA in seven (44 %) and severe OA in one (12 %) patient. One patient had undergone a total knee replacement. In comparison with the contralateral side, the injured knee joint had a worse OA grade on average. To each 45 % a suspicious or minimal OA was seen. Moderate OA was found in 9 % only. According to the reverse Maquet effect [4, 13], the medial knee joint and patellofemoral joints showed worse OA than lateral knee joints.

The side-to-side difference of posterior stress radiographs at 30° was 4 ± 5 mm and 6 ± 3 mm at 90° flexion. Breakdown into two groups showed a trend ($p > 0.05$) toward increased posterior instability at 30° (4.5 ± 4.1 vs. 3.7 ± 6.4) and 90° (8 ± 2.4 vs. 3.7 ± 3.1) for group 2. In contrast, side-to-side difference in bilateral varus stress radiographs was 0.4 ± 2.3 mm in group 1 and -0.5 ± 2.6 mm in group 2. A similar trend ($p > 0.05$) was indicated for the Dial test, with a side-to-side difference of $3^\circ \pm 4.5^\circ$ at 30° flexion and $4.1^\circ \pm 7^\circ$ at 90° for group 1 and $0^\circ \pm 0^\circ$ plus $1.1^\circ \pm 3.1^\circ$, respectively, in group 2.

Knees in group 1 showed less laxity on average while testing manually than the knees in group 2. In addition, a decrease in laxity at 90° of flexion in group 1 was recognised (Fig. 2).

Discussion

To our knowledge, there is no other clinical long-term study investigating patients after combined PCL reconstruction and popliteus bypass or popliteus tendon reattachment due to combined PCL and PLC injury. The most important findings of this study are twofold: Firstly, clinical outcome measurements showed only moderate to poor results, and groups did not differ significantly. In addition, a more severe OA and a higher degree of laxity were detected in comparison with other studies [24–27]. However, the average follow-up in this study was 24 years and, thus, clearly longer than in the other studies.

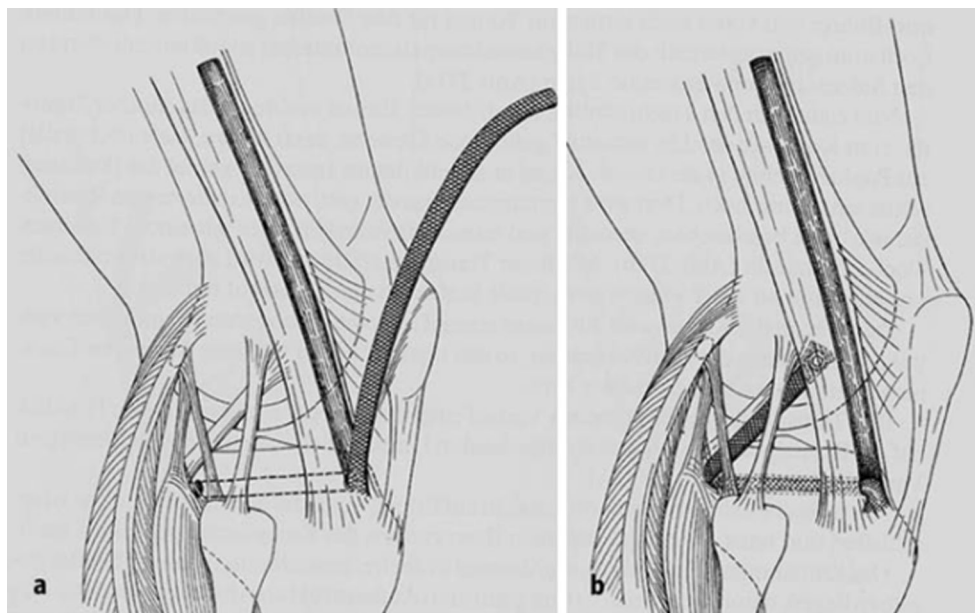
When compared with more modern anatomical reconstruction techniques, our patients showed inferior clinical and radiological results. However, there is no single study with such a long follow-up. Kim et al. [28] evaluated patients treated with single-bundle PCL reconstruction combined with a PLC reconstruction according to LaPrade. Patients were divided into two groups: one with a conventional PCL reconstruction and the other with a left remnant of the PCL in addition. Their follow-up was, on average, 49 and 45 months, respectively. Moreover, their patients were significantly younger [39 (range 14–62) years] than patients in our study. As expected, those authors reported better results than for patients in our study. However, Tegner score showed a worse result at

Table 1 Subjective and objective outcome scoring of patients at final follow-up

Outcome instrument	all: mean \pm SD (median, range)	group 1: mean \pm SD (median, range)	group 2: mean \pm SD (median, range)
IKDC subjective	40 \pm 22 (31, 12–84)	35 \pm 23 (30, 14–68)	39 \pm 22 (41, 12–84)
Total IKDC	n (%)		
A (normal)	0 (0 %)	0 (0 %)	0 (0 %)
B (nearly normal)	5 (31 %)	2 (29 %)	3 (33 %)
C (abnormal)	7 (44 %)	3 (43 %)	4 (44 %)
D (severely abnormal)	4 (25 %)	2 (29 %)	2 (22 %)
Lysholm	68 \pm 22 (76, 27–93)	69 \pm 22 (74, 27–93)	67 \pm 23 (77, 33–90)
Tegner preinjury	-(7, 4–10)	-(7, 4–10)	-(7, 4–10)
Tegner at follow-up	-(4, 2–10)	-(4, 3–6)	-(4, 2–10)
WOMAC symptoms	40 \pm 13 (39, 14–68)	40 \pm 8 (39, 25–50)	40 \pm 17 (36, 14–68)
WOMAC pain	26 \pm 24 (21, 0–69)	23 \pm 24 (17, 0–67)	28 \pm 25 (25, 0–69)
WOMAC activities	18 \pm 18 (15, 0–54)	13 \pm 15 (4, 0–35)	22 \pm 20 (19, 0–54)
WOMAC total	25 \pm 17 (20, 7–61)	21 \pm 15 (14, 7–42)	28 \pm 19 (20, 8–61)
KOOS sports/leisure	51 \pm 31 (58, 0–100)	46 \pm 30 (30, 15–85)	55 \pm 34 (65, 0–100)
KOOS quality of life	44 \pm 26 (44, 6–94)	43 \pm 24 (56, 6–69)	44 \pm 28 (38, 13–94)
WOMAC/KOOS total	30 \pm 19 (24, 7–66)	26 \pm 16 (24, 9–49)	32 \pm 21 (25, 7–66)

WOMAC Western Ontario and McMaster Universities Osteoarthritis Index, KOOS Knee Injury and Osteoarthritis Outcome Score, SD standard deviation

Fig. 2 Total anteroposterior (AP) laxity of manually tested knees. Category 0, 0–2 mm; category 1, 3–5 mm; category 2, 6–10 mm; category 3, >10 mm



the last follow-up, which is most likely due to the inferior Tegner score before the injury.

Yoon et al. [29] reported a study with 17 patients (mean age 37 years) with a mean follow-up of 40 months after posterolateral reconstruction according to LaPrade plus additional reconstruction of the PCL or anterior cruciate ligament (ACL). Average Lysholm score was 85 in comparison with the Lysholm score of in our study, with 68 on average. Moreover, their median Tegner score was higher—6 at final follow-up—versus 4.2 in our study.

Thirty-nine months after a posterolateral reconstruction using a modified Larson technique ($n=24$, mean age 19 years at time of surgery), Rios et al. [30] indicated better results in Lysholm (83 on average) and Tegner (6 on average) scores. However, at least one cruciate ligament was reconstructed additionally. Freeman et al. [31] published a series of 17 patients (mean age 31; range 21–47 years) on average 35 months after PCL or combined PCL/PLC reconstruction using the Larson technique. With an average Lysholm score of 69 and a Tegner score of 4.5 on average, these patients had similar results to our patients. However, the authors of that study stated that the PCL reconstruction alone showed worse results.

Interestingly, all the previous studies have a remarkably shorter follow-up and younger patients at the last follow-up compared with our study. Most of those studies showed superior results to ours, but Freeman et al. [31] showed comparable results in the Tegner and Lysholm scores. In summary, the inferior results found in our study are mainly due to a significantly longer average follow-up of 24 years. Another reason might be that a considerable number of patients complained of chronic instabilities.

The popliteus bypass according to Mueller might provide better stability than refixing the popliteus tendon, which might be explained by augmented static stability. This is in contrast to Fanelli [32], who stated that the popliteus bypass only gives stability in knee extension based on the missing dynamic component of the popliteus muscle. However, the popliteus bypass is considered an anisometric and nonanatomical reconstruction technique, a fact that could be the reason for inferior results of our study when compared with studies investigating outcomes after anatomical PLC reconstructions. Stannard [33] found in 56 patients with a 24-month follow-up that anatomical reconstruction showed better results than PLC refixation. In summary, PLC reconstruction techniques provide better outcome than refixation techniques.

Anatomical techniques might be superior than the presented nonanatomical, popliteus bypass technique. However, regardless of the differences between techniques, the main reason for inferior results of the study presented here is the significantly longer follow-up than all other mentioned studies. Secondly, the medial tibiofemoral as well as the patellofemoral knee compartment showed a higher degree of OA than the lateral tibiofemoral knee compartments. This finding is clearly in accordance with Lobenhoffer et al. [12], who showed that patients with posterior instability are more likely to develop OA of the medial tibiofemoral and patellofemoral knee joint ten to 20 years after PCL injury. Our study results confirm their findings. Furthermore, unaffected contralateral knee joints in our patients presented a less severe OA than the operated knee joints.

This study has several limitations: The small number of patients is the biggest limitation, but this is because evaluating long-term outcomes is difficult. Due to the small sample size,

statistical comparison of both groups must be considered with due care.

Conclusion

The challenging group of patients with combined PCL and PLC injuries treated by PCL reconstruction and popliteus bypass according to Mueller et al. or popliteus refixation showed only moderate clinical and radiological outcome, even when patient age at surgery and long-term follow-up is acknowledged. In summary, long-term results of treated combined PCL/PLC injuries are not satisfying. The type of PLC reconstruction using these two methods did not show any statistically significant difference in outcomes. A trend was recognised that the popliteus bypass leads to less laxity than does refixation, although a statistically significant difference could not be found. However, in order to restore PLC instabilities, anatomical techniques should be preferred over nonanatomical techniques, such as popliteus bypass according to Mueller presented in this study.

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