



## Intraoperative arthrometry in anterior cruciate ligament reconstruction

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Arthrometry has an established role in the measurement of knee laxity in anterior cruciate ligament injury and following reconstruction. The role of routine intraoperative arthrometry in anterior cruciate ligament reconstruction is poorly defined, and this study was designed to test the hypothesis that intraoperative arthrometry provides an objective method of documenting successful knee stabilisation following anterior cruciate ligament reconstruction.

A consecutive cohort of 100 patients with unilateral isolated anterior cruciate ligament disruption were prospectively evaluated using a Rolimeter arthrometer. A maximal manual force method was utilised by a single examiner. This allowed for side-to-side comparisons with the uninjured contralateral knee. Analysis of tibial translation was recorded preoperatively with patients both awake and asleep, intraoperatively following anterior cruciate ligament reconstruction, and postoperatively at 2 weeks and 3 months. Statistical analysis was performed using Spearman's correlation coefficients.

Intraoperative arthrometry of anterior cruciate ligament reconstructed knees revealed statistically significant correlation with measurements of uninjured knees ( $p < 0.0001$ ). These findings were reproducible at 2 weeks ( $p < 0.0001$ ) and at 3 months ( $p = 0.0002$ ).

Based on our findings, we conclude that intraoperative arthrometry can be simple and provide reproducible results. It is a useful method of immediately and objectively documenting successful anterior cruciate ligament reconstruction.

**Keywords** : anterior cruciate ligament ; reconstruction ; arthrometry.

## INTRODUCTION

Arthrometry has an established role as a clinical and research tool in the diagnosis and management of anterior cruciate ligament (ACL) injury. There are only a few reports of arthrometers being used in an intraoperative setting (7, 11, 13) and this practice is not commonplace.

The KT-1000 and KT-2000 arthrometers (Medmetric Corp, San Diego, Calif., USA) have been shown to provide accurate and reproducible methods of measuring knee laxity in ACL injury (8, 22). More recently reports have emerged revealing the Rolimeter arthrometer (Aircast, Europe) to be comparable in its accuracy to the KT-1000 (10) with good intra- and intertester reliability (17). Both methods are far more reliable than simple manual assessments of knee laxity (4). The Rolimeter has potential advantages over its competitors, and can be easily sterilised to allow for use in the intraoperative setting.

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The aim of this study was to record intraoperative Rolimeter arthrometric measurements of knee laxity immediately following ACL reconstruction (ACLR) with a view to defining a role for this practice.

### MATERIALS AND METHODS

A prospective study was conducted measuring knee joint laxity in 100 consecutive patients undergoing ACLR for isolated single ligament injury. The contralateral knee was normal in all cases with no history of injury, surgery or ligamentous laxity. There were 71 men and 29 women, with an average age of 28 years (range, 16-51 years). All patients were less than 6 months from injury at first assessment, and the average delay from office assessment to ACLR was 25 days (range, 1-210 days). All arthrometric measurements were made by the senior author (GK) who was experienced with the use of the Rolimeter. Arthrometry of both knees was conducted at initial office assessment and preoperatively under anaesthesia to compare awake and asleep recordings. Subsequently an arthroscopic single-incision ACLR with bone-patellar-tendon-bone autograft was performed in all cases by the senior author. Further arthrometry was performed intraoperatively of the ACL reconstructed knee, immediately following autograft fixation and with the knee drained of irrigation fluid. All patients underwent a standard rehabilitation program which included early weightbearing and range of motion training. Arthrometry was repeated on both knees at 2 week and 3 month follow-up. The examiner remained blinded to previous recordings.

Intraoperative correlations between the ACL reconstructed and uninjured knee were specifically analysed. Comparisons were made with pre- and postoperative measurements to assess the reproducibility of the method. The influence of age, gender, and delay from assessment to surgery on arthrometer measurements was also assessed.

#### Method of arthrometry

The Rolimeter arthrometer has been described in detail previously (4, 10, 17). It is constructed of stainless steel with a rubber strap for securing the device around the distal tibia. Anterior knee laxity can be assessed with an anterior drawer or Lachman test. For the latter the device is positioned on the mid patella and tibia with the knee in 25 degrees of flexion (fig 1). The uninjured knee was examined first to minimise apprehension in the con-



Fig. 1. — Position of rolimeter during Lachman test

scious patient, and muscle relaxation was actively encouraged. Pivot shift testing was performed after arthrometry, again to minimise the effects of apprehension and muscle spasm. The knee was preconditioned by applying a posterior translation force to the tibia three times. A Lachman test was then performed with the knee in neutral rotation, applying a maximal manual force. This resulted in displacement of a stylus on the device which provided a specific measurement of knee laxity (fig 2). The stylus has 2 mm increments and measurements were rounded to the nearest mm, and the average of three recordings noted.

#### Statistical methods

The significance of the level of correlation between anterior translation measurements of both knees was calculated using Spearman's correlation coefficients. A correlation coefficient ( $r$ ) greater than 0.7 was regarded as clinically significant, and a p-value of less than 0.05 was regarded as statistically significant.

### RESULTS

There were no losses to follow-up or complications, and none of the patients were noted to have more than a grade 1 effusion at postoperative review. Arthrometry revealed consistently significant differences in the averages between ACL deficient and uninjured knees, and consistently similar measurements between ACL reconstructed and uninjured knees throughout the study.

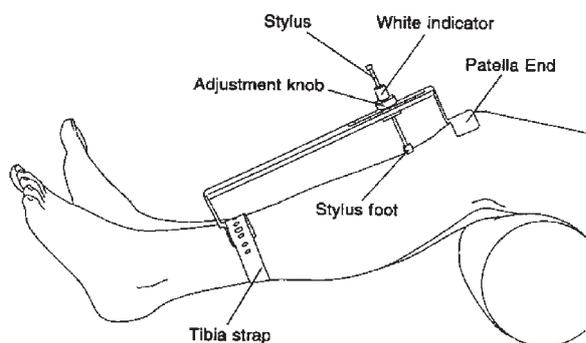


Fig. 2. — Schematic demonstration of components of rolimeter.

The average intra-operative translation in ACL reconstructed knees was 5.2 mm (range, 3-8 mm) and this was similar to the average intraoperative translation in uninjured knees, with a similar range (3-9 mm). Statistical analysis revealed a significant correlation ( $r = 0.8, p < 0.0001$ ). This side-to-side correlation between the ACL reconstructed and uninjured knees remained significant at both 2 week ( $r = 0.9, p < 0.0001$ ) and 3 month post-operative review ( $r = 0.9, p = 0.0002$ ).

Very little difference was noted between awake and asleep recordings in comparable groups of knees. Analysis of translation with respect to age (fig 3), gender (fig 4), and delay to surgery (fig 5), did not reveal any major differences in the average recordings.

### DISCUSSION

Instrumented arthrometry is a useful adjunct to clinical examination in the diagnosis of ACL rupture and subsequent follow-up of patients following reconstruction. Arthrometry has the advantage over clinical examination of being more accurate (19). Whilst it may not necessarily equate to a successful outcome compared to largely subjective functional knee criteria (11), it does provide an objective assessment of knee laxity (1, 3, 5-8, 12, 16, 18).

Daniel *et al* (8) performed KT-2000 arthrometry in 338 normal subjects, and observed no statistically significant difference in anterior-posterior knee displacement in patients grouped by age or sex. Our findings would support this observation. We did not specifically analyse right-to-left difference

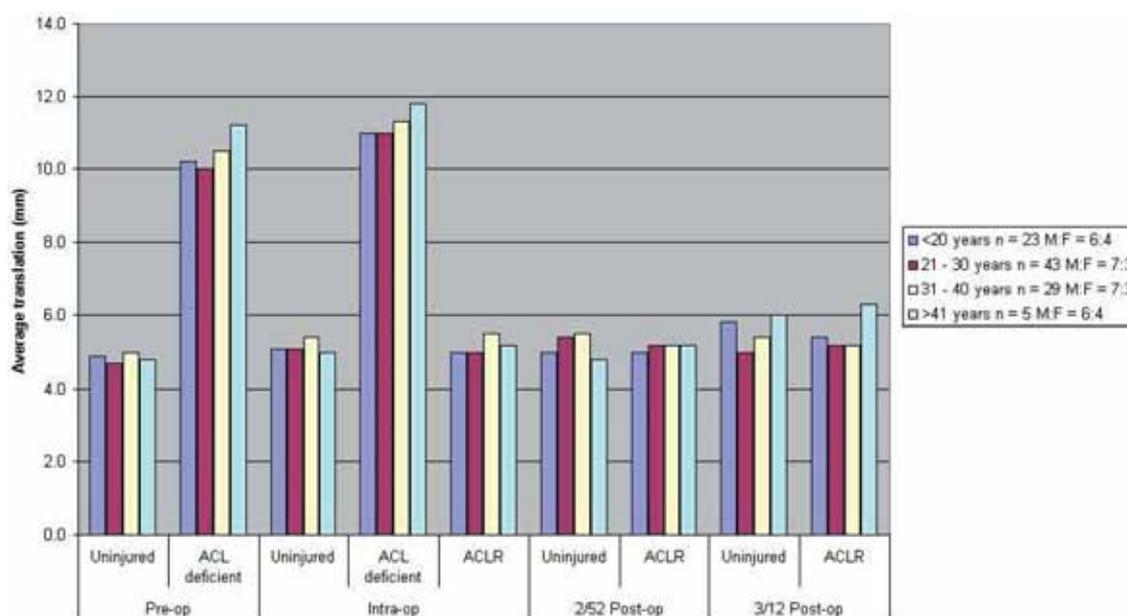


Fig. 3. — Average translation grouped by age

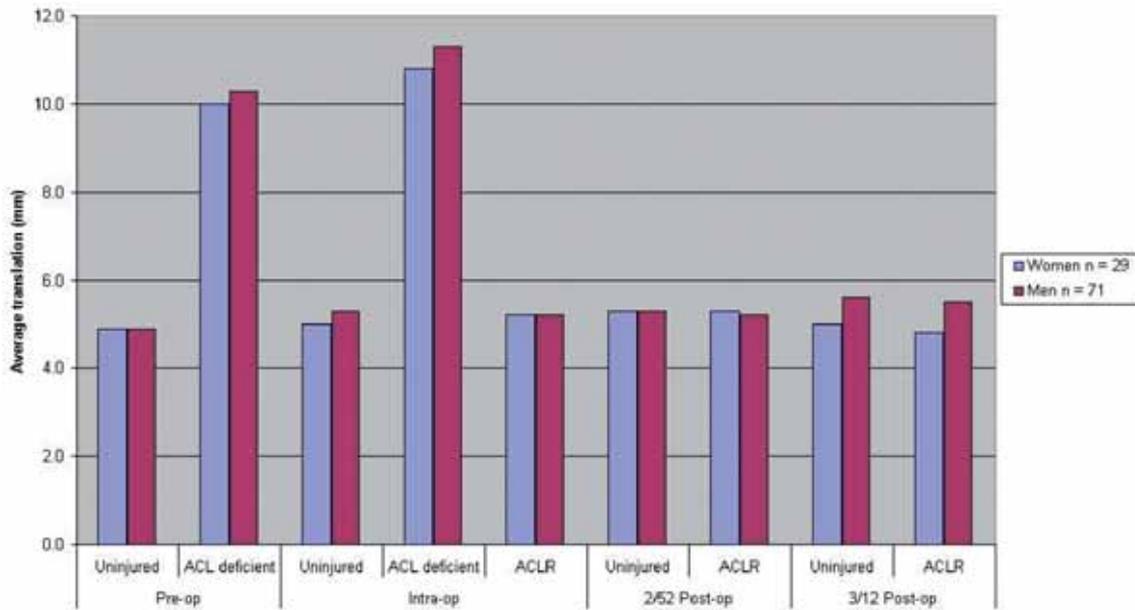


Fig. 4. — Average translation in relation to gender

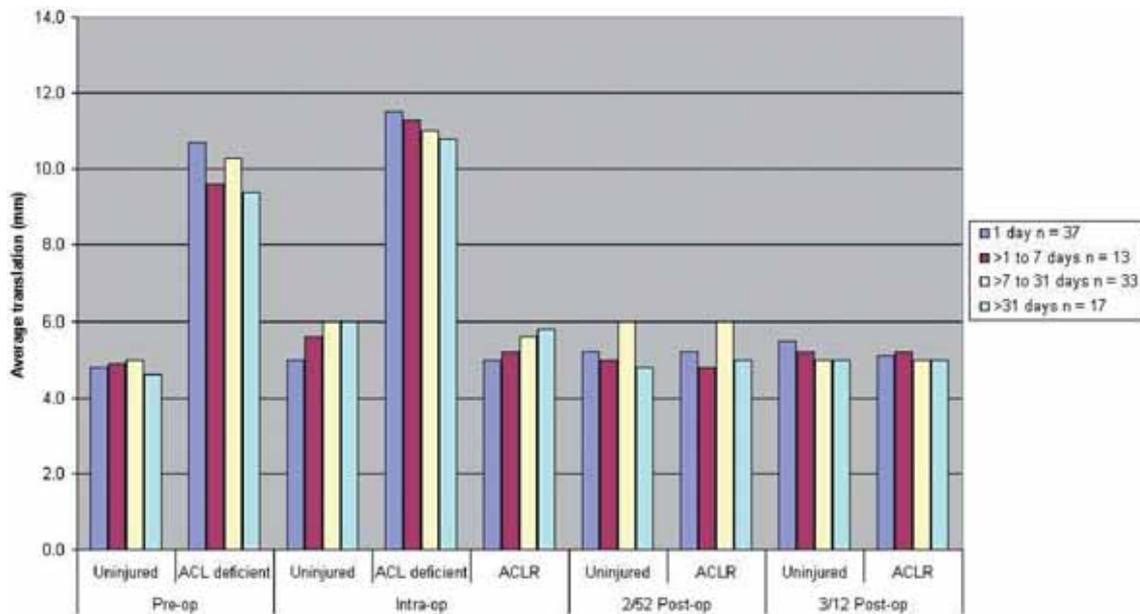


Fig. 5. — Average translation in relation to delay in surgery

in knees but there is evidence that it varies little in normal knees (8, 22), Daniel *et al* (8) also compared the differences in KT-2000 arthrometric measurements between the sides of normal subjects and between sides in 89 patients with unilateral ACL

disruption. A significant difference was noted with the uninjured knee in patients with ACL disruption showing greater laxity compared to normal subjects ( $p < 0.01$ ). This finding was in contrast to the findings of Markolf *et al* (15). This emphasizes that

whilst a measure of absolute anterior tibial translation in ACL injury is useful, of greater value is an assessment of side-to-side difference between the ACL deficient or reconstructed knee and the uninjured knee (1). Delay to surgery from initial assessment did not seem to affect the arthrometric measurements and hence degree of knee laxity. This observation is supported by Bach *et al* (2) who noted no relationship between translation and delay to surgery in chronic ACL injury.

The role of intraoperative arthrometry is poorly defined. Dahlstedt *et al* (7) examined 41 patients with ACL injury both awake and under anaesthesia and noted significant increases in tibial translation in the unconscious state ( $p < 0.001$ ), in both injured and uninjured knees. Highgenboten *et al* (13) reported similar findings in a study of 68 patients.

Whilst our results show a similar pattern we did not find the difference in awake and asleep measurements to be of clinical significance using the Rolimeter. Giannotti *et al* (11) performed KT-1000 arthrometer testing on 28 patients immediately following ACL reconstruction. The ACL reconstructed side was noted to be tighter than the uninvolved knee with an average difference of -2.1 mm. Our study examined a greater number of patients intraoperatively and found the measurements in ACL reconstructed knees to be comparable to those of the normal uninjured knee, with these findings extending into the postoperative period. This highlights the reproducibility and accuracy of a maximal manual force method using this device, and importance of making side-to-side comparisons.

Many factors affect the degree of knee joint displacement resulting from an external force. These include the position of the knee joint, external constraints on motion, the applied force (load, direction, point of application), muscle tone and generalised ligament laxity (8), and the presence of a knee effusion (14, 21). These factors can clearly lead to differences in measurements of anterior knee translation recorded by different arthrometers, and will vary between patients. Another confounding factor is intra- and intertester variance. Our results suggest that the Rolimeter appears to be less sensitive in highlighting such factors. Whilst we acknowledge a single tester may produce biased

results, in favour of producing similar results when making side-to-side comparisons, the maximal manual force method is best analysed using a single tester.

The Lachman test has been reported to be the best diagnostic test of ACL disruption (9, 20). It is easy to reproduce this test with the Rolimeter. We advocate this test in the hands of an experienced examiner, acknowledging the concerns of Muellner *et al* (17) in ensuring the Rolimeter position is carefully maintained.

## CONCLUSION

The ideal arthrometer should be economical, light, quick and easy to use with a short learning curve, and not cause undue patient discomfort. The results it produces should be accurate, objective and reproducible between patients and there should be little inter- or intratester variability. We believe the Rolimeter fulfils the majority of these criteria. Its greatest advantage is the ease with which it can be sterilised and used intraoperatively, immediately after autograft stabilisation in ACLR. We believe such a practice provides the least invasive, most simple and objective method of accurately documenting that ACLR has restored knee stability, using a side-to side comparison with the normal knee for reference. This also allows for future comparisons at postoperative review. Such intraoperative documentation is currently lacking in routine clinical practice in ACLR, and may provide a strong defense in the face of medico-legal issues.

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