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# Reduced-diameter lateral extra-articular tenodesis iliotibial band leaflets produce comparable outcomes to standard-diameter leaflets

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# Reduced-diameter lateral extra-articular tenodesis iliotibial band leaflets produce comparable outcomes to standard-diameter leaflets


## Abstract:

**Purpose:** The addition of a lateral extra-articular tenodesis (LET) during anterior cruciate ligament reconstruction (ACLR) reduces rotatory laxity and graft failure rates. Traditional leaflets for LET utilize a 10-mm wide strip of the iliotibial band (ITB), which can induce donor- site morbidity, especially shape change phenomenon. Given that the native anterolateral ligament width ranges from 4 to 7 mm, reducing the leaflet width may minimize morbidity without sacrificing stability.

**Methods:** This retrospective cohort study analysed 238 patients undergoing primary isolated ACLR using peroneus longus autograft combined with a modified deep Lemaire LET between 2021 and 2023. Patients were divided between two cohorts: Group 1 consisted of patients receiving a standard-diameter (10 mm) ITB strip (n=120), and Group 2 received a 5 mm diameter ITB strip(n=118). Clinical outcomes (International Knee Documentation Committee [IKDC], Lysholm, Visual analog scale [VAS], and Tegner scores) and objective stability (pivot-shift test and radiographic static anterior tibial translation [sATT]) were evaluated at a minimum 2-year follow-up.

**Results:** Postoperative Tegner activity levels and return to sport rates showed no intergroup differences. Objective elimination of a pivot jerk to Grade 0 was achieved in 79.6% of Group 1 and 72% of Group 2, with no residual Grade 2 or 3 laxity in either cohort. Postoperative IKDC, VAS, Lysholm scores, and sATT values were identical between the two groups. Lateral thigh pain and shape change of the knee were noted more in group-1.

**Conclusion:** A reduced-diameter (5 mm) ITB leaflet for LET yields equivalent functional outcomes, rotational stability, and translational control compared to a standard 10 mm graft at 2-year follow-up. This less-invasive modification reduces morbidity without compromising construct efficacy.



**Keywords: anterior cruciate ligament; lateral extraarticular tenodesis; Donor site morbidity; iliotibial band; rotational instability**

**Level of study: Retrospective cohort study, level 3**

**Introduction:**

Rotational stability, especially antero-lateral rotatory instability, following ACL reconstruction (ACLR) has always been a matter of concern for surgeons. To address this, the concurrent use of lateral extra-articular tenodesis (LET) has gained renewed interest[8, 10, 25]. LET has been proven to be useful in restricting tibial internal rotation during high-pivoting activities. The recent literature supports its use in patients with high-grade rotatory laxity or hyperextension, young active high-demand patients with hamstring or soft tissue grafts, revision ACLR, and skeletally immature patients[5, 11, 20, 22]. Various techniques are used for LET, the most commonly used one being the modified deep- Lemaire technique. In this procedure, a distally based iliotibial band (ITB) leaflet is routed under the lateral collateral ligament and fixed to a point posterior and proximal to lateral epicondyle[14]. The ITB leaflet remains a widely used autograft source for LET due to its easier access, robust biomechanical properties, and proximity to the surgical field[5, 12, 21]. Moreover, the use of ITB can help restore the Kaplan fibres of ITB, which have been postulated to reduce the pivoting after ACLR[17].

The traditional LET surgical technique recommends harvesting a 10- 15 mm wide strip of ITB, which poses a clinical trade-off, particularly regarding donor site morbidity, including lateral knee pain, reduced strength, shape change phenomenon, or numbness near the lateral thigh[16, 23, 25]. The “shape change phenomenon” has been described in the literature as a residual swelling outside the knee related to the ITB graft, giving rise to a perception of apparent shape change of the knee[1]. This brings us to the idea of using a reduced leaflet of ITB (5mm) for LET. The native anterolateral ligament width ranges from 4.11 +- 1.09 mm and diameter around 1.01+- 0.23 mm in cadaveric studies[2, 16], which raises the question of whether the volumetric quantity of the traditional leaflets of LET is directly proportional to the achieved rotational stability. Reducing the leaflet width could mitigate the graft site morbidity and complications while still fulfilling the objectives of the LET procedure.

Based on these considerations, this retrospective study hypothesized that similar functional outcomes and anteroposterior knee stability can be achieved even with half the standard diameter of ITB (more comparable to cadaveric ALL measurements) used during ACLR with LET.

**Methods:**

A retrospective study was planned with 315 patients undergoing ACL reconstruction and Lemaire lateral extraarticular tenodesis. All the patients were operated on by two senior orthopedic surgeons (SP and MA) specialized in knee ligament reconstruction (>1000 ACL reconstructions performed individually). The patients were included between January 2021 and December 2023. The surgical allocation followed a sequential timeline, wherein patients treated between January 2021 and December 2022 underwent LET with standard leaflet ITB(10 mm); thereafter, the senior surgeons transitioned to a reduced leaflet diameter (5mm). The inclusion and exclusion criteria were,

**Inclusion criteria:**

- Age ≥18 years
- Primary isolated ACL reconstruction using a peroneus longus (PL) autograft along with Lemaire type lateral extra-articular tenodesis
- Routine indications of LET were such as young, active individuals involved in high-pivoting sports or activities, hyperlax individuals, athletes < 25 years, and high-grade pivoting injuries, presence of high-grade or explosive pivot shift test on examination under anaesthesia

**Exclusion criteria:**

- Simultaneous procedures at the time of ACLR (e.g., meniscus repair, menisectomy, associated ligament repair or osteotomy)
- Revision ACL reconstructions
- Previous knee surgery requiring implant hardware
- Incomplete clinical or radiographic records
- Age <18 years or lack of prior informed consent for participation in the study

Among the 315 included patients, 44 patients were excluded for meniscus repairs or meniscal balancing, 2 patients had a previously fixed distal femur fracture, 15 patients had concomitant cartilage procedures (e.g., Autologous cartilage transfer or microfractures), 3 patients had associated high tibial osteotomy, and 13 patients had associated ligament surgeries (e.g., medial collateral and posterolateral corner injuries).

Among the 238 included patients, 120 patients were allocated to group 1 and 118 patients were in group 2. The group 1 patients had a standard width (10 mm) of ITB used for LET and a reduced leaflet of ITB was used (5 mm) group 2.

**Surgical technique:**

All of the patients were operated on by two senior orthopedic surgeons specializing in knee ligament reconstruction in two tertiary care corporate hospitals. Standard anteromedial and anterolateral portals were used for diagnostic arthroscopy. A low anteromedial portal was used to drill the femoral tunnel. Ipsilateral peroneus longus autograft was harvested through a longitudinal 2 cm incision above the tip of the lateral malleolus. Tenodesis was performed for the distal end of PL graft with peroneus brevis with number 2 Fiberwire (Arthrex ©, USA). Double folded graft passed through an adjustable loop endobutton (Endobutton CL ULTRA, Smith & Nephew ©, USA) with the ends whipstiched by number 2 Fiberwire (Arthrex ©, USA) and tensioned at 15 N. The tibial footprint was secured with bioabsorbable interference screw (BIOSURE REGENESORB interference screw, Smith & Nephew ©, USA). If the graft diameter was found to be less than 8 mm the graft was triple folded.

The modified deep Lemaire technique was used for LET. A 5 cm longitudinal incision is made over the anterolateral distal femur, starting 2cm proximal to the lateral epicondyle, extending towards Gerdy's tubercle. The iliotibial band (ITB) is exposed. The lateral epicondyle is marked. In group 1 patients, the standard 10mm wide 10 cm long ITB strip was harvested, keeping the distal part attached near Gerdy’s tubercle. The strip was whipstitched at the free end with a fiberwire no 2 (Arthrex, USA) and shuttled beneath the lateral collateral ligament. In group 2, the same was done with a 5mm wide 10 cm long ITB strip. The strip was fixed with a 2.6 mm knotless FiberTak anchor (Arthrex, USA) using an onlay technique approximately 1 cm proximal and posterior to the lateral epicondyle of the femur after ensuring the isometry. The graft was secured at 30 degrees of knee flexion and neutral rotation.

**Postoperative Rehabilitation Protocol:**

All patients were allowed to do full weight-bearing mobilization with long knee brace as tolerated. Closed-chain range of motion (ROM), isometric knee exercises were initiated immediately. Active quadriceps and hamstring strengthening exercises started from second week. All the patients were followed up until two years. A similar analgesia protocol was followed for all patients.

The stability of the knee was assessed with the Pivot shift test and static anterior tibial translation (sATT) by a single blinded observer. (RS) The sATT was assessed by a stress radiograph obtained while the patient stood in monopodal stance with the knee flexed at 20 degrees. The radiograph plate was placed on the medial knee, including 20cm of the upper tibia on the film, with the source situated 1 meter away from the plate (Figure I)[3, 15]. The sATT and pivot shift test was assessed at the preoperative period and postoperatively at 2 years of follow-up.

To assess measurement reproducibility, a subset of 50 separate patients was randomly selected for repeated sATT assessments by two independent observers. Intraobserver and Interobserver reliability showed excellent agreement ICC: 0.88; 95% CI, 0.72–0.93 and ICC: 0.82 ;95% CI, 0.61–0.90 for sATT, respectively.

The functional outcome was assessed with the Visual Analog Scale (VAS), Lysholm knee score, International Knee Documentation Committee (IKDC) score preoperatively and postoperatively at 6 months and 2 years by a single observer (RS) who was blinded to the groups. The Tegner activity scale was also used to assess the activity level preoperatively and postoperatively.

**Statistical Analysis**

Data analysis was performed using SPSS version 26.0 (IBM Corp, NY, USA). Parametric tests were applied to normally distributed data, including independent samples t-tests for independent groups and paired t-tests for related variables. Non-parametric comparisons utilized the Mann–Whitney U and Kruskal–Wallis tests as appropriate.

**Results:**

The mean age of the 238 included patients was 24.5 ±4.9 years, and 59.6% were males (Table I). The age, sex, and BMI were found to be similar between both study groups. With respect to pre-injury sports participation, a similar number of patients (group 1: 50%, group 2: 56.7%) were participating in competitive sports at the time of injury. Among them, 58 and 63 patients returned to competitive sports in groups 1 and 2 (53.3% and 59.3%), respectively (Table II). The percentage of hyperlax individuals enrolled in both groups was similar [Group 1: 19(16%), Group 2: 14 (13%)]. There was no difference in the Tegner activity scale in the preoperative (p: 0.9) or postoperative period (p: 0.8). No difference was noted in postoperative rotational stability assessed by the pivot shift test by a blinded observer (RS)(Table III).

A significant improvement in pain scores (VAS) and functional outcome scores (Lysholm and IKDC score) was noted postoperatively at 6 months and 2 years (Table IV). However, there was no significant difference in functional outcome measures between both groups at any given time period post-operatively. The sATT was similar in both groups in the preoperative and postoperatively at 2-year follow up (Table V).

Complications

Revision was needed for 9 patients in group 1 and 12 patients in group 2 after reinjury leading to graft tear. 4 patients cumulatively from both groups needed resurgery due to a cyclops lesion. All of them had intact ACL grafts. Arthrofibrosis needing manipulation under anesthesia was noted in 2 patients in group 1. Importantly, no patient had a failure of the LET graft on MRI in either group, even in the setting of concomitant ACL graft failure.

If we focus solely on complications related to lateral tenodesis, the shape-change phenomenon was noted in 31 patients in group 1 and 6 patients in group 2. Lateral thigh pain was the second most common complication noted in Group 1 (21.6% of patients). There was a significant difference in lateral thigh pain (p:0.01) and shape change phenomenon (p:0.01) between groups (Table VI).

**Discussion:**

The primary outcome of this retrospective study strongly supports the initial study hypothesis: a reduced ITB leaflet width (5mm; more comparable to cadaveric ALL measurements) for LET can yield functional and objective stability similar to that of standard-diameter LET with ACLR. Specifically, the lack of statistical difference in IKDC, Lysholm score, clinical pivot shift testing, and radiological parameters like sATT suggests a reassessment is warranted regarding the ideal width of ITB leaflets necessary for rotatory stability. A biomechanical comparison of rotatory instability between standard and reduced diameter leaflets would be warranted.

The effectiveness of LET in controlling rotatory laxity has been demonstrated in recent literature [12]. The landmark STABILITY trials have validated the use of modified Lemaire LET alongside ACLR while using hamstring tendon or other autografts in young high-risk individuals[5]. Even though multiple consensus and guidelines have been published, enlightening us about the right indications and pitfalls of it[11, 12, 20, 21]. However, the recent resurgence of LET alongside ACLR carries its own burden of complications, such as lateral thigh pain, lateral compartment overload of the knee leading to osteoarthritis, prominence of hardware or the need for hardware removal, tunnel coalition, iliotibial band snapping, hematoma formation, etc [24]. A recent systematic review has reported that the complication rates after adding LET can range even upto 7.5% of cases[24]. The most common being hematoma formation, which may be minimized by lesser dissection and harvesting a smaller diameter of ITB [4, 24]. Furthermore, smaller diameter tunnels for smaller ITB grafts can minimize tunnel coalitions. The cadaveric studies have confirmed that the native anterolateral ligament is a relatively thin, flat structure with a width ranging from 4mm to 7mm, while the thickness ranges from 1 mm to 2.5mm[2]. Therefore, using a 5-mm width of graft makes perfect sense.

The tissue-sparing philosophy aligns with biomechanical studies that have validated the role of superficial fibers of ITB in rotatory stability[13]. Thus, damaging more of these native fibers to perform a procedure to stop anterolateral instability defeats the purpose of it. Using a reduced-width graft can make the tension in ITB closure also less and restore the structure of ITB better.

Among the patients recruited for the study, almost 40% were professional athletes (40.8% in group 1 and 44.9% in group 2). The majority of them could return to sports in both groups, demonstrating that a reduced ITB graft width does not adversely affect return-to-sports in professional athletes. The rotatory instability, evaluated clinically via pivot shift test, significantly improved postoperatively with no significant intergroup differences. Objective elimination of a pivot-shift jerk to Grade 0 was achieved equally in both groups: 79.6% of group 1 and 72% in group 2, with no residual Grade 2 or 3 subluxations at 2 years (Table), thereby confirming the study hypothesis. Although static anterior translation does not directly indicate rotatory laxity, it was evaluated to provide an objective, between-group comparison of sagittal laxity. The sATT showed an identical trajectory as rotational laxity, showing a significant but similar reduction in laxity postoperatively (Table). The pain scores or functional outcome didn't differ between groups, indicating that reducing the diameter doesn't reduce postoperative pain but also does not compromise overall clinical function. Using the PL autograft for primary ACL reconstruction is surgeons' preference, as there has been abundant literature in support of it with no to minimal morbidity to the ankle[6, 7, 18, 19].

Complications associated with LET have been infrequently reported in the literature[9, 23]. Hardwire removal, the most commonly reported complication in the literature[23], was not noted in this study. The fixation of the graft with suture anchor may be the reason behind it. However, lateral thigh pain was significantly higher in group 1 patients (p: 0.01), justifying the use of a reduced leaflet of ITB. The complaints of swelling and deformed lateral aspect of the knee have been frequently encountered in our practice, leading to the coining of the term "The shape change phenomenon"[1]. This puffiness near the LET site is usually the result of fibrosis and scarring of the graft, which may or may not reduce over the period of time. This complication has been noted significantly higher (p: 0.001) with the use of a bulkier graft in group 1. There were 3 superficial wound infections at LET site, which were managed by debridement. None of the patients had any ITB snapping or hematoma at the LET site. The overconstrained lateral compartment has been noted to be frequently associated with LET; however, no such complication was encountered in this study.

While the functional outcomes and stability assessment failed to show any difference, utilizing a smaller graft could theoretically result in long-term creep or relaxation. However, a minimum of two-year follow-up data confirms the sustained efficacy of the reduced diameter graft. Future scope of biomechanical studies showing the stress patterns and graft forces with a smaller diameter graft in ACL reconstruction setting remains.

**Limitations:**

This study is constrained by certain limitations. First, its retrospective nature carries inherent risk of selection bias. Second, while the pivot-shift test was carried out by a blinded independent observer, a shortcoming of objective assessment remains. Finally, a 2-year terminal milestone for follow-up may underrepresent the long-term effects of graft attenuation or complications related to the lateral compartment of knee.

**Conclusion:**

A reduced diameter (5mm) ITB graft utilized for a modified Lemaire LET along with a primary ACL reconstruction with PL autograft yields equivalent functional outcomes, rotational and translational stability compared to a standard 10-mm ITB graft at 2 years follow up. This highly effective but smaller modification of the standard technique can minimize the structural disruptions and complications related to lateral knee envelope without sacrificing clinical stability.

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**Tables:**

**Table I: Summary of demographic variables**

| Parameters | Age | BMI | Injury and surgery interval |
|---|---|---|---|
| Mean | 24.5 | 22.7 | 23.4 |
| SD | 4.9 | 5.1 | 48.6 |
| Range | 16-42 | 16.9-35.1 | 21-401.8 |

**Table II: Summary of Tegner activity scale between groups**

| | Group 1 (n=120) | | Group 2 (n=118) | |
|---|---|---|---|---|
| Tegner scale | Pre operative | Post operative | Pre operative | Post operative |
| 1 | 0 | 0 | 0 | 0 |
| 2 | 5 | 4 | 3 | 2 |
| 3 | 3 | 2 | 5 | 5 |
| 4 | 7 | 7 | 6 | 4 |
| 5 | 18 | 21 | 11 | 16 |
| 6 | 27 | 22 | 26 | 21 |
| 7 | 11 | 15 | 14 | 16 |
| 8 | 19 | 16 | 20 | 22 |
| 9 | 23 | 26 | 25 | 25 |
| 10 | 7 | 7 | 8 | 7 |

**Table III: Summary of the comparison of pivot shift test between groups**

| | | Group 1(n=120) | | Group 2(n=118) | | |
|---|---|---|---|---|---|---|
| Parameters | Level | Number | Percentage | Number | Percentage | p-value |
| Pre-operative pivot shift test | Grade 0 (Normal) | 0 | 0 | 0 | 0 | - |
| | Grade 1 (Glide) | 0 | 0 | 0 | 0 | - |
| | Grade 2 (Jump) | 34 | 28.3 | 31 | 26.3 | 0.7 |
| | Grade 3 (Locked subluxation) | 86 | 71.7 | 87 | 73.7 | 0.7 |
| Post-operative pivot shift test | Grade 0 (Normal) | 91 | 75.8 | 85 | 72 | 0.6 |
| | Grade 1 (Glide) | 29 | 24.2 | 33 | 27.9 | 0.6 |
| | Grade 2 (Jump) | 0 | 0 | 0 | 0 | - |

| | | | | | | |
|---|---|---|---|---|---|---|
| | Grade 3 (Locked subluxation) | 0 | 0 | 0 | 0 | - |

331

332 **Table IV: Comparison of functional outcome before and after surgery**

| | Mean | Standard deviation | Range | 95% Confidence intervals | p-value |
|---|---|---|---|---|---|
| Pre-operative IKDC score | 51.7 | 5.9 | 34-71 | 49.2-53.9 | <0.001 |
| Post-operative IKDC score 6months | 70.1 | 6.8 | 49-86 | 68.9-71.2 | |
| Post-operative IKDC score 2 years | 83.2 | 3.4 | 72-95 | 81.8-83.7 | |
| Pre-operative VAS | 4.9 | 2.7 | 1-8 | 4.1-5.6 | <0.001 |
| Post-operative VAS 6 months | 2.1 | 1.1 | 0-5 | 1.4-2 | |
| Post-operative VAS 2 years | 1.1 | 0.3 | 0-1 | 0.5-0.1 | |
| Pre-operative Lysholm score | 61.3 | 8.8 | 39-81 | 59.8-62.9 | <0.001 |
| Post-operative Lysholm score 6 months | 79.4 | 7.09 | 59-98 | 78.2-81.4 | |
| Post-operative Lysholm score 2 years | 93.9 | 4.8 | 81-100 | 91.1-94.05 | |
| Preoperative sATT | 8.2 | 3.8 | 4-14.1 | 7.6-9.5 | <0.001 |
| Postoperative sATT at 2 years | 3.9 | 1.9 | 3.6-4.2 | 3.4-4.3 | |
| Footnote: | | | | | |

333

334 **Table V: Comparison of functional outcomes and clinical parameters between groups**

| | Group 1 (n=120) | | Group 2 (n=118) | | p-value |
|---|---|---|---|---|---|
| | Mean | Standard deviation | Mean | Standard deviation | |
| Preoperative IKDC | 55.7 | 7.9 | 57.1 | 6.8 | 0.1 |
| Postoperative IKDC 6 months | 71.1 | 6.5 | 70.04 | 7.02 | 0.3 |
| Postoperative IKDC 2 years | 82.8 | 3.6 | 83.4 | 3.3 | 0.2 |
| Preoperative VAS score | 4.7 | 2.05 | 4.3 | 1.8 | 0.1 |
| Postoperative VAS 6 months | 2.1 | 1.03 | 2.2 | 0.8 | 0.4 |
| Postoperative VAS 2 years | 1.0 | 0.4 | 0.9 | 0.6 | 0.1 |

| | | | | | |
|---|---|---|---|---|---|
| Preoperative Lysholm score | 59.7 | 5.8 | 58.9 | 6.1 | 0.3 |
| Preoperative Lysholm 6 months | 80.2 | 7.5 | 78.9 | 5.7 | 0.1 |
| Postoperative Lysholm 2 years | 93.8 | 4.7 | 93.1 | 5.4 | 0.3 |
| Preoperative AOFAS | 99.1 | 1.3 | 99.3 | 1.2 | 0.2 |
| Postoperative AOFAS 2 years | 99.5 | 1.1 | 99.7 | 0.9 | 0.1 |
| Preoperative sATT | 7.7 | 4.9 | 8.4 | 4.1 | 0.2 |
| Postoperative sATT 2 years | 4.09 | 2.06 | 3.8 | 1.8 | 0.3 |
| Footnote: | | | | | |

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336 **Table VI: Comparison of complications of lateral extraarticular tenodesis between groups**

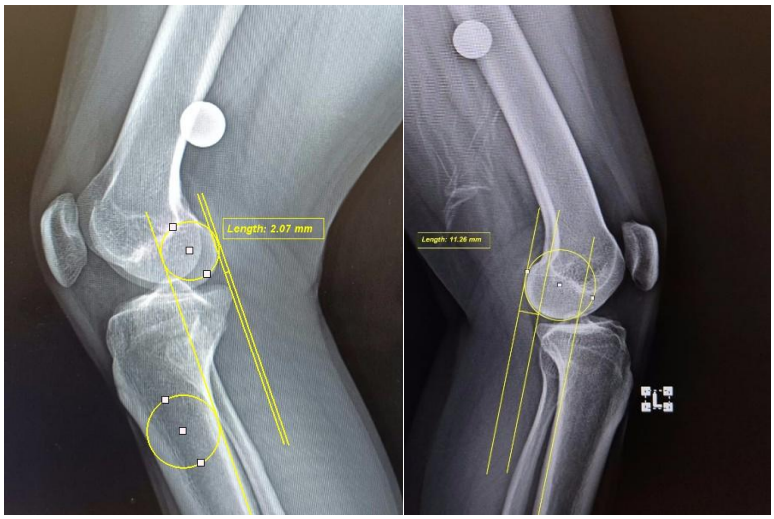
| | Group 1 (n=120) | | Group 2 (n=118) | | p-value |
|---|---|---|---|---|---|
| | Number | Percentage | Number | Percentage | |
| Surgical site infection | 1 | 0.8 | 2 | 1.7 | 0.7 |
| Lateral thigh pain | 26 | 21.6 | 11 | 9.3 | 0.01 |
| "Shape change phenomenon" | 31 | 25.8 | 6 | 5.08 | 0.001 |
| Numbness along lateral thigh | 9 | 7.5 | 11 | 9.3 | 0.6 |
| Hardwire irritation | 7 | 5.8 | 8 | 6.7 | 0.8 |

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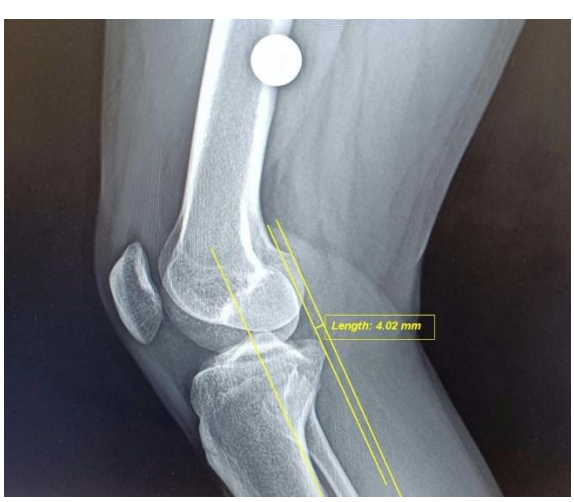
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339 **Figures:**

340 **Figure I: Figure showing radiograph with static anterior tibial translation**




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