Quantitative Analysis of Pivot Shift Test for Anterior Cruciate Ligament Injury of Knee Joint

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ABSTRACT

BACKGROUND

Of all the tests done to assess the anterior stability of knee joint i.e. anterior cruciate ligament (ACL) intactness, the pivot shift is a dynamic but passive test of knee stability, carried out by the examiner without any activity of the patient. It shows asynchrony between rolling movement and gliding movement of the knee joint. The patient lies in supine. The movement is a combination of axial load and valgus force, applied by the examiner, during a knee flexion from an extended position. When the test is positive, it indicates an injury of the anterior cruciate ligament.[1,2] We wanted to study the tibio-femoral translation when the knee is in neutral position and when it is flexed to 30°.

METHODS

This study was conducted in the Department of Orthopaedics in A.C.S.R. Govt. Medical College from January 2017 to June 2019. In 20 patients with anterior cruciate ligament injury who volunteered for the examination, measurements were taken in anterior tibio-femoral translation with knee in neutral position and when it is flexed to 30°. Of 20 patients 16 patients are male and 4 patients are female. Patients were in the age group of 17-36 years with average age of 27 years. All 20 patients had instability of knee joint on clinical examination in the form of positive anterior drawer and Lachman tests. Every patient was checked by pivot shift test under anaesthesia. All the 20 patients included in the study had positive pivot shift test under anaesthesia. Bony landmarks in the form of lateral epicondyle of femur marked as point A, Gerdy's tubercle on proximal tibia as point B and fibula head as point C were localized. These bony landmarks were transfixed using K-wires. The distance between these points was measured. The distance between points A and B is measured as AB, between points B and C is measured as BC and the distance between points A and C is measured as AC. All these lengths AB, BC & AC were calculated at knee in full extension and at 30° flexion (In case of positive pivot shift test for all most all patients the angle at which the subluxated proximal tibia gets reduced is 30° which was confirmed by goniometer).

RESULTS

The data of measurements were collected and tabulated. The results are correlated using Spearman's Rank correlation coefficient of the variables. The coefficient for AC is calculated which is 0.7554 in 0° and 30° flexion and for AB it is 0.4387 in 0° and 30° flexion. Hence the correlation of AC in 0° & 30° is strong and the correlation of AB in 0° & 30° is moderate to low.

CONCLUSIONS

Pivot shift test despite of being a subjective test we have concluded that there is a moderate to strong correlation between relative movements of distal femur (represented by lateral femoral epicondyle) & proximal tibia (represented by Gerdy's tubercle & fibular head).

KEYWORDS

Pivot Shift, ACL Injury

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BACKGROUND

In 1919, Hey Groves et al. described the characteristic symptoms of ACL deficiency. In particular, he described the reduction process following subluxation near extension. Anterior subluxation of the lateral tibial plateau near extension in ACL deficiency was originally described by Lemaire as a separate stability test in 1967. Later in 1980 Galway and MacIntosh described the same.[4] With an ACL tear, the knee which will remain reduced in full extension will subluxate anteriorly with appropriate stress and will gets reduced at 30° to 40° of flexion. In the normal people with intact ligamentous stability when the knee joint is moved from flexion into extension, the lateral condyle rotates forwards and is limited by intact ACL and the medial condyle synchronously rotates backward which is limited by PCL resulting in locking of the knee with tightening of both cruciate ligaments. When flexing the extended knee, tibia undergoes medial rotation over femur which is unlocking of knee by popliteus muscle. The unlocking or rotation movement relaxes tension of collateral ligaments and permits flexion of knee. During the extension and locking, femur rotates medially, and the tibia move forwards and rotates laterally which results in tightening of collateral ligaments.[5]

Method of Eliciting Pivot-Shift Phenomenon-

When the test is performed the patient should lie in supine position and the examiner should stand on the side of the knee that is being examined. It is necessary to keep the hip in abduction and flexion to relax the iliotibial band. With one hand the ankle or the lower leg is grasped, and tibia is internally rotated to 20°. With other hand the proximal leg is grasped at the level of head of fibula at which valgus stress is applied maintaining the internal rotation. Now knee is slowly flexed applying the axial load and valgus stress maintaining the internal rotation. Pivot shift test is positive if the tibia is anteriorly subluxated (lateral > medial) at extension and reduces on femur at 20 to 40 degrees of flexion.[6,7] While it is widely stated in the literature that the pivot shift test is characteristic of anterolateral instability, a positive test still requires an intact iliotibial band. However, in high grade anterolateral instability may be due to concomitant injury of the iliotibial band.

Jakob Grading[8]

Grade I pivot shift- Tibia is subluxated anteriorly over femur only when held in maximum medial rotation. This is absent in neutral and lateral rotation positions.

Grade II pivot shift: Tibia is subluxated anteriorly over femur when held in medial rotation (with a clunk) and neutral positions. This is absent in lateral rotation position.

Grade III pivot shift: Tibia is subluxated anteriorly over femur in medial rotation, neutral and lateral rotation positions indicating anterolateral and anteromedial laxity.

METHODS

This prospective study was carried out at Orthopaedics department of A.C.S.R. Medical College from January 2017 to June 2019, after obtaining approval from our institutional board and informed consent with a subgroup of 20 patients. The criterion of patient selection is those who are having post traumatic isolated ACL tear which is supported by the patient's complaints of pain and instability, clinical examination with findings of positive anterior drawer test and Lachman test, radiological findings of positive anterior translation in anterior drawer stress x-rays and signal intensity changes and fibres disruption on MRI. The patient selection is irrespective to acute or chronic injuries. Among 20 patients there are 16 male patients and 4 female patients. The mode of trauma among 13 males and 2 females is sports injury. In rest 2 females, mode of trauma is fall and twisting injury from standing at height. In rest of the male patients the mode of trauma is road traffic accident. Among 20 patients 16 had right knee involved and 4 had left knee involved. Patients having bilateral knee injuries, multiple ligamentous injuries, arthroscopic revision ACL reconstructions and patients with ACL tear who show negative pivot shift test even when examined under anaesthesia are excluded from this study subgroup.

All these patients underwent thorough evaluation in the form of elaborate history taking and thorough clinical examination. Radiographic examination was done in the form of anteroposterior and lateral x-rays in neutral position and lateral x-rays with anterior stress and posterior stress. MRI scan of involved knee was done in each patient which reported changes suggestive of ACL tear in the form of signal intensity changes in ACL, fibre discontinuity, decrease in the inclination angle and/or coexistent buckling of PCL. Necessary blood reports and pre anaesthetic check-up was done in every patient. 19 patients were given short general anaesthesia. After administering anaesthesia examination of the involved joint was done under anaesthesia in the form of anterior drawer test, Lachman test and pivot shift test, varus & valgus stress test. Patients having positive pivot shift test and without having any significant joint opening in the varus and valgus stress test were taken into consideration for the data collection.

After clinical examination, under anaesthesia painting and draping was done. Bony landmarks were palpated and labelled with sterile marker at Point A- Lateral epicondyle of femur, Point B- Gerdy's tubercle on proximal tibia. Point C- Prominence of head of fibula. After identifying the bony landmarks, K-wires were used with electric drill machine to transfix these bony points and then measurements were taken as follows- AB- distance between bases of K-wires at points A & B, BC- distance between bases of K-wires at points B & C, AC- distance between bases of K-wires at points A & C.

These measurements were taken with knee at full extension when the tibia was subluxed anterolaterally and at the angle of knee arc when the anterolaterally subluxed

proximal tibia reduces with a click when knee is flexed from extended position with valgus stress at knee hip abducted & an axial compression of the affected lower limb (method of pivot shift test) which came out to be 30° in most of the patients. All the measurements were collected in the form of AB, BC and AC in centimetres at knee joint extended and at knee joint flexed at 30°. The data was interpreted using Spearman's Rank correlation coefficient.

Figure 1. Pins Fixed into Bony Prominences and Marked as A, B and C

Figure 2. Measuring Distance Between the Pins in Extension of Knee

Figure 3. Measuring Distance Between the Pins in 30° Flexion of Knee

RESULTS

All the measured data was collected and tabulated. Spearman's Rank correlation coefficient of the variables is calculated which 0.4387 for AB in 0° & 30°, 0.7554 for AC in 0° & 30°.

For values of coefficient of 0.9 to 1, the correlation is very strong. For values of coefficient between 0.7 and 0.89, correlation is strong. For values of coefficient between 0.5 and 0.69, correlation is moderate. For values of coefficient between 0.3 and 0.4.9, correlation is moderate to low. For values of coefficient between 0.16 and 0.29, correlation is weak to low. For values of coefficient below 0.16, correlation is too low to be meaningful. Hence the correlation of AC in 0° & 30° is strong, the correlation of AB in 0° & 30° is moderate to low.

Name of the Patient	Age & Sex	Knee in Full Extension			Knee in 30° Flexion		
		AB	BC	AC	AB	BC	AC
S. Krishna Prasad	M/32	5 cm	3.5 cm	5.5 cm	5 cm	3.5 cm	5.5 cm
Jamuna. K	F/36	5.5 cm	4 cm	6.5 cm	6 cm	4 cm	7 cm
Surendra Paul. A	M/26	5 cm	3.1 cm	6 cm	5.3 cm	3.3 cm	6 cm
M. Muni kumara	F/19	5.5 cm	3.8 cm	5.5 cm	5.2 cm	3.8 cm	5.5 cm
J. Jeevaratnam	M/32	6.8 cm	3.5 cm	7.5 cm	6.8 cm	3.5 cm	7.5 cm
P. Madhukiran	M/20	6.3 cm	4.3 cm	6.3 cm	7.5 cm	4.3 cm	7 cm
K. Venkaiah	M/35	4.5 cm	5.5 cm	7 cm	5.5 cm	5.5 cm	7.2 cm
Sk. Rubeena	F/32	4.2 cm	3.2 cm	5.5 cm	4.4 cm	6 cm	3.8 cm
L. N. Murthy	M/35	5.6 cm	4 cm	7.5 cm	5.8 cm	4 cm	6.5 cm
V. Hari	M/36	5 cm	3.5 cm	5.5 cm	5.6 cm	3.5 cm	6 cm
K. Suman	M/27	5.7 cm	4.5 cm	6.5 cm	6 cm	4.5 cm	7.2 cm
N. Mani Babu	M/21	3 cm	3.5 cm	5.5 cm	4.5 cm	3.5 cm	5.7 cm
V. Amarnath	M/19	4.5 cm	4 cm	6 cm	4.6 cm	4 cm	6 cm
K. Sasikumar	M/27	4 cm	4.2 cm	5.1 cm	4 cm	4.2 cm	5.5 cm
Annamalai	M/25	4.5 cm	4.5 cm	5.5 cm	5 cm	4.5 cm	5 cm
Anandkumar. J	M/20	4 cm	4 cm	6 cm	4 cm	4 cm	5.5 cm
K. Rajendra	M/17	3.5 cm	5.5 cm	5 cm	3.5 cm	5 cm	4.5 cm
J. Suma Reddy	F/22	4 cm	5.5 cm	5 cm	4.5 cm	6 cm	5 cm
P. Teja	M/22	5 cm	3.5 cm	5.5 cm	5.6 cm	3.5 cm	6 cm
S. Aravind	M/36	5 cm	3.1 cm	6 cm	5.3 cm	3.3 cm	6 cm

Table 1

Comparison	Spearman's Rank Correlation Co-Efficient
AB of 0° & 30°	0.4387
AC of 0° & 30°	0.7544

Table 2

DISCUSSION

Anterior cruciate ligament injuries were the most common knee injuries and account for 86.5% of total knee injuries. 8 The three major tests for determination of ACL injury are anterior drawer test, Lachman test and pivot shift test. Pivot shift test unlike the other two tests it determines the instability and functional security of the knee joint and is an important determinant of the functional and stability outcome of the knee. Pivot shift is a subjective test. Grading of the pivot shift as by Jakob's is as grades I, II & III which is subjective way to determine, so this is not useful to use this grading for the treatment algorithms of ACL instability. So instead of using this subjective grading for the treatment protocol of the patients it will be more useful to quantify the pivot shift and use the measurable classification to use in the treatment algorithms. As per the measurements of the relative movements of the femur with respect to tibia and fibula which in our study showed strong to moderate correlation, it was determined that pivot shift is not absolutely subjective hence quantification is done. Thus, pivot shift test which tests the rotational instability of the knee with respect of femur with the tibia and fibula can be used to measure the rotational instability.

Assessing knee stability with only the Lachman test and anterior drawer test and using pivot shift test without quantifying were not applicable to screen patients needing extra-articular tenodesis. This quantification of the pivot shift is most useful in determining which patient needs extra-articular tenodesis for restoring rotational stability and which patients needs only the ACL reconstruction.[9]

CONCLUSIONS

Pivot shift test despite being a subjective test shows moderate to strong correlation between relative movements of distal femur (represented by lateral femoral epicondyle) and proximal tibia (represented by Gerdy's tubercle & fibular head). Hence, we have quantified the pivot shift test which is not absolutely subjective.

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