PROPRIOCEPTION AND FUNCTION AFTER ANTERIOR CRUCIATE RECONSTRUCTION

D. S. BARRETT

From the Royal National Orthopaedic Hospital, Stanmore

We have assessed 45 patients who had undergone anterior cruciate reconstruction by a modified MacIntosh-Jones method. The results, using standard knee scores and clinical ligament testing, correlated poorly with the patient's own opinion and with the functional result. However, measurement of proprioception in the knee correlated well with both function ($r = 0.84$) and with patient satisfaction ($r = 0.9$).

This study indicates that proprioception, rather than the clinical excellence of the repair, is a major factor in the outcome of anterior cruciate ligament reconstruction.

Rupture of the anterior cruciate ligament may result in anterolateral instability of the knee. This manifests as a feeling of instability and repeated episodes of 'giving way' in which the knee fails under conditions of rotational stress. Conservative management of the symptomatic knee with anterior cruciate deficiency has been shown to lead to progressive rotatory instability, meniscal tears and premature joint degeneration (McDaniel and Dameron 1980; Noyes et al 1983; Satku, Kumar and Ngoi 1986).

To restore stability, reconstruction of the anterior cruciate ligament may be performed by a variety of procedures, and follow-up studies have used a variety of methods to assess their efficiency and success. However, irrespective of the system used, many authors have commented on the poor correlation between the clinical signs, knee assessment scores and the patient's satisfaction and functional abilities (Clancy et al 1982; Noyes et al 1983; Paterson and Trickey 1986).

Some patients who have persisting ligamentous laxity after operation report no difficulty in returning to sport. Others, with a clinically satisfactory repair, good ligament tension and high knee scores, continue to complain of instability and giving way although the knee does not sublux on clinical testing. These patients appear to be reporting poor joint position sense: lack of proprioception.

The quality of proprioception was recorded in

patients, after anterior cruciate reconstruction, using a new technique (Barrett, Cobb and Bentley 1991). Proprioception and standard knee scores were then correlated with the patients' own assessment of knee stability and a score of functional ability. The aim was to identify the factors which were most important for the success of anterior cruciate reconstruction.

PATIENTS AND METHODS

Three groups were studied, consisting of patients with normal intact knees, anterior cruciate deficient knees, and anterior cruciate reconstructed knees.

Proprioception in cruciate deficient knees was compared with that in 20 normal knees in age-matched controls. The normal volunteers formed part of a previous study to verify the accuracy of measurements of proprioception (Barrett et al 1991). Ten patients with arthroscopically proven, isolated anterior cruciate ruptures who had not undergone reconstruction were tested for proprioception.

Forty-five patients had undergone anterior cruciate reconstructions, 33 men and 12 women. Their average age was 26.4 years (16.5 to 50.1) and the mean follow-up after operation was 3.2 years (1.2 to 6.7). Most patients had sustained damage to the anterior cruciate from a sports injury; 64% of them were playing soccer. Three were involved in road traffic accidents.

Anterior cruciate rupture had been confirmed by examination under anaesthesia and by arthroscopy, during which any necessary meniscal surgery was performed. Patients then had three months of intensive physiotherapy. Only those who complained of giving way during normal activities, including their work, after this treatment were offered anterior cruciate reconstruction.

D. S. Barrett, BSc, FRCS, Clinical Lecturer in Orthopaedics
Royal National Orthopaedic Hospital, Brockley Hill, Stanmore,
Middlesex HA7 4LP, England.

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Operation. The anterior cruciate ligament was reconstructed by a modified Jones method, using one-third of the patellar tendon as a free graft (Jones 1963; Paterson and Trickey 1986). This was supplemented by a lateral extra-articular tenodesis of the type described by MacIntosh (Galway, Beaupré and MacIntosh 1972). Postoperatively, the knee remained in plaster for four weeks at 30° of flexion. Patients were readmitted for a period of intensive physiotherapy and passive motion exercises were continued until 70° of flexion had been achieved.

Assessment. Patients were assessed by five methods: the modified knee scoring system of Tegner and Lysholm (1985), clinical ligament testing, the patient's subjective assessment, functional score, and proprioceptive assessment.

All 45 patients were reviewed for ligament testing by the author who had not been involved in their previous care or management. Clinical grading of the laxity of the four major ligaments of both knees in each patient was carried out. The medial and lateral collateral structures were tested in 15° to 20° of flexion. Anterior cruciate stability was determined clinically by the anterior drawer test with the knee flexed at 90° and by the Lachman test (Torg, Conrad and Kalen 1976), grading each of these results from 0 to 3. The pivot shift test (Galway et al 1972; Slocum et al 1976) was performed on the conscious patient and graded as negative, causing apprehension (1

The functional outcome was assessed by the degree of return to pre-injury activity, competitive level of sport, frequency and type of sport undertaken. Ability to squat and the range of movement was then compared with the normal knee. Results were graded 0 (excellent functional results with return to original level of sport) to 10 (poor function, unable to squat, decreased range of movement and retirement from normal sporting activities).

Fig. 1

A Thomas splint with a Pearson knee flexion piece which is moved to give flexion from 0° to 30°.

Fig. 2

Figure 2 – The reliability of proprioception testing in 20 normal knees ($r = 0.82$). Figure 3 – Accuracy of joint sensation compared among patients with ACL deficient knees, ACL repaired knees and normal knees.

Fig. 3

point), positive (2 points), or positive with blocking of the tibia (4 points). The ligament scores were added to produce a score between 0 (excellent clinical result with no detectable laxity) and 10 (marked clinical ligament laxity with a positive pivot shift and blocking of the tibia).

Patients were asked to express their satisfaction in terms of the security and stability of the knee on a linear analogue scale. Scores from 0 (extremely dissatisfied) to 100 (excellent) were recorded.

Proprioceptive assessment. A modified Thomas splint with a Pearson knee flexion piece was used to measure proprioception. It provided well-padded support to the leg, and its axis of flexion approximated to that of the knee. A protractor measured the angle of the Pearson knee piece, as it was moved passively by an observer in a range from 0° to 30° (Fig. 1).

The subjects were supine on a couch with one leg supported in the Thomas splint, and screened from view. The knee was then moved passively to ten different

predetermined positions of flexion. The subjects indicated their perception of the degree of knee flexion on a visual analogue model which incorporated a goniometer. Inaccuracy was recorded as the difference between the perceived angle and the actual angle of flexion. Both knees were measured, and the final inaccuracy was expressed as the error for the operated knee minus that recorded for the normal knee. This method has been shown to be both reliable and reproducible (Barrett et al 1991). The results were subjected to simple correlation analysis.

RESULTS

To test the reproducibility of measurements of proprioception, 20 healthy volunteers had two sets of ten readings each. The correlation of these two sets of readings ($r = 0.82$), indicates the reliable performance of the apparatus (Fig. 2).

Fig. 4

Fig. 6

Anterior cruciate deficiency. Anterior cruciate deficient knees showed significantly poorer joint position sense than did the knees of age-matched patients after anterior cruciate replacement ($p < 0.02$), and normal knees ($p < 0.01$, Fig. 3).

Anterior cruciate reconstruction. After reconstruction, there was good correlation between Lysholm scores and clinically assessed ligament scores ($r = 0.82$, Fig. 4). However, there was poor correlation between Lysholm scores and patient satisfaction ($r = 0.18$, Fig. 5), and between Lysholm scores and functional outcome ($r =$

0.24), Fig. 6). Similarly, clinical assessment of ligaments correlated poorly with both the patients' subjective assessment ($r = 0.18$) and the functional outcome ($r = 0.19$). Thus both standard knee scoring and clinical assessment of ligaments were poor indicators of objectively recorded functional outcome, and of subjective function as perceived by the patients.

Patient satisfaction correlated well with functional outcome, ($r = 0.83$, Fig. 7), reflecting the high level of accuracy of the patients' own assessment of functional capabilities. However the accuracy of proprioception in the knees after reconstruction correlated well with both patient satisfaction ($r = 0.9$, Fig. 8) and with functional outcome ($r = 0.81$, Fig. 9). Good proprioception was closely associated with good function and a satisfied patient. There was poor correlation between proprioception and clinical ligament testing ($r = 0.04$) showing that proprioception was not related to the 'tightness' of the knee.

Fig. 5

Figure 4 - Lysholm scores related to ligament scores after anterior cruciate reconstruction ($r = 0.82$). Figure 5 - Lysholm score related to patient's satisfaction ($r = 0.18$). Figure 6 - Lysholm score correlated with functional outcome ($r = 0.24$).

DISCUSSION

This study confirms the view that, after anterior cruciate reconstruction, clinical assessment of ligament tightness and knee scoring systems correlate poorly with the patient's satisfaction and the functional capability of the knee (Clancy et al 1982; Noyes et al 1983; Paterson and Trickey 1986): those with high knee scores and clinically tight repairs do not necessarily achieve the best function.

Knee proprioception is closely correlated with both the functional outcome and the patient's satisfaction.

Indeed, within certain limits, return to sport appears to be more dependent on proprioception than on ligamentous tension. Some patients can return to sport despite clinical laxity, but equally, poor proprioception may prevent a well-motivated athlete with a clinically satisfactory procedure from returning to normal activity. Although the knee may never actually sublux, the athlete feels that his knee may give way.

The relationship between proprioception and the feeling of stability and security of the knee has been demonstrated. Athletes with chronic knee ligament injuries often report the beneficial effect of an elasticated stocking or strapping, though these provide little or no biomechanical support. Proprioception in these patients has been shown to be significantly increased ($p < 0.001$) by such external support (Barrett et al 1991), probably by stimulation of cutaneous pressure receptors. This appears to promote the sensation of stability.

Fig. 7

Figure 7 - Good correlation between patient's satisfaction and functional outcome ($r = 0.83$). Figure 8 - Proprioception related to patient satisfaction ($r = 0.9$). Figure 9 - Proprioception related to functional outcome ($r = 0.81$).

Joint position sense is significantly improved by cruciate reconstruction, although no change has been made to the basic receptors for proprioception by the operation. After an anterior cruciate rupture, proprioceptive sensation must arise from undamaged collateral and capsular receptors. But the anterior cruciate deficient knee moves in a non-physiological axis; alteration in gait and movement may follow (Berchuck et al 1990). Thus, the remaining proprioceptive output will be non-physiological and disorganised. Patients feel the knee to be unstable because cortical interpretation and analysis of knee position is disturbed. By restoring physiological movement by anterior cruciate reconstruction, cortical

interpretation is probably enhanced and the sensation of improved stability seems to follow.

The gait of a patient with a cruciate deficient knee is designed to prevent excessive anterior displacement of the tibia (Berchuck et al 1990), and results from abnormal proprioception. In healthy elderly patients, gait may be altered in the absence of knee pathology (Murray, Kory and Clarkson 1969). It has been shown that proprioception in the knee is decreased in these patients: their abnormal, wide-based gait may be an attempt to maximise this reduced sensation (Skinner, Barrack and Cook 1984). A similar effect is observed in the anterior cruciate deficient knee.

The unphysiological gait of the patient with an anterior cruciate deficient knee may cause abnormal loading in the knee and leads to degenerative changes in the long term.

Conclusion. The knee is a semi-constrained, compound

Fig. 8

Fig. 9

joint and it appears that proprioception plays a major role in its function. Success after ligament reconstruction may not depend directly on the tightness or strength of the reconstruction, as was thought, but rather on the quality of recovery of proprioception.

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