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Magnetic tracking: a novel method of assessing anterior cruciate ligament deficiency

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ABSTRACT

INTRODUCTION The Lachman test is commonly performed as part of the routine assessment of patients with suspected anterior cruciate ligament (ACL) deficiency. A major drawback is its reliance on the clinician's subjective judgement of movement. The aim of this study was to quantify Lachman movement using a magnetic tracking device thereby providing a more accurate objective measure of movement.

PATIENTS AND METHODS Ten patients aged 21–51 years were assessed as having unilateral ACL deficiency with conventional clinical tests. These patients were then re-assessed using a Polhemus Fastrak™ magnetic tracking device.

RESULTS The mean anterior tibial displacement was 5.6 mm (SD = 2.5) for the normal knees and 10.2 mm (SD = 4.2) for the ACL-deficient knees. This gave an 82% increase in anterior tibial displacement for the ACL deficient knees. This was shown to be highly significant with $P = 0.005$.

CONCLUSIONS The magnetic tracking system offers an objective quantification of displacements during the Lachman test. It is convenient, non-invasive and comfortable for the patient and is, therefore, ideally suited for use as an investigative tool.

KEYWORDS

Anterior cruciate ligament – Biomechanics – Magnetic tracking device

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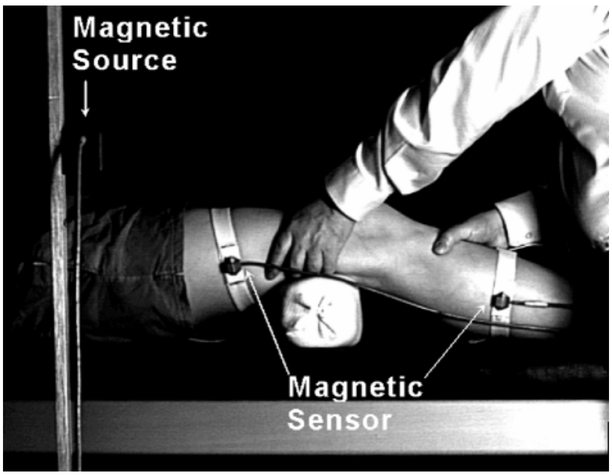
A major function of the knee's anterior cruciate ligament (ACL) is to limit anterior tibial translation.[1] When this ligament is ruptured, excessive translation can be detected by pulling the tibia anteriorly during the Lachman test.[2] The main drawback with this test is its reliance on the clinician's subjective judgement of movement. For a more objective measurement, an arthrometer,[3] radiological drawer[4] or dynamic MRI test[5] can be used. However, these tests require bulky, expensive equipment. This article describes how a light-weight magnetic tracker can quantify Lachman movement in a clinical setting.



PATIENTS AND METHODS

Following ethics committee approval, 10 patients aged 21–51 years were tested with a Polhemus Fastrak™ system, as shown in Figure 1. Each patient had one clinically normal knee and one ACL-deficient knee. Meniscal tears

Figure 1 Clinical set-up for quantifying Lachman movement with a Polhemus Fastrak™ magnetic tracking system. The patient is positioned on a non-magnetic wooded couch beside the system's magnetic source. Magnetic sensors are then attached around the femoral and tibial mid-shafts, using Velcro straps. These sensors connected to a personal computer (PC). The PC records sensor movement at a sampling rate of 10 Hz. Position co-ordinates (X, Y and Z) are recorded with an accuracy of 0.8 mm. Orientations (azimuth, elevation and roll) are

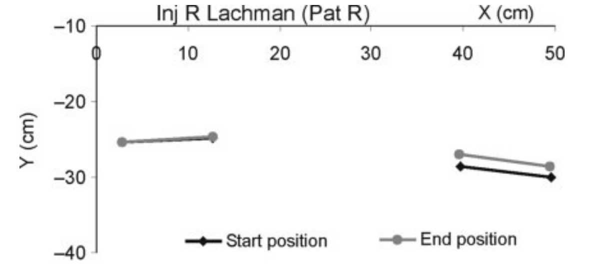


Figure 2 Typical bone displacement following a Lachman pull. Sensor co-ordinates are shown at the left of each line, with vectors showing femur and tibia orientation (azimuth angle). The anterior displacement of the tibia is displayed as a 'Y' co-ordinate displacement.

were excluded. A specialist knee surgeon performed the Lachman test three times on each normal and injured knee.

RESULTS

Figure 2 shows a typical tibial displacement for a Lachman pull. The main movement is an anterior 'Y' displacement of the tibia with respect to the femur. There is also a small proximal 'X' displacement. The groups' displacements are summarised in Table 1.

In the 'Y' direction, the mean anterior displacement for the normal and injured knees were 5.6 mm and 10.2 mm, respectively. Hence the ACL-deficient knees had 4.6 mm (82%) more movement. A paired t-test showed a significant difference, with $P = 0.005$.

In the 'X' direction, there was no significant difference ($P = 0.12$) between the small movements of the normal and injured knees.

Sample size

A power analysis showed $n = 7$ to be a sufficient sample size for the paired t-test, with a power of 0.8 and significance level of 0.05.

DISCUSSION

The results from this study compare favourably with previously published studies using alternative measurement techniques. This study reports mean anterior displacements of 5.6 mm and 10.2 mm in normal and injured knees, respectively. A KT1000 arthrometer study reported displacement of 5.6 mm and 13.0 mm.[3] A stress radiographic study reported displacement of 4.3 mm and 9.8 mm.[4] A dynamic MRI study reported displacement of 4.7 mm and 14.1 mm.[5] The MRI study[5] used subjects with one injured knee and one normal control knee. This 'auto-matching' helps to negate the effects of extraneous variables such as joint size. A study of bilaterally normal subjects reported a normal left–right displacement difference of less than 2 mm.[5]

Table 1 **The horizontal and vertical displacement of the tibia following a Lachman pull**

Patient	Normal X (mm)	Normal Y (mm)	Injured X (mm)	Injured Y (mm)
1	1.4	7.2	–2.1	12.4
2	–0.6	0.1	–4.5	6.5
3	–0.2	8.0	1.4	14.7
4	0.4	5.1	–0.2	9.1
5	–2.1	5.4	0.5	17.9
6	–4.8	4.1	–1.9	6.6
7	–2.1	9.5	–4.5	8.5
8	–0.7	6.7	–2.2	14.3
9	–1.5	6.7	–9.9	3.6
10	2.6	3.7	2.6	8.6
Mean	–0.7	5.6	–2.1	10.2
SD	1.9	0.25	3.4	4.2

A negative 'X' displacement indicates a proximal movement.
A positive 'Y' displacement indicates anterior movement.

Tests using a magnetic tracker or arthrometer can be undertaken in a clinical setting. They are, therefore, quicker and much less expensive than radiographic or MRI tests. The main advantage of the tracker over the arthrometer is that its light-weight sensors cause minimal disturbance to the established test. This allows the clinician to assess movement qualitatively at the same time as the quantitative measurement.

CONCLUSIONS

Magnetic tracking provides a precise, objective quantification of anterior tibial displacement during the Lachman test, with the benefit of simultaneously permitting qualitative assessment by the examiner.

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