Functional Outcome Assessment of The Knee Joint After Anterior Cruciate Ligament Reconstruction
SK Roy1, S Debnath2, DP Mahara3, RR Kairy4

Abstract:
Anterior Cruciate Ligament injury is a common problem, frequently requires reconstruction especially for the young and active patient. Post operative assessment is mandatory for the demanding patients. There are different types of rehabilitation protocol including timing, range of motion, muscles strength, stability, proprioception, agility test (functional test) and scoring system. Here we used Lysholm and Gillquest knee score. In our study we include only 10 patients because we got total documentations for those patients only; we got normal function (95-100) in one case, near normal (84-94) in 9 cases and none of those fall in abnormal (< 84) category. We conclude that scoring assessment well correlates with the functional outcome.

Introduction:
Anterior cruciate ligament (ACL) injury is a common knee injury in young and sportsperson. Arthroscopy assisted ACL reconstruction with various grafts is the most popular knee surgery and also technically demanding. Following surgical anterior cruciate ligament reconstruction, deficits of proprioception and strength have been widely reported.1-6 The major goals of ACL surgery and rehabilitation are to restore normal joint anatomy, to provide static and dynamic knee stability and return to the pre-injury level of activity (young sportsmen) as soon as possible. It is very important that the patient should involve actively in the rehabilitation, both before and after the operation. ACL surgery and rehabilitation have undergone dramatic changes over the past decade due to extensive clinical experience, improved surgical techniques and better understanding of rehabilitation. Post operative rehabilitation unlike in other procedures is very exhausting for six months to one year with need of patient compliance. Post operative (6 months to 1 year later) assessment is mandatory to declare when return to demanding functional activities or a sport is safe or not.

Many Rehabilitation protocols are followed, among them few are as follows:7
* Campbell Clinic Protocol
* Shelbourne & Nitz Protocol( Accelerated)
* Kerlan-Jobe Clinic Protocol
* Paulos and Stern Protocol
* Others

Protocol after ACL Reconstruction:7
Traditional Restrictive (graft protection) Protocol (6M-12M)
Accelerated Rehabilitation Protocol (6M-12M)

Goal:
1. Return to pre-injury level, which requires restoration of:
   * Normal Range of motion
   * Normal Muscle Strength
   * Stable Knee
2. In Athletes: further requirements are:
   * Agility
   * Skill
   * Speed

ACL reconstruction protocol has been changed significantly in the past from traditional or earlier restrictive (graft protective) protocol to recent more aggressive or accelerated protocol.

Traditional Restrictive (graft protection) Protocol:
Exercise protocols commonly combine uniplanar, non-weight bearing, open kinetic chain exercises and more functional, multiplanar, closed kinetic chain exercises.8-10
* Knee splinting in slight flexion
* Non weight bearing crutch walking (6 Months)
* Delayed agility training (7 to 8 Months)

Poor result and non compliance:
* Adhesions/ joint stiffness
* Flexion contracture
* PF pain/ Crepitus
* Profound Quadriiceps weakness and atrophy (about 40% atrophy)
* Inability to return to pre-injury level even by 1 yr

Accelerated Rehabilitation Protocol:
This protocol provides better result.
* Knee splinted in full extension
* CPM & Weight bearing in day 1 (i.e. early ROM & WB)
* Early CKC exercises (Mini squat/ cycling)& only selective OKC exercises (Isometric Quad Exercise /SLR Exercise)
* Return to light sports activities by 2 months
* Return to full sports activities by 4m - 6 month late

References:
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**CKC Exercise:**
- Motion at knee accompanied by motion at hip and ankle
- Foot in contact with pedal, platform, or ground surface.
- Involves simultaneous contraction and contraction (concentric and eccentric) of quadriceps and hamstrings
- Increase joint compressive forces (physiological)
- Decrease or no shearing forces or strain on ACL
- Hence incorporated early in rehabilitation programme.

As for example:
- Mini squat
- Cycling
- Leg press
- Step up/down

**OKC Exercise**
Motion at knee is independent of motion at hip and ankle
Foot is free to move, e.g. Leg in extension, Leg curls
Excessive strain on ACL graft & elongation.
Hence, avoided during early rehabilitation
It increase joint mobility
Early reeducation of proprioceptive receptors
Stimulates functional and sports related activities
Increase muscle strength.

**Material and Methods:**
This is a perspective study, includes those patient underwent ACL reconstruction in Different hospital of Dhaka and Kathmandu during the period of 2006 to 2009 and having full documentations.
Number of patient is ten; follow up period was 9 months to 16 months (Mean 11.7 months). Here we followed Lysholms score system also included functional hoop test (Agility test), ROM (Range of Motion) and JPS (Joint Position Sense) components.

**Functional outcome assessments:**
There are batteries of assessments to determine when an athlete after ACL reconstruction can safely return to functional activity or sports, which vary slightly according to different rehabilitation protocol, but in general they are:

1. **Timing**
2. **Range of motion**
3. **Muscle strength** (Dynamic Stability)
4. **Stability** (Static)
5. **Proprioception**
6. **Agility test** (Functional test)
7. **Scoring system** (Questionnaires)

The aforementioned tests are being performed for evaluation of function following ACL reconstruction.

### Table 1

<table>
<thead>
<tr>
<th>Serial No.</th>
<th>Time (in months)</th>
<th>Post op Age (Yrs)</th>
<th>Lysholm Single Hop (normal)- (°)</th>
<th>Lysholm Single Hop (Ope)- (°)</th>
<th>Hop for distance (% of Normal)</th>
<th>Hop for over distance (% of Normal)</th>
<th>Cross Quadriceps Hamstrings strength (°)</th>
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<td>Average</td>
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</table>

### Table 2

<table>
<thead>
<tr>
<th>Total No</th>
<th>Anterior Drawer Test</th>
<th>Lachman Test</th>
<th>Pivot shift test</th>
</tr>
</thead>
<tbody>
<tr>
<td>Right: -6</td>
<td>Negative-3(stable)</td>
<td>Negative-2(stable)</td>
<td>Normal: 3</td>
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<tr>
<td>Light: -4</td>
<td>5 Partially</td>
<td>6 Partially</td>
<td>Glide: -7</td>
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<td>+ &gt; 2 stable</td>
<td>+ &gt; 2 stable</td>
<td>Chuk: Nil</td>
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<td>+ + &gt; 2 Nil</td>
<td>+ + &gt; 2 Nil</td>
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**Timing:**
- Usually 6 month - 12 month (Surgeons preference)

In our study average timing: 11.7 months

**Range of Motion (ROM):**
- Should be full (0 - 1300 to1400 )

Our result:1330

**Swelling (Joint effusion):**
- There should be no swelling or joint effusion when the athlete is ready to go back to sports
* Persistent joint effusion produces significant quad atrophy (neuromuscular inhibition)
- Isometric quadriceps setting Ex. ankle pumps, limb elevation, compression bandage help to control or reduce the edema and joint effusion
(4) Muscle strength Tests (Dynamic stability):
* Any standard series measures the isokinetic strength of quadriceps and hamstrings by the use of special device such as Cybex isokinetic dynamometer or Kim Con dynamometer.
* Most protocol recommend 80 - 90% isokinetic strength of these muscles as compared to uninvolved side as the prerequisite for safe return to sports
IN OUR SET-UP: We have measured the strength of quadriceps and hamstrings of both limbs with the use of simple STRAIN GAUGE weighing machine with the patient seated on chair at 900 knee flexion
* Three readings of each muscle strength are taken
* Average is calculated
* Average muscle strength found of involved limb was
  - Quadriceps --- 96.32-% of normal side
  - Hamstring ---- 95.08-% of normal side

(5) Stability Test (Static):
* Standard series measures the anterior stability of the involved knee joint accurately with a sophisticated device like KT-1000 Arthrometer and grade the laxity.
* We totally rely on clinical tests alone, namely
  - Anterior Drawer Test (ADT) at 900 flexion
  - Lachman Test (LT) at 20-300 flexion
  - Pivot Shift Test (Extension to flexion method)

LT
Normal (No instability) = 2
+ = 6
++ = 2
+++ = Nil

ADT
Normal (No instability) = 3
+ = 5
++ = 2
+++ = Nil

Pivot Shift Test:
Negative (Normal) = 3
Glide (nearly normal) = 7
Clunk (abnormal) = Nil

(6) Proprioception or Joint Position Sense (JPS):
* Normal ACL is rich in mechanoreceptors for JPS
* Disrupted ACL is devoid of these receptors impairing JPS
* It is unclear: WHETHER RECONSTRUCTED ACL CAN RESTORE OR IMPROVE LOST PROPRIOCEPTION OR JPS
* Ochi et al (1999) suggested "sensory innervations occurred in reconstructed ACL"
* JPS improves at least 9 months or later after ACL reconstruction
* Prolonged immobilization after ACL reconstruction
  * Impair proprioceptive functions of other intact structures like capsules, ligaments, tendons, and muscles thereby increasing the chance of re-injury

Accelerated Rehabilitation:
* Improves JPS by re-educating proprioceptive receptors
* Early: by ROM, WB and CKC Ex
* Later: by Agility training

General Recommendation:
Proprioception of Reconstructed knee should be almost normal for safe return to sports activities

In our study:
- No of patients: 10 (only documented cases are taken in study)
- Post op period: 9 - 16 months
- Functional Weight bearing (Flexion) Protocol at 00 to 300
  - Both reconstructed & normal knees compared
  - Goniometer taped (fixed) on lateral aspect of the knee with the hinge at the level of lateral femoral epicondyle
* Targeted angle (TA) between 00 - 300 flexion attained activity, held for about 5 seconds - knee straightened for about 7 seconds - instructed to reproduce the angle (RA)
* Five repetitions done at different random angles (to avoid learning effect)
* Difference in TA & RA is calculated, averaged, and compared with the normal knee

* Result: No loss of JPS of any patient as compared to the Normal

(7). Functional Hop Tests (AGILITY TESTS):
These tests provide quantitative functional status of the knee
Four most commonly used tests are:-
* One-legged single Hop for distance
* One-legged timed Hop
* One-legged triple Hop for distance
* One-legged cross-over Hop for distance

Methods and Calculation
Each test is performed three times for each extremity and then averaged.
(i) Single Hop: Person stands on one limb, hops as far as possible, and lands on the same limb. The distance obtained for each extremity is measured and used for comparison.
In other words it is simply one hop for a maximum distance
Limb symmetry = Involved x 100
                  Non-involved
Result: 87.73%
(ii) Timed Hop.11, 12: Person stands on one limb and then hops a distance of six meter. The time is measured for each extremity and used to determine the symmetry index.
That is the time required to hop a distance of six meter
Limb symmetry = Non- involved x 100
                  Involved
Result: 94.2%
(iii) Tripple Hop 13: Person stands on one limb and performs three consecutive hops, landing on the same foot. The distance is measured for each extremity and used to determine the symmetry index.
It is the three consecutive hops for a maximum distance on the same extremity
Limb symmetry = Involved x 100
                  Non involved
Result: 93.3%
(iv) Cross- over Hop 13: Person hops three times on one limb over a 15 cm wide center strip. The distance for each extremity is measured and used for comparison.
Is the three consecutive hops for a maximum distance but crossing the midline
Limb symmetry = Involved x 100
                  Non-involved
Result: 93.2%
Interpretation:
Operated leg is compared with the non-operated leg and difference of 15% in each one is considered an abnormal result.
(8). Knee Scoring: (Subjective evaluation).14, 15 Draper and Ladd16 used the Lysholm and Gillquist Knee Score scale to assess knee function and activity levels of patients with ACL reconstructed knees.
It is a subjective scoring system evaluating
- Limp-------------------------5
- Supports---------------------5
- Symptoms of locking---------15
- Instability------------------25
- Pain-------------------------25
- Swelling---------------------10
- Stair climbing---------------10
- Squatting--------------------5
Lysholm and Gillquist Knee Scoring System:
Limp
None 5
Slight 3
Severe/constant 0
Support
None 5
Stick/crutch 3
Weight bearing impossible 0
Locking
None 15
Catching but no locking 10
Occasional locking 6
Frequent locking 2
Locked on exam 0
Instability
Never 25
Rarely/severe exertion 20
Frequent with athletics 15
Occasionally with ADLs 10
Often with ADLs 5
Every step 0
Pain
None 25
Slight 20
Marked with exertion 15
Marked walking > 2 km 10
Marked walking < 2 km 5
Constant 0
Swelling
None 10
Severe exertion 6
Ordinary exertion 2
Constant 0
Stair Climbing
No problems 10
Slight impair 6
One step at a time 2
Impossible 0
Squatting
No problem 5
Slight impair 4
Not beyond 900
Impossible 0
Total Score---------
Score Evaluation System:14, 15
Evaluation Score = 0-100
95-100 = Normal function
84-94 = Symptoms only with vigorous activity, &< 84 = Symptoms with activity of daily livings (ADLs)
Our results:
We used this system for its simplicity & easy interpretation
Normal function (95-100) = 1
Near normal (84-94) = 9
Abnormal (< 84) = Nil
Conclusion:
Aggressive or Accelerated post operative rehabilitation protocol after ACL reconstruction with early involvement of passive mobilization, weight bearing, closed kinetic chain exercises with selected open kinetic chain exercises and later involvement of various agility and sports specific exercises have proved the test of time with the best functional outcome.
To declare the safety on return to sports/ functional activities, the functional outcome of the surgery needs to be assessed with battery of objective-subjective tools like ROM, Isokinetic muscle strength testing, stability testing, Proprioception, hopping for distance and scoring system in conjuncture to each other. No one test is complete in its own to be used alone for the same purpose.

References: