

Acute isolated injury of the posterior cruciate ligament treated by a dynamic anterior drawer brace

A PRELIMINARY REPORT

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We investigated the role of a functional brace worn for four months in the treatment of patients with an acute isolated tear of the posterior cruciate ligament to determine whether reduction of the posterior tibial translation during the healing period would give an improved final position of the tibia. The initial and follow-up stability was tested by Rolimeter arthrometry and radiography. The clinical outcome was evaluated using the Lysholm score, the Tegner score and the International Knee Documentation Committee scoring system at follow-up at one and two years. In all, 21 patients were studied, 21 of whom had completed one-year and 17 a two-year follow-up.

The initial mean posterior sag (Rolimeter measurement) of 7.1 mm (5 to 10) was significantly reduced after 12 months to a mean of 2.3 mm (0 to 6, $p < 0.001$) and to a mean of 3.2 mm (2 to 7, $p = 0.001$) after 24 months. Radiological measurement gave similar results. The mean pre-injury Lysholm score was normal at 98 (95 to 100). At follow-up, a slight decrease in the mean values was observed to 94.0 (79 to 100, $p = 0.001$) at one year and 94.0 (88 to 100, $p = 0.027$, at two years).

We concluded that the posterior cruciate ligament has an intrinsic healing capacity and, if the posteriorly translated tibia is reduced to a physiological position, it can heal with less attenuation. The applied treatment produces a good to excellent functional result.

Injuries to the posterior cruciate ligament (PCL) are less common than those to the anterior cruciate ligament (ACL).^{1,2} The prevalence of injury to the former varies between 1% and 44% of injured knees with a haemarthrosis.^{1,3-7} High-quality, evidence-based treatment guidelines for isolated PCL injuries are lacking.⁸ Nevertheless, according to Shelbourne and Rubenstein⁹ it is widely recommended that patients with minor instability (grade 1 and grade 2) with a posterior sag ≤ 10 mm should be treated conservatively, whereas those with higher-grade instability (grade 3), which is commonly part of a combined instability may benefit from surgical reconstruction. Most studies on the conservative treatment of injury to the PCL have reported good results.^{7,10-13} It is also known that, in most cases, the ruptured PCL heals and regains continuity.^{14,15} Because of forces across the knee, healing takes place with posterior tibial translation and elongation of the PCL. In patients with isolated injuries, Jung et al.¹⁶ demonstrated successful healing of the PCL with reduction of the posterior tibial translation. They applied conservative treatment with the knee immobilised in a cast in full extension for six weeks. The cast held the tibia in an anterior drawer position.

Subsequently, treatment was continued using a dynamic brace. This method confirmed that healing of the ligament is possible in an improved position with less posterior sag.

Similar to the method of Jung et al.,¹⁶ we applied functional treatment which held the tibia in a reduced position, but from the beginning of the treatment we used a specially designed dynamic brace, the PCL-Jack (Albrecht GmbH, Stephanskirchen, Germany). We now present the results of the use of this anterior drawer brace for acute isolated injuries to the PCL.

Patients and Methods

From September 2003, all patients with acute isolated grade-1+ and grade-2+ injury to the PCL representing a posterior translation of 6 mm to 13 mm, have followed a prospective treatment and follow-up protocol in our institution. Of the 21 patients who had a minimum follow-up of 12-months, 17 have now reached their 24-month review. All the PCL injuries were sustained between September 2003 and January 2009. There were 19 men and three women with a mean age at the time of injury of 29.2 years (17 to 60). All the injuries

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Fig. 1

Photograph of the PCL-Jack brace.

were mid-substance or distal ligamentous tears. The exclusion criteria were minor instability (grade 1, mean posterior sag, < 6 mm), combined lesions such as posterolateral injuries, bicruciate injuries, proximal PCL injuries (peel-off injury), associated meniscal tears, osseous avulsion of the PCL, chronic lesions, or lesions older than three weeks since injury, patients unwilling to follow the treatment protocol or inability to comprehend it. Minor ligament tears such as collateral tears without clinical instability were included. According to the 'intention-to-treat' principle, we report each patient initially included in the study.

Initial assessment. Patients underwent clinical examination of the knee using the Rolimeter arthrometer (Aircast; DJO, Vista, California) in 70° of flexion and with application of a manual posterior force, measuring the posterior tibial translation in comparison with the opposite side,¹⁷ radiological evaluation by standard radiographs and arthroscopy with Puddu views and bilateral lateral views in 70° of flexion with hamstring contraction,¹⁸ MRI and assessment using the Lysholm knee function scoring scale,¹⁹ the Tegner activity level rating scale²⁰ and the International Knee Documentation Committee (IKDC) knee scoring system.²¹

Treatment protocol. Patients with acute mid-substance or distal PCL tears were treated conservatively by the PCL-Jack brace. The prefabricated brace was adjusted by an orthopaedic technician and applied for four months. Full weight-bearing was allowed from the start of the treatment. A full range of movement, to the extent possible in the brace, was allowed giving patients a range of flexion of 0° to 110° in most cases. Removal of the brace was allowed in only two

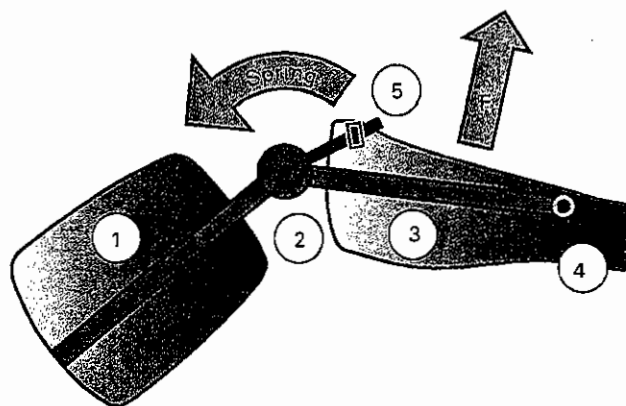


Fig. 2

Diagram showing that the brace consists of an upper thigh (1) and a leg part (3) connected through a hinge at the knee (2) and ankle (4). The load is applied through a relocatable load arm (5) from the hinge to the leg part, which rotates around the distal hinge (4). F = force.

positions, upright with full extension and contraction of the quadriceps (recommended for showering) and in the prone position and full extension of the knee. In both the tibia remained in a reduced position. Special attention was given to the instruction to patients with written information and regular assessment of compliance in the initial phase of treatment. After four months, the brace was removed and exercises and physiotherapy was started to aid the recovery of muscle strength and full mobility. Sporting activity which involved pivoting was allowed after six months. Patients received thromboprophylaxis during the first four weeks of treatment with low-molecular-weight heparin due to the compressive nature of the brace on the proximal calf.

Characteristics of the brace. The PCL-Jack brace is a dynamic anterior drawer brace with inbuilt springs which apply an anteriorly directed force to the posterior proximal tibia (Figs 1 and 2). This force corrects the posterior sag of the PCL-deficient knee, reducing the tibial displacement and approximating the stumps of the torn PCL. The brace consists of an upper-thigh and a leg section which are connected through a hinge at the knee and ankle. The hinge at the knee allows flexion and extension movement and the hinge at the ankle allows independent anterior translation. The force is applied from the hinge at the knee through a relocatable load arm to the leg splint. The particular feature of the brace is that knee movement is disengaged from the force transmission. The spring inside the hinge at the knee can be loaded in up to 15 positions, each unit increasing the translation force. In general, 12 units were chosen, corresponding to an anterior force of 6 kg to 7 kg. The force was maintained throughout the range of movement of 0° to 90°.²²

Follow-up assessment. This followed a defined protocol. Scheduled assessments took place at four, six, 12 and 24 months. They involved clinical examination of the knee, bilateral comparative Rolimeter arthrometry, and radiological evaluation with Puddu views and lateral views in

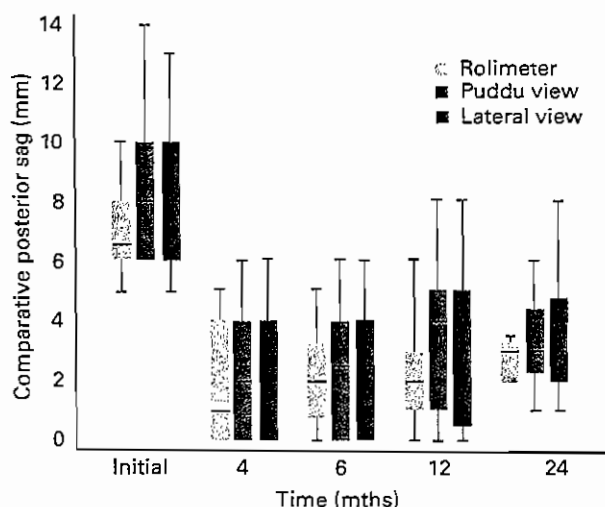


Fig. 3

Box-and-whisker box plots comparing the initial and follow-up (bilateral comparison) posterior sag (in mm) measured clinically by a Rolimeter and radiologically with Puddu and lateral views.

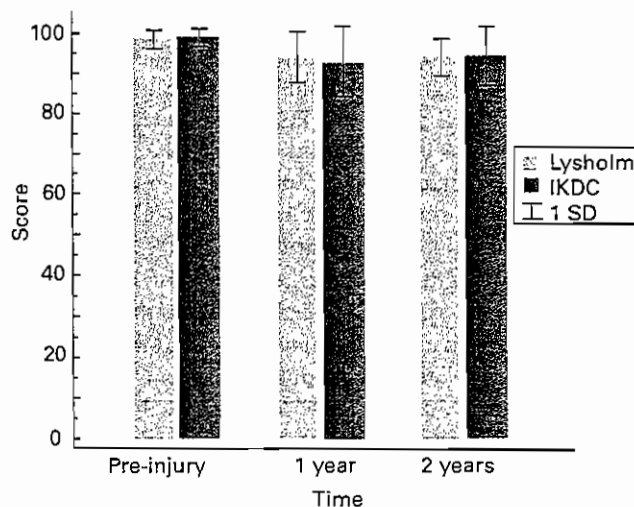


Fig. 4

Histogram comparing the pre-injury, and one- and two-year follow-up Lysholm and International Knee Documentation Committee (IKDC) scores (error bars indicate the SD).

70° of flexion and hamstring contraction. A MR scan was performed after six months, and patients completed the follow-up by evaluation using the Lysholm scale, the Tegner scale and the IKDC score at 12 and 24 months.

Statistical analysis. The data are presented as the mean and range. Due to the limited number of patients and data characteristics, the latter were considered to be non-parametric. Significance was therefore calculated using the Wilcoxon signed-rank test and, a p -value ≤ 0.05 was considered to be significant. Calculations and graphs were performed using MedCalc Software version 10.4.8.0 (MedCalc Software bvba, Mariakerke, Belgium).

Results

The treatment was started at a mean of 12 days (1 to 20) after the injury. At the four month review, a flexion limit of around 110° was present due to the limitation in the brace. All patients recovered full flexion uneventfully at six months. No patients were lost to follow-up.

Arthrometry. Bilateral comparative rolimeter arthrometry showed a mean initial posterior sag of 7.1 mm (5 to 10). This was significantly reduced after 12 months to a mean of 2.3 mm (0.0 to 6.0, $p < 0.001$) and to a mean of 3.2 mm (2.0 to 7.0) after 24 months ($p = 0.001$). Radiological arthrometry (Puddu) in the tangential and lateral views showed a mean initial posterior sag of 8.5 (6.0 to 14.0) and 8.1 (6.0 to 13.0), respectively. The corresponding respective follow-up assessments showed a significantly reduced mean posterior sag at 12 months of 3.3 mm (0.0 to 8.0, $p = 0.008$) and 3.1 mm (0.0 to 8.0, $p = 0.0078$). The corresponding mean results at 24 months were 3.6 mm (1.0 to 9.0, $p = 0.0088$) and 3.4 mm (1.1 to 8.1, $p = 0.0088$, Fig. 3). Five patients had a posterior sag which exceeded 3.0 mm after 12 months. Between the four- and 24-

month assessments, an increase in the posterior sag was observed in all measuring modes, but was only of the order of 1.0 mm which was not statistically significant ($p = 0.24$).

Functional outcome. Functional outcome was evaluated using the pre-injury and follow-up (12 months and 24 months) Lysholm and IKDC scores (Fig. 4). Whereas the mean Lysholm pre-injury value was normal at 98.0 (95.0 to 100.0), a slight but significant decrease was observed at follow-up evaluations to a mean of 94 (79.0 to 100.0, $p = 0.001$ at one year and to 94.0 (88.0 to 100.0, $p = 0.027$ at two years). Qualitatively, the outcome was excellent in ten, good in ten and fair in one patient at 12 months. The corresponding values for the mean IKDC score were as follows: pre-injury, 99.0 (93.0 to 100.0); at the one-year follow-up, 93.0 (72.0 to 100.0, $p = 0.001$; and at two-year follow-up 95.0 (76.0 to 100.0, $p = 0.008$). The mean Tegner score before injury was 7.5 (5.0 to 10.0), 7.2 (5.0 to 10.0) at 12 months and 7.2 (3.0 to 9.0) at 24 months.

MRI results. The MR scans at six months revealed the PCL healed in continuity in all but one of the patients. The patient with the most persistent instability showed a lengthened PCL with only partial healing.

Complications. The four-month treatment period proceeded without major problems, except for two minor skin lesions caused by the brace. Adaptation of the brace allowed healing to occur during the treatment period. In one of our patients poor compliance could have explained the persistence of the instability. There was one unsatisfactory result in a 60-year-old patient with pre-existing advanced patellofemoral osteoarthritis. The posterior sag was reduced from 6.0 mm to 2.0 mm, but the osteoarthritis became increasingly symptomatic resulting in a poor functional outcome.

Discussion

In this prospective study, we treated 21 PCL-deficient knees with grade-1+ to grade-2+ lesions after an acute isolated injury to the PCL using the PCL-Jack dynamic anterior drawer brace. This led to a significantly reduced mean posterior tibial translation of 2.0 mm to 3.0 mm at all 24-month follow-up assessments. Good to excellent functional results were obtained in all patients. The PCL-Jack brace allowed full weight-bearing and movement of the knee within the limits of the brace throughout the period of treatment thereby allowing functional rehabilitation with normal walking. The four-month treatment period was chosen arbitrarily, but, because ligament healing is a continuous process and the forces on the PCL during daily activities are consistently present, this seemed reasonable. We have no clinical data to suggest that a different duration of bracing would have affected the result. It can be expected that the capacity of ligament healing decreases with time from the initial injury. We only included patients who had sustained an injury within three weeks. This limit was also chosen arbitrarily and an earlier commencement of treatment may have lead to better results, although healing might still be possible after a longer delay.

Our results can be compared to other studies. Jung et al.¹⁶ improved PCL stability by conservative treatment and achieved similar results with immobilisation in a cast for six weeks followed by treatment in a dynamic brace. Simple functional treatment of isolated injuries to the PCL has given consistently good results after a longer follow-up.¹¹ Functional scores were slightly inferior at the one- and two-year reviews and it is not known if the persistence of some laxity had an effect on the development of osteoarthritis in the long term. Most PCLs seem to regain continuity despite posterior translation of the tibia, underlining the healing capacity of the PCL.^{14,15} Bringing the PCL into the correct position to allow healing in the correct length is therefore appropriate. Shelbourne and Gray¹⁰ found in a prospective study on 271 patients that the residual laxity did not correlate with the functional results and calls into question the need to reduce the sag. Our IKDC final scores were better than those reported by Shelbourne and Gray¹⁰ but it is not certain if this was due to our limited number of patients, or to the shorter follow-up, or if reduction of the posterior sag improved the final clinical outcome. A prospective study comparing functional treatment with and without dynamic bracing could answer this question.

One disadvantage of the treatment is the long period of bracing with a relatively bulky brace. This is reliant on good compliance from the patient. The fibres of the PCL must stay continuously in the correct position during the healing period, and this is threatened if the brace is removed and the spring forces released. Careful instruction to the patient and control of the brace are therefore essential. This treatment is not self-explanatory, and the essential repetition of instructions is time-consuming. Insufficient

compliance may explain the persistence or laxity in one patient.

Our study has limitations because the two senior authors (EG, RPJ) are co-inventors of the brace, which introduces the possibility of bias. Validation of the data by an independent group is therefore needed. Furthermore, the series was relatively small, and an internal control group was not included in the protocol. The fact that the pre-injury scores are collected after the injury is unavoidable, but can cause some recall bias.

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