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Diagnostic Value of Lachmeter in Measuring Anterior Tibia Translation on Post-Anterior Cruciate Ligament Tear Reconstruction Compared to CT Scan

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Abstract

BACKGROUND: Anterior translation of the tibia (ATT) is a secondary sign of an anterior cruciate ligament (ACL) tear. With advances in technology, new tools such as the Lachmeter are expected to replace computed tomography scanning (CT scan) in measuring the ATT.

AIM: This study aims to determine the diagnostic validity of the Lachmeter in measuring the ATT 6–12 months after ACL tear reconstruction.

MATERIALS AND METHODS: A retrospective diagnostic test with a Lachmeter was used to measure ATT in patients 6–12 months after ACL tear reconstruction, compared with the gold standard CT scan and using a consecutive sampling technique. The optimal cutoff value of ATT was determined with Lachmeter afterwards. Statistical Package for the Social Sciences version 21.0 was used for the data analysis.

RESULTS: There are 28 persons with a positive ATT (≥ 5 mm) and four people with a negative ATT (<5 mm) measured using CT scan out of 32 samples. The optimal cutoff of ATT with Lachmeter is ≥7.28 mm (Area under curve = 0.88, 95% CI, 0.67–1.00 and p = 0.004) with a sensitivity of 84.62%, specificity 83.33%, positive predictive value 95.65%, negative predictive value 55.56%, positive likelihood ratio (LR) 5.08, negative LR 0.18, and 84.38% accuracy.

CONCLUSION: Lachmeter is a new tool for determining ATT that is highly efficient and easy to use. With good sensitivity and specificity values, this new tool has been proven to be very good at measuring ATT compared to CT scan as the gold standard.

Introduction

The anterior cruciate ligament (ACL) is a critical supporting ligament in the knee that contributes to the stability and mobility of the knee [1]. Meanwhile, ACL injuries are common in the active population and athletes, with an annual incidence of ACL tears ranging between 30 and 78 people per 100,000 cases, or 0.08% [2]. More than 70% of ACL injuries occur as a result of injuries that do not involve direct contact with the knee joint as the cause of injury, such as landing from jumping movements or movements in sports such as basketball and soccer [3].

The orthopedic examiner will analyze the patient's posture, edema, range of motion, and perform the lachman and anterior drawer tests when there is a suspected ACL tear [4]. Along with physical examination, there are several digital tools available to assist in diagnosing ACL tears such as the KT 1000 arthrometer and the new Lachmeter. After being clinically tested in various studies, the latter has relatively similar results to the KT 1000 arthrometer, making it the primary digital tool of choice for anterior translation of the tibia (ATT) measurements [5]. A study by Heffernan *et al*. that tested the accuracy of 64-slice MDCT against magnetic resonance imaging (MRI) in diagnosing ACL tears stated that computed tomography scanning (CT scan) have high specificity and sensitivity in detecting the presence of tears and secondary signs of ACL tears such as Segond fracture, posterior cruciate ligament buckling, ATT, and deep lateral femoral notch [6].

ACL reconstruction surgery is the primary treatment for ACL injuries. In the United States, it is estimated that between 250,000 and 350,000 ACL repair operations are performed each year [7]. Follow-up examinations such as physical examination and imaging are necessary to determine the operation's success, which are best performed 6 months postoperatively, as full restoration of the biological and mechanical properties of an intact ACL

occurs after 6 months [3]. Despite its radiation exposure, CT scans can provide more information than other imaging modalities in cases of post-ACL reconstruction. The Lachmeter, a novel tool for determining ATT that is both highly efficient and easy to use, can be used to conduct physical examinations. However, because this tool is so new, it is difficult to obtain because it is only available in a few countries; also, the price is rather high; additionally, operator dependence and instrument inaccuracy in digital tools are disadvantages of the Lachmeter. On this basis, this study was done to verify the Lachmeter's diagnostic validity in measuring ATT 6–12 months following ACL tear reconstruction using CT scan.

Materials and Methods

This study is a retrospective diagnostic test which will determine the specificity, sensitivity, positive and negative predictive values (NPV), positive and negative likelihood ratios (LR), and accuracy. The research used secondary data from patients who were 6–12 months post-ACL reconstruction at Sanglah Hospital, Denpasar (Ethical clearance approved: 284/UN14.2.2.VII.14/LT/2021). The purpose of this study is to compare ATT measurements taken with a Lachmeter to CT scans as the gold standard.

Between October 2020 and July 2021, the study enrolled 32 subjects who had undergone ACL reconstruction surgery at least 6 months before the CT scan. The CT scan was performed with a 128 slice CT scan (Somatom, Siemens, Erlangen, Germany) with the patient's knee flexed 20–30^{o} on the Lachmeter pillow and the cruris straight. The ATT was then measured at the parasagittal level between the lateral condyle of the femur and the posterior tibia using a bone window (Figure 1). Researchers obtain the ATT distance measured with a Lachmeter (Figure 2) from medical records.

Data were analyzed using Statistical Package for the Social Sciences version 21 for Windows. Descriptive statistics were used to represent the continuous variables. Diagnostic analysis were presented by a two-by-two (2 × 2) table to explain the sensitivity, specificity, positive predictive value (PPV), NPV, positive LR, negative LR, and the diagnostic accuracy. A perfect diagnostic test has an area under curve (AUC) 1.0, whereas a non-discriminating test has an area 0.5. $p < 0.05$ was considered statistically significant.

Results

In the current study, a total of 32 subjects (27 males and 5 females) with a mean age of 29.6 ± 7.84 were included. Sports-related injuries and motorbike accidents are the most common reasons for reconstructive surgery. There were 24 people who get ACL repair utilizing a peroneus longus graft and eight people who undergo hamstring graft reconstruction (Table 1).

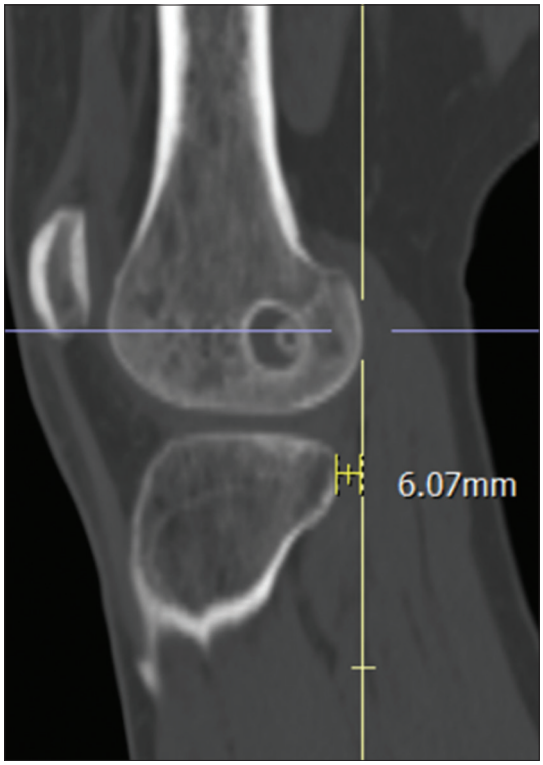

Figure 1: ATT CT scan

According to the CT scan results, there were 28 persons with ATT T 5 mm (87.5%) and four additional people (12.5%) with ATT < 5 mm (Table 2). The results of Lachmeter measurements were gathered from medical records and were the average result of 3 Lachmeter examinations. Therefore, no interobserver

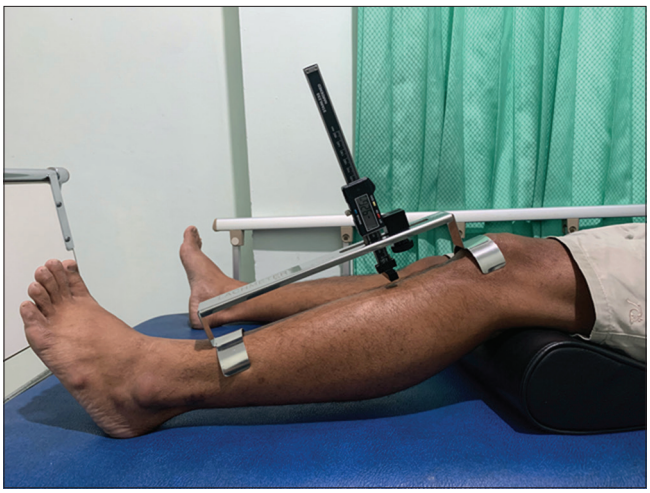

Figure 2: The Lachmeter has a high practical value since it is practical, small, and easy to carry. The use of a Lachmeter to determine ATT is also advantageous in situations where advanced radiological modalities such as CT scans are unavailable; it is quick and simple to use by experienced examiners

Table 1: Characteristics of research subjects

Variable	n = 32
Age (year) mean (SB)	29,6 (7,84)
Gender (n)	
Male	27
Female	5
Reason for reconstruction operation (n)	
Sport	23
Basketball	6
Football/futsal	17
Motorcycle accident	9
Type of graft used (n)	
Peroneus longus	24
Hamstring	8

test was carried out in this study when measuring ATT with Lachmeter.

The following is a description of the receiver operating characteristics (ROC) curve analysis (Figure 3) which has a wide AUC which is calculated at 0.88 with a 95% CI 0.67–1.00 and p = 0.004.

Table 2: Comparison of ATT measurement results between CT scan and Lachmeter

Subject	Lachmeter (mm)	CT scan (mm)
1	2,86	2,00
2	4,30	4,02
3	4,50	4,90
4	4,80	4,90
5	8,72	5,00
6	9,27	5,02
7	3,80	5,20
8	6,53	5,29
9	5,53	5,88
10	7,60	6,01
11	7,26	6,07
12	6,50	6,08
13	7,30	6,28
14	9,27	6,48
15	7,50	7,00
16	7,60	7,01
17	8,40	7,03
18	8,60	7,03
19	8,60	7,05
20	8,70	7,10
21	8,60	7,15
22	8,76	7,20
23	8,09	7,29
24	8,50	7,30
25	8,30	8,03
26	10,10	9,07
27	10,12	9,28
28	13,50	10,10
29	7,44	10,27
30	10,10	12,08
31	11,50	12,88
32	7,41	12,90

ATT: Anterior translation of the tibia, CT scan: Computed tomography scanning

The optimal cutoff result for the ATT measurement with Lachmeter is m 7.28 mm, which is based from the diagnostic test results (Table 3), with a sensitivity of 84.62% (95% CI 65.13–95.64%), specificity 83.33% (95% CI 35.88–99.58%), PPV 95.65% (95% CI 78.49–99.25%), NPV 55.56% (95% CI 32.15–76,73%), LR (+) 5.08 (95% CI 0.84–30.61), LR (–) 0.18 (95% CI 0.07–0.49), accuracy 84.38% (95% CI 67.21–94.72%), and prevalence 81.25% (95% CI 63.56–92.79%). The cutoff value with the highest

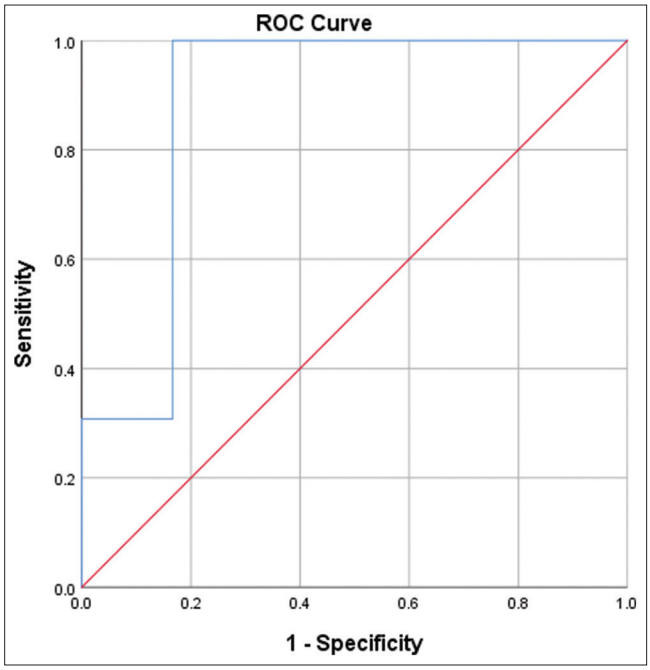

Figure 3: ROC sensitivity and 1-specificity curves on lachmeter in diagnosing ATT were compared with the gold standard CT scan (AUC = 0.88, 95% CI, 0.67 – 1.00 and p = 0.004)

sensitivity was <5.16 mm with a specificity of 83.3% and the cutoff value with the highest specificity was 8.74 mm with a sensitivity of 30.8%.

Discussion

ACL injuries frequently occur in young adults, particularly among the active population, people who engage in high levels of activity, and athletes. The subjects in this study had a mean age of 29.6 ± 7.84 years (range 21–47 years), with men accounting for 84.4% of the total. It is in accordance with the previous study which stated that the age of incidence of ACL tear injury was 14–45 years [4]. Moses *et al*. also reported a male predilection for ACL tear injuries in their previous study [4], [8]. Sports injury (23 people) was shown to be the most common reason for ACL tear reconstruction in this study. Singh also showed that soccer and basketball players have a higher rate of ACL tear injuries [9].

CT scan is the gold standard radiological imaging for ATT measurement, and Heffernan *et al*. mentioned that a distance of ≥5 mm is already considered abnormal [6]. In addition, the CT scan can

Table 3: ATT diagnostic parameter on Lachmeter compared to CT scan

Cutoff (mm)	Sensitivity (%) 95% CI	Specificity (%) 95% CI	PPV (%) 95% CI	NPV (%) 95% CI	LR (+) 95% CI	LR (–) 95% CI	Accuracy (%) 95% CI
≥7,28	84,6 65,13–95,64	83,33 35,88–99,58	95,65 78,49–99,25	55,56 32,15–76,73	5,08 0,84–30,61	0,18 0,07–0,49	84,38 67,21–94,72
<5,16	100,39,76-100	83,33 81,65–99,91	96,29 36,86–96,48	100	5,99 4,09–191,88	NA	96,87 83,78–99,92
≥8,74	30,8 13,22–48,67	100 39,76–100	100	16,6 713,66–20,18	NA	0,690,57–96,49	43,7721,1–56,31

PPV: Positive predictive value, NPV: Negative predictive value; LR (+): Positive likelihood ratio, LR (–): Negative likelihood ratio, NA: Non-applicable, CI: Confidence interval.

provide other critical information for post-reconstruction evaluation of ACL tears, such as the diameter of the femoral or tibial tunnel and the angle at which the graft is positioned following reconstruction. These factors must be evaluated to find out whether the ligamentization process has occurred, and if there are any future complaints on the operated knee, it may be related to the graft remodeling process taking too long due to the widening of the tunnel diameter.

In this study, 28 patients had an impression of abnormal ATT (Tthis st–12 months after reconstruction of an ACL tear, while four others had normal ATT (<5 mm) as evaluated by CT scan. This positive ATT result implies that ligamentization happened during the 6–12 month timeframe. It is in accordance with Claes *et al*., which found that remodeling and maturation of the ACL graft began 6 months following reconstruction [10]. Claes *et al*. reported that the presence of negative results/patients with ATT <5 mm could be related to inadequate rehabilitation duration factors and the length of time the patient returns to activities/exercise before reconstructive surgery [10].

The ROC curve analysis yielded an excellent result, where the AUC is measured at 0.88 with a 95% CI 0.67–1 and p < 0.004. The optimum cutoff value of ATT with the Lachmeter from the ROC curve is ≥7.28 mm with a sensitivity of 84.62% (95% CI 65.13–95.64%), specificity 83.33% (95% CI 35,88–99.58%), PPV 95.65% (95% CI 78.49–99.25%), NPV 55.56% (95% CI 32.15–76.73%), LR (+) 5.08 (95% CI 0.84–30.61), LR (–) 0.18 (95% CI 0.07–0.49), and accuracy 84.38% (95% CI 67.21–94.72%). This new tool has a relatively high sensitivity and specificity value, making it ideal for measuring ATT, which is considered abnormal with a cutoff of 7.28 mm. The prevalence in this study was 81.25%, which means that if ATT is suspected during a physical examination and followed by a Lachmeter examination, the ATT is most likely to increase to 95.65%. Because the abnormal ATT cutoff for a Lachmeter with 100% sensitivity is < 5.16 mm, an ATT below 5.16 can be used to rule out the diagnosis. This cutoff value can be utilized for screening because it has a specificity of 83.3% and a very high accuracy of 96.87%.

Meanwhile, the abnormal ATT cutoff with 100% specificity (8.74 mm) has a sensitivity of 30.8% and a PPV of 100%. An ATT of more than 8.74 mm confirms the diagnosis of abnormal ATT, suggesting further therapy to prevent secondary osteoarthritis and additional damage.

The findings of this study provide essential information to clinicians about the optimal ATT cutoff when using a Lachmeter, as well as the most specific and sensitive ATT cutoff value. Because no other study has ever examined the diagnostic utility of this novel instrument, this information is extremely important.

There are certain limitations to this research. First, a lack of available samples because patients who met the inclusion criteria had to be at least 6 months post-ACL reconstruction; thus, patients who had recently undergone surgery were excluded. Second, the CT scan plane experienced an issue, impeding the CT scan process for the included patients. Third, there is a subjectivity aspect from the Lachmeter examination, as the size of the pulling force applied can change the amount of ATT acquired. Therefore, we recommend a prospective study with larger samples for a more accurate result. Another advanced radiological modality, such as MRI, can also be utilized in further study to simultaneously assess the attached ACL graft.

Conclusion

Lachmeter is a new tool for determining ATT that is highly efficient and easy to use. With good sensitivity and specificity values, this new tool has been proven to be very good at measuring ATT (which is considered abnormal using a cutoff of 7.28 mm) compared to CT scan as the gold standard. Lachmeter has a higher practical value where this tool is smaller in size, easy to carry, and very useful in conditions where advanced radiological modalities are not available.

Author's Contributions

Marsha Ruthy Darmawan: Conception, literature review, analysis, data collection, writing-review, and editing. Elysanti Dwi Martadiani, I Made Dwija Putra Ayusta, I Gede Raka Widiana: Conception, methodology, supervision. Celleen Rei Setiawan: Literature review, analysis, data collection, and editing. I Gusti Ngurah Wien Aryana: Methodology and supervision.

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