

Anterior Cruciate Ligament Reconstruction Using Patellar Tendon Autografts - A Review of Results

M Y Tan, S J Yeo, B K Tay

Aim: The aim of this retrospective study was to review the results of anterior cruciate ligament reconstruction using patellar tendon autografts.

Methods: Forty-one knees were available for evaluation at a minimum of 24 months follow-up. Objective, subjective, functional and KT-1000 arthrometric tests were performed.

Results: 92.7% had a negative or trace pivot shift at follow-up. None of the patients had rupture of the autografts at review. The mean post-operative single-legged hop was 81%. The KT-1000 arthrometric evaluation post-operatively revealed a mean maximum manual difference of 0.5 mm; 90.2% of these patients had a maximum manual difference of less than 4 mm. Five patients (12.2%) had a "tighter" reconstructed knee (a negative mean maximum manual difference). More than 70% of the patients in this series had good to excellent results on functional, subjective and objective evaluation scores.

Conclusion: Excellent motion recovery, reliable stabilisation rates, good arthrometric results and encouraging post-operative functional, subjective and objective evaluation scores can be expected in patients undergoing anterior cruciate ligament reconstruction with patellar tendon autografts.

Keywords: ligament, reconstruction, patellar, tendon, autografts

INTRODUCTION

Anterior cruciate ligament functions as a stabilizer of the knee joint. It controls the forward motion as well as medial and lateral rotation of the tibia on the femur. Thus, after anterior cruciate ligament rupture, other structures such as menisci, the posterior cruciate ligament and joint surfaces are exposed to a higher risk of injury. Of the many methods^(5,6,8,11,13,16-19,25,27,30,31,34,35,38,39,40-42) of anterior cruciate ligament reconstruction, bone-patellar tendon-bone is viewed by many authors^(1,23,28) as the gold standard.

The aim of this retrospective study was to review the results of anterior cruciate ligament reconstruction clinically, subjectively, objectively and functionally. At the same time, we also evaluated the KT-1000 arthrometer and the genucom testing.

MATERIALS AND METHODS

All the knees with anterior cruciate ligament reconstruction using patellar tendon substitution done during a 3-year period from January 1989 to January 1992 in the Singapore General Hospital, Orthopaedic Surgery "C" Department were reviewed. Patients with multi-ligament reconstruction, prior reconstruction, allograft reconstruction and contralateral anterior cruciate ligament insufficiency or reconstruction were excluded. Only 50 cases fulfilled the criteria. Forty-one knees were available for clinical evaluation at a minimum of two years postoperatively. The other nine patients were lost to follow-up as they were either foreign workers who had returned to their hometowns or Singaporeans who had emigrated.

All the 41 patients in this study group were males. Their ages ranged from 19 to 41 years at the time of anterior cruciate ligament reconstruction (Fig 1). The mean age was 27.6 years and the median age was 27 years. About half of the patients (20 patients) were below the age of 25 years. Only three patients were 40 years old and above.

There was no acutely reconstructed knee (defined as ≤ 4 weeks from injury). All the patients had the reconstruction done more than 12 weeks after the injury. The mean interval from injury to reconstruction was 24 months (range 3 months to 62 months).

Twenty-seven patients had their right knee reconstructed and 14 patients, their left knee. More than two-thirds of the patients (28 out of 42 patients) sustained their torn anterior cruciate ligament during sports, usually contact sports (Fig 2). The others sustained their torn anterior cruciate ligament during army training (8 patients), road traffic accidents (3 patients) or industrial accidents (2 patients).

All patients were operated on by consultant orthopaedic surgeons. They were clinically evaluated post-operatively by a registrar to exclude the surgeon's bias.

A questionnaire was drawn up for subjective and functional evaluations of these patients and to allow pre- and post-operative participation level and activity grades to be recorded.

Both knees of all patients were examined clinically and scored objectively by the same evaluator. Thigh girth measurements were made 10 cm proximal to the patella to determine the degree of quadriceps atrophy. Knee effusion was

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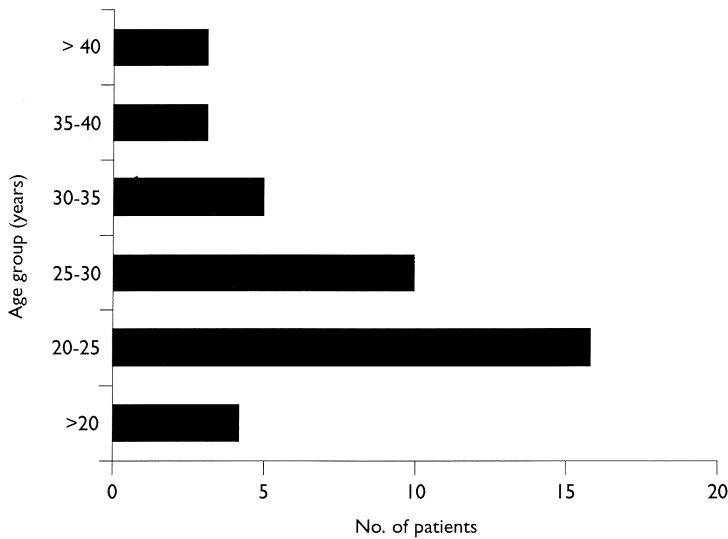


Fig 1 - Age

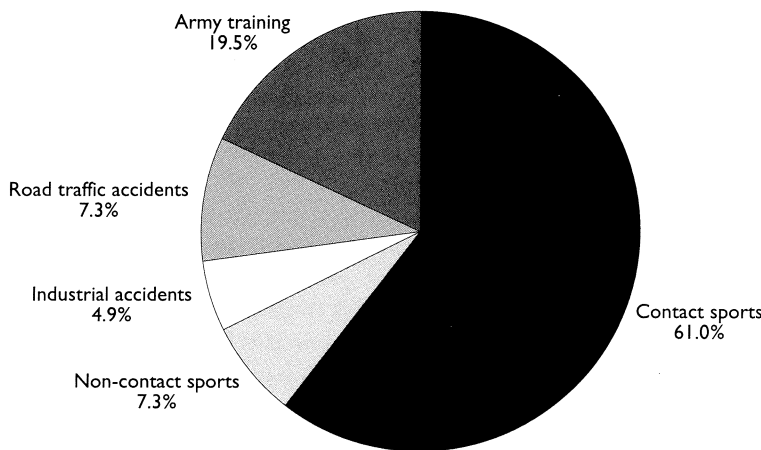


Fig 2 - Etiology

subjectively graded as absent, trace, mild, moderate or severe. Patello-femoral crepitation was palpated as the patients actively extended their knee and graded as absent, mild, moderate or severe. Range of motion of the knee was measured by a goniometer. Knee flexion contracture was assessed with the patient in the prone position and the heel height difference was measured⁽³³⁾. Lachman, anteroposterior drawer and pivot shift tests were performed and graded^(3,12,20,21,26,28,37) as follows: Grade I (0-5 mm) Grade II (6-10 mm) and Grade III (> 10 mm). The pivot shift phenomenon was graded as trace, I (slip), II (jump) or III (transient lock) in the position of abduction and tibial internal rotation to maximise the pivot shift sign^(3,28). Single-legged jumps were used as functional analysis measures.

All arthrometric evaluations with KT-1000 arthrometer which measures the antero-posterior displacement between the tibia and femur as described by Daniel et al^(9,10) and Malcom et al⁽²²⁾ were done post-operatively by the same examiner. Maximum manual (= 30 pounds) anterior force readings and side-to-side maximum manual

difference (MMD) were calculated. An objective KT-1000 arthrometer failure was defined as an MMD > 4 mm. A negative MMD indicated a "tighter" knee.

All genucom testing were carried out in the physiotherapy department by a single physiotherapist. Genucom tests the antero-posterior displacement of the ACL with the knee in 90° and 30° flexion.

Statistical analysis was performed using the SPSSX software package. Descriptive statistics, analysis of variance testing, chi-square analysis and linear regression analysis were employed where applicable. Statistical significance was established at $p < 0.05$.

Surgical technique and rehabilitation

All 41 patients had bone-patellar tendon-bone as the graft for anterior cruciate ligament reconstruction. Ten to 12 mm middle third grafts were harvested leaving at least 20 mm width of the remaining patellar tendon. The principles⁽³²⁾ of adequate notch preparation, anatomic placement of tibial and femoral tunnels and rigid graft fixation with interference screws were used.

None of these 41 patients had any attempt made at primary repair of the ruptured anterior cruciate ligament and none of them had augmentation of the graft at the time of reconstruction.

Post-operatively, continuous passive motion machines were used during hospitalisation. Range of motion was gradually increased from 0° to 40° initially, to 0° to 70° within two weeks. Active flexion and isometric quadriceps contractions were encouraged in the early post-operative period. Touch-down weight-bearing was allowed at two weeks and was advanced gradually with the aim of weaning off the crutches at six weeks post-operatively.

Patients were reviewed at six weeks intervals until 1 year post-operatively and thereafter at six monthly intervals.

Symptomatology and diagnosis

More than 80% of the patients were not able to continue with activities immediately after their injuries. About two-thirds of the patients heard or felt a 'pop' sound during the injury. The other symptoms which were consistently experienced were pain and effusion. A high percentage of patients in this study (92.7%) had recurrent giving way of the injured knee. This is one of the main indications for anterior cruciate ligament reconstruction. Majority of the patient (87%) had at least three symptoms associated with anterior cruciate ligament rupture. More than half of the patients had all the four symptoms associated with tearing of the anterior cruciate ligament such as hearing or feeling a "pop" sound during the injury, swelling within 24 hours of injury, inability to continue with the activity immediately after the injury and recurrent giving way of the injured knee.

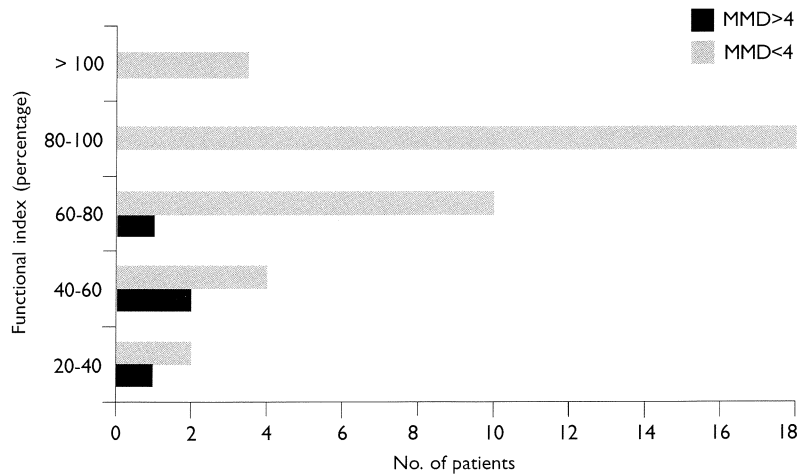


Fig 3 - Functional index vs post-operative MMD

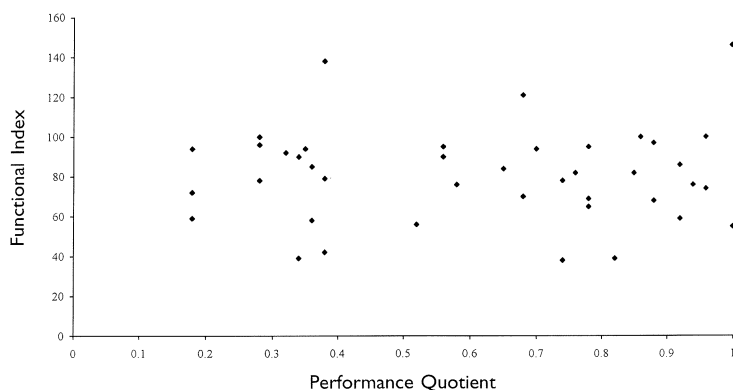


Fig 4 - Performance quotient vs functional index

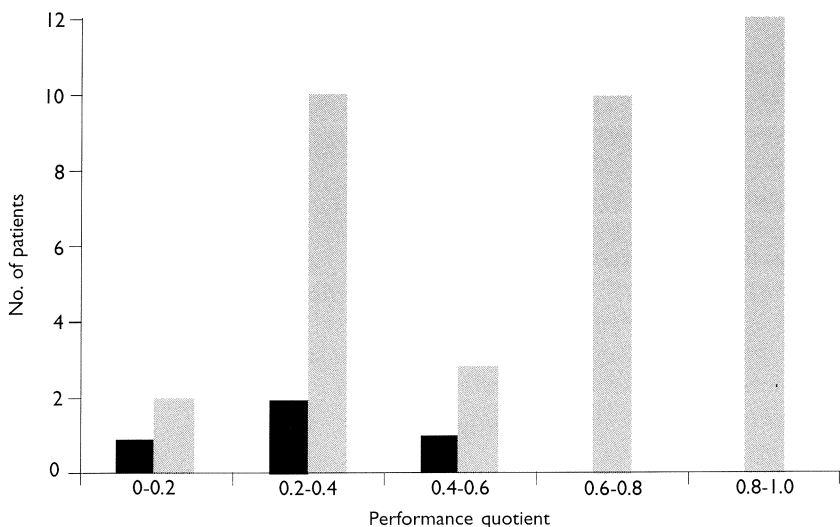


Fig 5 - Performance quotient vs post-operative MMD

Associated injury and surgical findings

Of the 41 knees, 39 had complete anterior cruciate ligament tear, only two patients had incomplete anterior cruciate ligament tear (90% tear). There were nine knees with isolated anterior cruciate ligament tear without associated intra-articular injury.

Thirty-two knees had associated injury to other structures in the knee. Thirty-one had meniscal tear (either lateral, medial or both). Four had medial collateral ligament injury, one lateral collateral ligament injury, one posterior cruciate ligament tear and three osteochondral fractures.

RESULTS

Demographics

The age of the patients at the time of anterior cruciate ligament reconstruction revealed no difference in the functional index, subjective score, objective rating scale or KT-1000 arthrometry parameter post-operatively.

No relationship could be established between the interval to surgery and functional index, subjective score, objective rating scale or KT-1000 arthrometry parameter.

Associated injury

There was no statistical difference in functional index, subjective grade, objective rating scale and KT-1000 arthrometry parameter in those patients who had isolated anterior cruciate ligament tear or those with associated injury.

Physical examination findings

Post-operatively, the Lachman test was normal (≤ 3 mm) and symmetric in 37 patients (90.2%). Grade I Lachman test (4-5 mm) with a firm end point was present in two patients (4.8%). The other two patients had grade II Lachman test.

After anterior cruciate ligament reconstruction, 38 patients (92.7%) had a negative or trace pivot shift. Two patients were graded as having grade I pivot shift and one patient had grade II pivot shift.

Post-operatively, the mean range of motion was 0° to 140° of flexion. Three patients (7.3%) had asymmetric prone heel heights of more than 1 cm indicative of flexion contracture. Two patients had 1.5 cm and 1 patient, 2 cm heel height differences.

Patello-femoral crepitation was detected in 20 patients (48.8%) post-operatively. Of those patients with post-operative patello-femoral crepitation, 70% had mild crepitation. No significant relationship between patello-femoral crepitation and knee pain could be established.

Thigh girth atrophy (asymmetry of > 1 cm) was noted in 8 patients (19.5%). There was no relationship between thigh girth atrophy and post-operative patello-femoral crepitation, knee flexion contracture, functional index, subjective grading or post-operative KT-1000 arthrometry parameter.

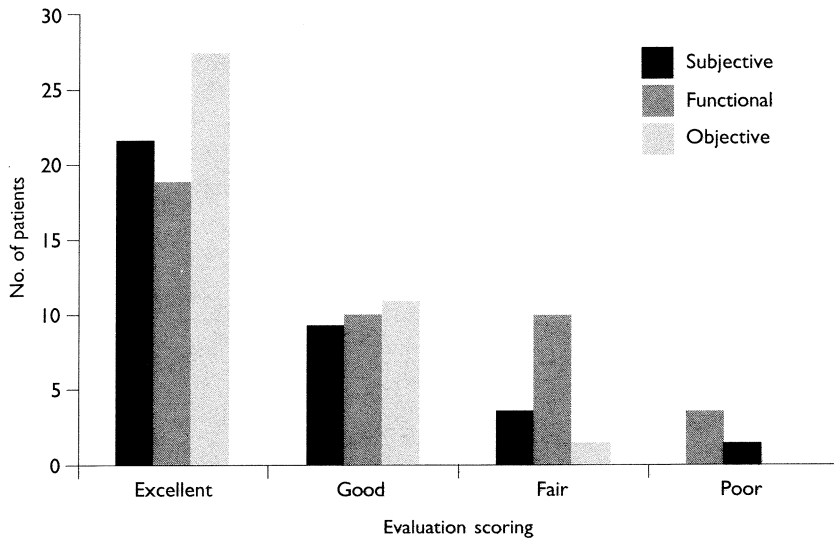


Fig 6 - Subjective, functional and objective evaluation scoring

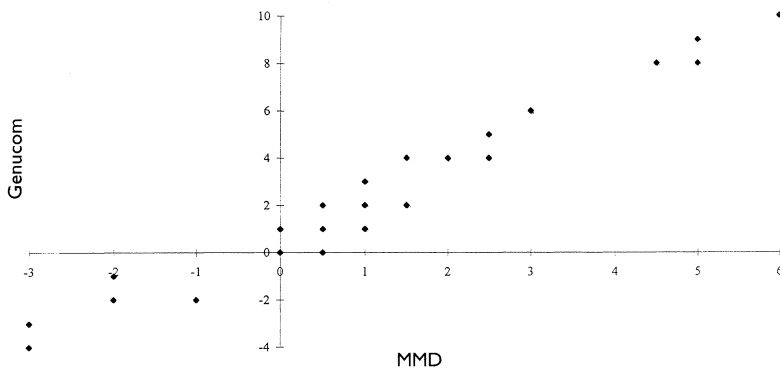


Fig 7 - KT-1000 arthrometric parameters vs genucom testing

Functional index

Single-legged hop was used as functional analysis measure. The reconstructed knee was 81% of the normal knee on single-legged hop. The ranges were from 38% to 146%. There was no statistically significant difference in this functional index in those patients with thigh girth atrophy, knee pain symptom, patello-femoral crepitation, knee flexion contracture or associated intra-articular injury. In those patients with positive pivot shift or MMD of > 4 mm by KT-1000 arthrometer assessment, the single-legged hop comparison was reduced to 54% (Fig 3). Post-operative complications also decreased the single-legged hop comparison to 41%.

Performance quotient & functional index

Performance quotient which compared the post-operative participation level and activity grade with that recorded pre-operatively was 0.61. No correlation was noted between the performance quotient and functional index (Fig 4). There was no statistically significant difference in the performance quotient in those patients with thigh

girth atrophy, knee pain symptom, knee flexion contracture, patello-femoral crepitation or associated intra-articular injury. However, patients with positive pivot shift or MMD of > 4mm by KT-1000 arthrometer assessment had a decrease performance quotient of 0.37 (Fig 5). In patients with post-operative complications, their performance quotients were reduced to 0.17.

The mean functional score was 88.2 (range 66 to 97). The functional evaluation score results were defined as follows: excellent (90 to 100 points), good (80 to 89 points), fair (70 to 79 points) and poor (< 70 points). 46.3% of the patients had excellent results, 24.4% good, 24.4% fair and 4.9% poor results (Fig 6). There was no correlation between the functional evaluation score and the performance quotient or the single-legged hop.

Subjective scores

The mean subjective evaluation score was 86.8 (range 66 to 95). 53.7% of the patients had excellent results, (90 to 100 points), 21.9% good (80 to 89 points), 12.2% fair (70 to 79 points) and 12.2% poor (< 70 points)(Fig 6). Out of the five patients with poor subjective scores, two patients had MMD of > 4 mm on KT-1000 arthrometer assessment and had positive pivot shift.

In our series, five patients (12.2%) had patello-femoral pain symptoms. All these patients experienced pain only with strenuous sports.

Objective scores

The mean objective evaluation score was 90.2 (range 72 to 96). 68.3% of the patients had excellent results (90 to 100 points), 26.8% good (80 to 89 points) and 4.9% fair (70 to 79 points). There was no patient with poor objective evaluation scoring (Fig 6). There was no correlation between the objective score and the functional score, the performance quotient, or the subjective score. However, the two patients with fair objective scores had positive pivot shift; their MMD by KT-1000 arthrometer assessment was more than 4 mm and their single-legged hop was reduced.

Table I - Stratification of MMD post-operatively

(A) Stratification of post-operative maximum manual differences (MMD)

Size (mm)	MMD	(%)
≤ 3	37	90.2
> 3 - 4	0	0
> 4 - 5	3	7.3
> 5	1	2.5

(A) Stratification of post-operative maximum manual differences (MMD) that were ≤ 3mm

Size (mm)	MMD	(%)
≤ 3 - 0	32	86.5
≥ -1 - < 0	1	2.7
≥ -2 - < -1	2	5.4
< -2	2	5.4

KT-1000 arthrometer evaluation

Post-operatively, the mean side-to-side maximum manual difference (MMD) was 0.5 mm. The range was from -3 mm to 6 mm. 90.2% of these patients had an MMD of less than 4 mm (Table I). Four patients (9.8%) had an MMD of more than 4 mm, three of these patients had a positive pivot shift. Five patients (12.2%) had a negative MMD indicating a tighter knee by KT-1000 arthrometer assessment. No statistically significant difference was noted between negative post-operative KT-1000 arthrometer parameters (tighter knee) and the incidence of knee flexion contracture, knee pain symptom, patello-femoral crepitation, functional index, subjective score or objective rating scale.

Genucom testing

Only 27 patients had Genucom testing done in the physiotherapy department. The Genucom results correlated well with the results obtained with KT-1000 arthrometer (Fig 7). The Genucom values increased with the side-to-side maximum manual difference. Those four patients with MMD of more than 4 mm had Genucom values of at least eight and above. The tighter reconstructed knees (as evidenced by negative MMD) in the five patients were also detected by Genucom testing.

Complications

None of the 41 patients had any donor site morbidity such as patellar fracture, intra-patellar tendon rupture or wound infection. There were three patients with positive pivot shift (7.3% incidence). Four patients met the criteria for failure by KT-1000 arthrometric evaluation (MMD > 4 mm); three of whom demonstrated a positive pivot shift.

Two patients developed complications post-operatively. One of them had superficial wound infection which subsided with antibiotic treatment. He did not require removal of his graft. However, his single-legged hop performance quotient and subjective score were reduced. His objective score, MMD by KT-1000 arthrometer measurement and pivot shift were normal.

The other patient had impingement syndrome due to cyclops lesion requiring debridement and notchplasty.

DISCUSSION

Our study demonstrates that anterior cruciate ligament reconstruction with immediate aggressive range of motion and early weight bearing can yield reliable stability results. This study confirms the findings by O'Brien et al^(28,29) and Bach et al⁽⁴⁾ that there were no significant differences in subjective complaints of instability, Lachman and pivot shift tests or KT-1000 arthrometric measurements.

Regarding the indications for anterior cruciate ligament reconstruction, age has been one of the controversies^(7,24). This study shows that age does not affect the post-operative results in terms of functional index, subjective score, objective rating scale or KT-1000 arthrometric measurements.

Patients in their 30s and 40s can undergo anterior cruciate ligament reconstruction successfully without developing motion problems.

Post-operative range of motion was good in this study. According to Sachs et al⁽³³⁾, 1 cm prone heel height discrepancy corresponded with 1° of knee flexion contracture. Although 7.3% of the patients in this series had knee flexion contracture (defined as asymmetric prone heel heights of more than 1 cm), none of the patients had more than 2 cm heel height discrepancy. No correlation between knee flexion contracture and tighter KT-1000 arthrometric measure, thigh girth atrophy, knee pain symptom or functional index could be established in this study. Sachs et al⁽³³⁾ noted a relationship between knee flexion contracture and patellar pain symptom; however, this relationship was not established by Bach et al⁽⁴⁾.

In recent years, patello-femoral pain symptoms^(1,2,14,15,23,33,36) after anterior cruciate ligament reconstruction have received much attention. Studies are difficult to compare because definitions and methods of assessment vary. In our series, five patients (12.2%) had patello-femoral pain during strenuous exercise. No correlation could be established between patello-femoral pain with post-operative knee flexion contracture, thigh girth atrophy or tighter KT-1000 arthrometric measurement.

Thirty-seven of our patients (90.2%) had an MMD of < 4 mm on arthrometric measurement. This clinical finding is similar to the incidence reported by O'Brien et al⁽²⁸⁾ (90%). Four patients (9.8%) met the definition of arthrometric failure (ie. MMD > 4 mm). Five patients (12.2%) in our series had tighter knees (negative MMD). This incidence compares favourably with those reported by Bach et al⁽⁴⁾ who observed that 28% had an MMD < 0 mm. Like Bach et al⁽⁴⁾, we found no relationship of tighter knees with knee pain symptom, knee flexion contracture, patello-femoral crepitation, functional index or post-operative subjective rating scale.

On single-legged hop comparison, the reconstructed knee was 81% of the normal knee. Bach et al⁽⁴⁾ reported that the reconstructed knee was 88% of the normal knee on single-legged jump comparison. Like the series by Bach et al⁽⁴⁾, no correlation could be established between this functional index and thigh girth atrophy, knee pain symptom, knee flexion contracture or associated intra-articular injury. However, single-legged hop comparison was reduced in those with positive pivot shift, MMD of > 4mm by KT-1000 arthrometric assessment and post-operative complications.

More than 70% of the patients in this series had good to excellent results on functional, subjective and objective evaluation scores (Fig 6). No correlations could be established between these evaluation scores. There was also no correlation between the evaluation scores and functional index and performance quotient.

CONCLUSION

Excellent motion recovery, reliable stabilisation rates, good arthrometric results and encouraging post-operative functional, subjective and objective evaluation scores can be expected in patients undergoing anterior cruciate ligament reconstruction with bone-patellar tendon-bone graft.

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