Intercondylar notch width and the risk for anterior cruciate ligament rupture

A case-control study in 46 female handball players

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We measured the intercondylar notch of the femur in female handball players from radiographs of 20 players with previous unilateral anterior cruciate ligament injury, and 26 controls without injury. The groups were comparable regarding age, height, weight and level of performance.

Intercondylar fossa radiographs were obtained in a posteroanterior axial position. The anterior opening of the intercondylar notch was narrower in the healthy knee of the injured group compared to the controls. There was an increased risk of anterior cruciate ligament injury associated with decreasing notch opening: female handball players with 17 mm or less anterior notch width were 6 times more susceptible to anterior cruciate ligament injury compared to players with wider notch width.

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One of the main contributors to female anterior cruciate ligament ruptures in Norway is European team handball. The incidence of anterior cruciate ligament ruptures is increasing owing to greater participation in recreational and competitive sports (Strand et al. 1990). Each year some 5 percent of women who compete in high-level handball sustain an anterior cruciate ligament rupture (Myklebust et al. 1992).

We have studied whether female handball players with previous anterior cruciate ligament rupture had a narrower notch than players with no history of such injury, and if a critical notch width could be determined, which might predict a higher risk of rupture.

Patients and methods

26 female handball players without a history of knee ligament injuries and 20 female handball players with a previous unilateral anterior cruciate ligament rupture were examined. The average age of the group with ligament injuries was 20 (17–28) years, weight 64 (53–83) kg, and height 170 (160–180) cm. All ruptured ligaments had been reconstructed by use of a mid-third bone-patellar tendon-bone autograft (Clancy et al. 1988) and average time from surgery to examination was 15 (8–30) months .

In the control group the average age was 21 (16–27) years, weight 67 (55–82) kg, and height 173 (163–183) cm. Lachman's test was used to identify anterior cruciate ligament deficiency and did not exceed 1+ for any of the knees in either group.

Radiographs were obtained with vertical beam and Ff distance 100 cm. The patient kneeled on the film with 70° flexion in the knee and with the tibia parallel to the table (Holmblad 1937, Figure 1). This position gives a view of the intercondylar notch. Both knees were projected on one film. The same technician performed all the radiographic examinations.

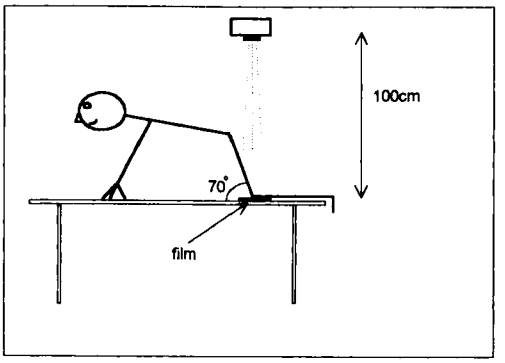


Figure 1. Radiographic examination. Note vertical beam and 70° angulation of femur.

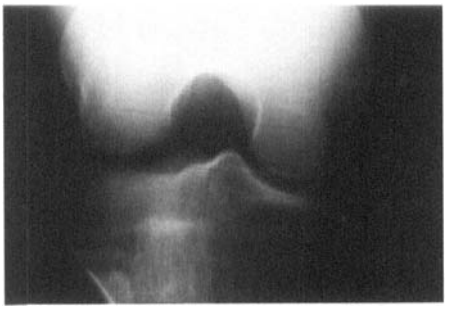
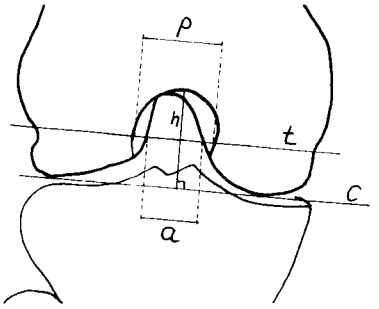


Figure 2. Example, Holmblad technique.



Condylar line (c), transcondylar distance (t), anterior opening (a), and posterior opening (p) at half notch height.

The measurements of the films were performed jointly by a radiologist (SA) and an orthopedic surgeon (JG) in the following way (Figure 2). The condylar line was drawn as a tangent to the subchondral bone of both femur condyles. The perpendicular to this line was erected to the deepest part of the notch roof. This line was divided into two halves and a line parallel with the condylar line drawn. The interception with the most medial and lateral points of the condyles constituted the transcondylar distance. The presumable anterior and posterior notch widths were found in similar ways. The width index (NWI) was calculated as the anterior notch width to the total condylar width ratio.

We averaged the notch width of the right and left knees for the uninjured group because of the high correlation (0.84) between these. Notchplasty had been performed in all the reconstructed knees. We therefore compared the uninjured knee in the injured group with the average control width.

To determine whether the narrower portion of the notch was situated anteriorly or posteriorly, we made plain notch view radiographs with 50°, 60° and 70° knee flexion and a T1-weighted MRI scan at half-notch height, angled 20° with regard to the femur, parallel with the notch roof, of one uninjured knee (Figure 3).

Statistics

We used Cochran-Mantel-Haenszel statistics in the case-control and trend analysis. Nonparametric tests, Mann-Whitney *U*-test and Wilcoxon test for related samples were used. *P*-values below 0.05 were considered significant.

Results (Table 1)

The radiographs with different angles of knee flexion indicated that the narrower contour was anterior because this contour was displaced inferiorly with decreasing flexion. The MRI scan of the same knee, made at half notch height, confirmed this.

In the control group the average anterior opening of the right and left knees was 18.5 mm, posterior opening 23.0 mm and the NWI was 0.243. The uninjured knee in the injury group showed an anterior opening of 16.7 mm, posterior opening of 21.8 mm and a NWI of 0.224. The anterior opening and the NWI in the injured group were narrower than in the controls. For the posterior opening the differences were of borderline significance. The reconstructed knee in the injured group showed an anterior opening of 18.2 mm, which was, on average, 1.5 mm wider than in their healthy knee.

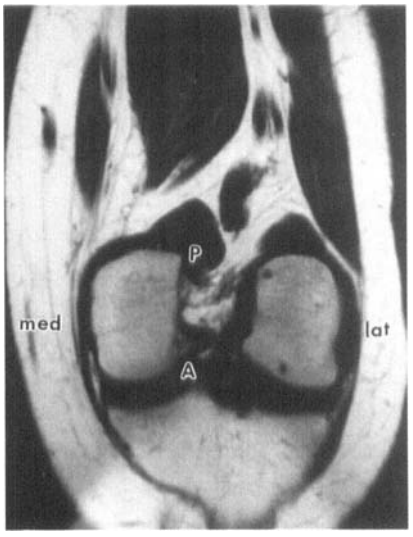


Figure 3. MRI scan parallel with the notch roof at half notch height. Note that the anterior portion of the notch (A) is narrower than the posterior (P).

Table 1. Radiographic measurements

	Injury group		Control group
	Uninjured knee	Reconstructed knee	Average dxt/sin
n	20	20	26
Age	20 (17–28)		21 (16–27)
Weight	64 (53–83)		67 (55–82)
Height	170 (160–180)		173 (163–183)
Anterior outlet mm *SD*	16.7 *2.0*[a]	18.2 *2.1*	18.5 *3.1*
Notch width index	0.224 (0.026)[b]	0.243 (0.028)	0.243 (0.038)
Posterior outlet mm *SD*	21.8 *1.9*[c]	22.6 *2.4*	23.1 *2.4*
Total width mm *SD*	74.6 *2.2*[d]	74.8 *2.9*	76.2 *3.6*

[a] Difference from reconstructed knee *P* 0.003 and control group *P* 0.02
[b] Difference from reconstructed knee *P* 0.003 and control group *P* 0.04
[c] Compared with the control group *P* 0.05
[d] Compared with the control group *P* 0.07

We dichotomized the measured values of the anterior opening. In players with a notch width smaller than or equal to 17 mm, there was an odds ratio of 7 (2–24, 95 percent confidence limits, *P* 0.003), compared to having a notch width wider than 17 mm. The analogous risk, using dichotomized NWI values, was 5 (1.3–17, 95 percent confidence limits, *P* 0.01). We also divided the notch width into tertile values, which showed a trend of increased risk of injury associated with decreasing notch width (chi-square trend 4.8, *P* 0.03). A nearly identical trend was found using NWI.

Discussion

Several studies have examined the role of the intercondylar notch related to anterior cruciate ligament injuries. It has been hypothesized that the anterior cruciate ligament may be stretched over the posterior cruciate ligament or the lateral condyle by internal or external rotation in knees with a stenotic notch (Feagin and Lambert 1985, Souryal and Freeman 1993). Houseworth et al. (1987) concluded in a computer graphics study that the posterior arch area was smaller in a group with this injury compared with normal individuals. In a CT study Anderson et al. (1987) found differences in the notch opening angle and notch width index at 2/3 of notch height between normal and anterior cruciate ligament-injured knees. Good et al. (1991) measured the anterior opening directly with calipers and found a narrower notch in a group with acute ligament tears and even more narrowing in chronic ligament-insufficient knees compared with normals. As a consequence, they suggested that notchplasties should be performed routinely.

If handball players were to be screened for rupture risk, plain radiography might be a more feasible method than using CT measurements. Schickendantz and Weiker (1993) concluded, however, that notch width index measurements from plain radiographs were not reliable predictors of injury to the anterior cruciate ligament. On the other hand, Souryal and Moore (1988) used radiography and found that patients with bilateral ligament ruptures had narrowing of their intercondylar notch. They found no difference between the group with unilateral acute ligament rupture and the controls. In a prospective study, Souryal and Freeman (1993) found that 10 of 14 athletes with unilateral non-contact anterior cruciate ligament injury had NWI ratios that were 1 SD or more below the mean. In their study the female average NWI was 0.217. Their study, like ours, was designed for screening and gives little information about the notch configuration, as studied by Anderson et al. (1987) and by Tanzer and Lenczner (1990).

The radiographic technique employed in this study is technically simple and since the magnification is approximately 5 percent this factor can be ignored when comparing different films performed with our method. To obtain true values, 1 mm caused by magnification should be subtracted from our measurements. The corrected anterior opening values for the injury group were therefore 15.8 mm and for the controls 17.6 mm. These figures are smaller than those Good et al. (1991) found by direct measurement of the maximal notch width, just above the meniscal plane, 18.1 mm and 20.4 mm.

As the measurements were done on plain radiography, we cannot be certain that the narrower contour of the notch was the anterior opening. Therefore, plain radiographs with different angles of flexion in the knee and a MRI scan at half-notch height

were made (Figure 3). These images confirmed that the narrower contour is the anterior opening.

After an average of 15 months, there was a difference in notch width in the reconstructed knees compared with the uninjured knees but, compared with the controls, there was no difference. This is in accordance with a report from Dahlstedt et al. (1990) who concluded that the notch remained open in stable knees.

In conclusion, our study indicates that a narrow anterior opening is associated with increased risk of anterior cruciate ligament injury. The results suggest that female handball players with an anterior opening less than 17 mm, measured with our method, should be counseled concerning their relatively high risk of ligament injury associated with continued participation in high-level handball. Further research in comparable groups with an increased sample size is needed to verify these findings.

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