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Precision in reconstruction of the anterior cruciate ligament

A new positioning device compared with hand drilling

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To evaluate the precision of a drill guide for use in anterior cruciate ligament reconstruction and the reproducibility of the results, the device was tested in 30 operations (Group 1); 17 operations were done freehand (Group 2); 10 cadaver knees served as anatomic controls.

The internal orifices of the bony channels in Groups 1 and 2 and the central point of the anterior cruciate ligament attachments in the cadaver group were identified on lateral radiographic views.

The position of the tibial ligament attachments in the cadaver group did not differ from the orifices of the drilled channels in Groups 1 and 2. The position of the femoral attachments in the cadaver group did not differ from the orifices of the drilled channels in Group 1, but between the cadaver group and Group 2, and Groups 1 and 2, the positions of the femoral attachments differed. The hand-drilled channels were generally located too far anteriorly, and the scatter of the attachments was 1.8 times greater.

The drill guide enables reproducible anatomic positioning of an anterior cruciate ligament graft.

When reconstructing the anterior cruciate ligament, it is difficult to position the drill channels, especially the internal orifices on the femur and tibia. Guides have been designed to facilitate drilling towards predetermined points believed optimal for location of the ligament attachments; the drilling has to be done for the femur and tibia separately (Hewson 1983, Lindstrand et al. 1982, Theve et al. 1975).

We have designed an isometric drill guide (Odensten and Gillquist 1986), the precision of which is reported here in studies of anterior cruciate ligament reconstruction.

Materials and methods

Group 1. Thirty patients, 22 men and 8 women with a mean age of 26±6 years, underwent reconstruction of the anterior cruciate ligament using our isometric drill guide.

Group 2. Seventeen patients, 11 men and 6 women with a mean age of 26±6 years, underwent reconstruction with free-hand drilling of the bony channels.

Cadaver group. Knees from 10 young persons with no history of knee injury or degenerative joint disease served as controls.

Group 1. Guided drilling. Via a small anteromedial arthrotomy, the intercondylar distance was measured and notchplasty was performed on the lateral wall and the roof of the tunnel, making sure to remove osteophytes, to create a tunnel 21 mm wide to restore the normal space for the ligament graft.

With the knee in 90° of flexion and the tibia in neutral rotation, the lower end of the fixed guide tube was placed at the center of the normal, easily identified attachment of the ligament at the tibia. The handle of the guide was held parallel to the

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long axis of the femur in the coronal plane, with the tip of the fixed guide tube leaning against the medial aspect of the lateral condyle (Figure 1). This point corresponds to the center of the normal attachment of the anterior ligament on the femur, because the guide-tube length, 31 mm, is equal to the mean length of the ligament, and the inclination of the tube against the long axis of the guide handle, 28°, is equal to the mean angle between the ligament and the long axis of the femur in the lateral projection in 90° of flexion (Odensten and Gillquist 1985).

The position could be checked on a lateral view using an x-ray image intensifier. The drill guide was secured by the adjustable lower guide tube, which was fixed to the anteromedial aspect of the tibia. Drilling was performed in a straight line through the tibia and femur, first with a thin guide pin, which was then overdrilled with a cannulated reamer of appropriate gauge.

Group 2. Freehand drilling. The procedure was similar, but drilling was done freehand. Knowledge acquired in cadaver studies was again applied. After drilling the tibial channel, aiming at the center of the tibial ligament attachment, a point on the lateral condyle located on a line inclined 28° to the long axis of the femur and at a distance of 31 mm was indicated. From this point, a K-wire was passed through the lateral femoral condyle and overdrilled by a cannulated reamer.

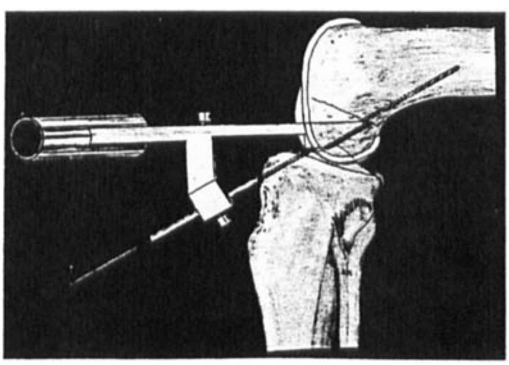

Figure 1. The drill guide in situ. The intraarticular distance (31 mm) is given by the length of the fixed guide tube.

Cadaver group. The anterior cruciate ligament was carefully detached, the attachments were outlined with ink, and a metal indicator was fixed to the bone at the center of each outlined area.

In Groups 1 and 2 a ligament prosthesis containing radiopaque tapes was used (Dacron Knee Augmentation Graft, Stryker Inc.). All three groups were radiographed in lateral projections, and the internal orifices of the drill channels were identified (Figure 2). Their positions and the positions of the metal indicators in the cadaver group were plotted on a diagram. To allow comparisons between different sized knees, a relative scale was used. On the femur the reference distance (100 per cent) was the mean of the sagittal depth of the lateral and medial condyle just below and parallel to the line of Blumensaat. On the tibia the reference distance was the sagittal depth of the medial plateau at the bone-cartilage junction (Figure 2).

Precision is defined as the proximity of the attachments of the ligament substitute to those of the normal ligament. Reproducibility was the repeated achievement of the desired result, reflected by the scatter of the positions in each group.

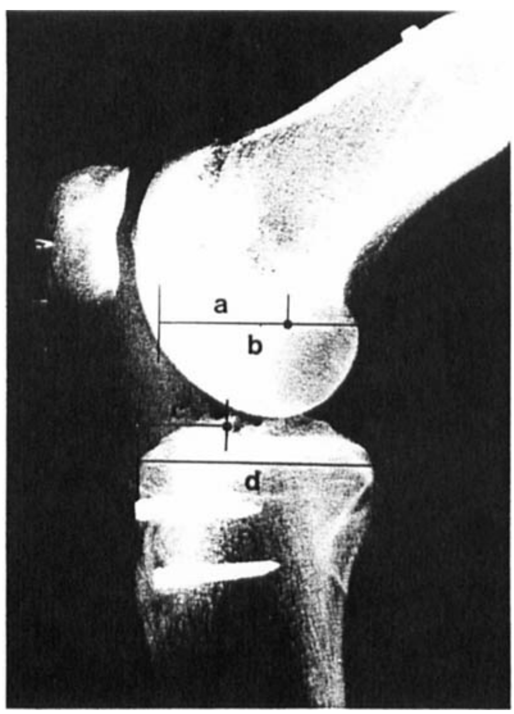

Figure 2. The positions of the inner orifices of the drill channels are given by the a/b and c/d ratios.

Results

There were differences between Groups 1 and 2 ($P < 0.001$) and between Group 2 and the cadaver group ($P < 0.05$), but not between Group 1 and the cadaver group concerning the femoral attachments, whereas no differences were seen between the tibial attachments (Table 1, Figure 3).

The standard deviation, ±4 per cent (±2 mm on the standard plot), of the center of the mean femoral ligament attachment in the cadaver group was assumed to represent an acceptable range for the orifices of the femoral drill channels in the other two groups. Hence, the precision can also be expressed as the fraction of drill channel orifices falling within this range (Table 2). These values were 0.8 in Group 1 and 0.5 in Group 2 ($P < 0.05$).

The scatter of the femoral attachments is given by the standard deviation of the mean attachments and the corresponding coefficients of variation (Tables 1 and 3). The mean of the absolute difference between the position of each single attachment and the mean position of the group, viz., the mean deviation (Table 3) indicated a twofold better reproducibility with the drill guide compared with freehand drilling. The number of attachments falling within the range of ±2 mm of the own group mean, 70 percent in Group 1 and 24 per cent in Group 2 (Table 3) implies even better reproducibility with the drill guide if the worst positioning errors are excluded.

Table 1. The mean attachments drilled in Groups 1 and 2 and metal indicated in the cadaver group, expressed in percent (SD) on a relative scale (Figure 2)

	Femur a/b	Tibia c/d
Group 1 n 30	67 (5)	32 (3)
	$P < 0.001$	NS
Group 2 n 17	60 (8)	33 (5)
	$P < 0.05$	NS
Cadavers n 10	66 (4)	33 (3)

Table 2. Number of femoral attachments in relation to a range of ± SD (2 mm) of the average anterior cruciate ligament attachment in the cadaver group, reflecting degree of precision

	Anterior	Within	Posterior
Group 1 n 30	1	23	6
Group 2 n 17	8	8	1
Significance level of difference	$P < 0.0005$	$P < 0.05$	NS

Table 3. Number of femoral attachments falling within ± 2 mm of the own group mean and the coefficients of variation and mean deviation of the femoral attachments in per cent, reflecting degree of reproducibility.

	Within	Coefficient of variance	Mean deviation
Group 1 n 30	21	7	3.7
Group 2 n 17	4	13	6.7
Significance level of difference	$P < 0.005$		$P < 0.01$

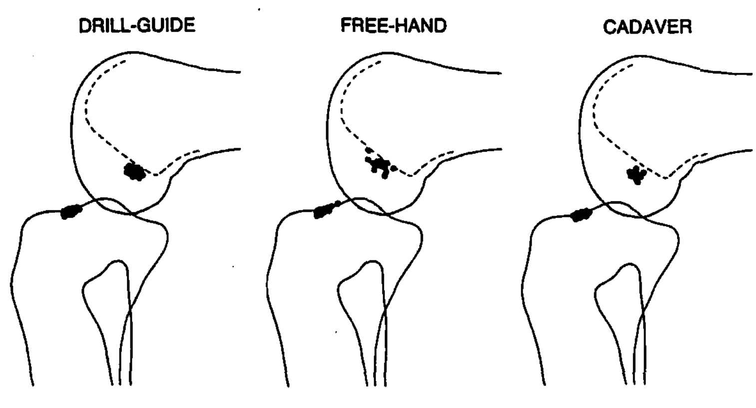

Figure 3. Standard plots of the internal orifices of the drill channels or the metal indicators in the three groups. The tibial attachments show no differences, whereas the attachments on the femur in the freehand group show a significantly greater scatter, and on an average are located more anteriorly than in the drill-guide and cadaver groups.

Discussion

Previous drill guides for cruciate ligament reconstruction have not actually guided the surgeon to correct placement of the graft, but have merely served to direct the drill bit to a predetermined spot. All positioning devices need a reference point. The easier it is to identify this point, the better the result. The best landmark to operate from is the remnant of the tibial attachment of the cruciate ligament: no differences were found between the tibial attachments in the three groups.

Owing to the oblique course of the drill bit in relation to the tibial articular surface, a small aberration in vertical positioning of the drill guide will result in a relatively larger aberration of the position of the drill channel orifices in the sagittal plane. We have found that this problem is avoided if the soft tissue on the tibial attachment is closely removed and the drill guide is firmly placed on bony surface. Once this is done, there are two additional ways of checking that the spot chosen is the correct one: 1) the grove on the guide frame should correspond to the meniscosynovial junction; 2) in the lateral radiographic projection the tip of the fixed guide tube should be just below the point where Blumensaat's line curves posteriorly and upwards.

In clinical practice, we accept a pistoning motion of the graft of 2 mm between 0° and 105° of knee flexion. Hefzy et al. (1987) found that the zone within which the femoral attachment should be located to maximize a distance alteration between the internal offices to 2 mm is narrow, and in that respect resembles the standard deviation (±2 mm) of the mean femoral attachment of the cadaver knees.

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