Anterior Cruciate Ligament Reconstruction Alters the Patellar Alignment

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Summary: Although there are many articles dealing with anterior cruciate ligament (ACL) reconstruction, there are none dealing with the possibility of changes of the patellofemoral alignment after these procedures. Forty-six patients were evaluated preoperatively and 1 year postoperatively, after undergoing intra-articular ACL reconstruction, for changes of the patellofemoral alignment. Patella-tilt and congruence angles were measured on tangential view radiographs that were taken in the supine position. Analysis of covariance was performed and revealed a significant change of the congruence angle 1 year postoperatively. The patella-tilt did not change. One year postoperatively, the patella shifted on average 5° medially after ACL grafting. It can be deduced that anterior knee pain after ACL reconstruction could be caused by distinct changes in the patellofemoral alignment.

Key Words: Anterior cruciate ligament—Patellar tendon graft—Patellar alignment.

Normal function of the patellofemoral joint depends on the interaction of several elements including the patellofemoral alignment, bony and soft tissue stability, and muscular interaction. Patellofemoral disorders encompass a wide range of conditions from anterior knee pain to arthrosis. Considering the patellofemoral joint is a subtle system, minor changes in the soft tissue alignment may lead to disturbed patellofemoral interaction. There are several reports claiming that the patellar tendon shrinks a certain percentage after anterior cruciate ligament (ACL) reconstruction.1-3 Two articles associate this shortening with anterior knee pain.3,4 Furthermore, Shino et al.5 reported deteriorative changes of the patellofemoral articular surfaces after ACL reconstruction. These changes were detected, at second-look arthroscopy, with an incidence rate of 44% for ACL reconstruction using allografts and an incidence rate of 57% using autografts. Hsieh et al.5 recently showed a cadaver model in which the removal of the ACL led to significant changes of the lateral patellar tilt and lateral patellar shift during knee motion. However, none of these studies1-6 investigated possible changes of the patellar alignment after ACL reconstruction as a result of scarring and contracture of the patellar tendon with obvious changes after the development of an infrapatellar contracture syndrome, as described by Paulos et al.,2,7 but perhaps with more subtle alterations in patients without arthrofibrosis. The aim of this study was to investigate the influence of harvesting the central third of the patellar tendon in comparison with the multiple suture repair ACL reconstruction on both the lateral patellofemoral and the Merchant’s angles.

MATERIALS AND METHODS

This study included patients who were operated on because of an ACL deficiency between 1993 and 1994.
The inclusion criteria consisted of: (1) informed consent of additional radiographs, (2) an isolated ACL tear, (3) no history of patellofemoral problems, (4) radiological confirmation of a normal patella and patellofemoral joint, (5) no former knee operations, and (6) free range of motion and no failure of the ACL reconstruction at follow-up. All knees were arthroscopically evaluated and any internal derangements were treated before ACL reconstruction. When the ACL tear was not older than 2 weeks, high proximal ruptures of the ACL were repaired using the technique described by Marshall et al.,8 with a mini-arthrotomy on the medial side of the patellar tendon (group A). All other ACL tears were reconstructed with the central third of the patellar tendon as a bone-tendon-bone graft9 (group B). The gap in the patellar tendon after harvest was not closed. The osseous defects at the patellar apex and tibial tuberosity were filled with spongious bone obtained from the shaping of the bone blocks. Thirty patients underwent ACL reconstruction within 6 weeks of injury, and 16 patients underwent reconstruction 6 weeks after injury or later. The ACL repairs (group A) and the ACL grafts (group B) were augmented with the synthetic augmentation device (Ligament Augmentation Device; 3M, St. Paul, MN) that was led over-the-top, and fixed in a rigid double-end fixation technique with a preload of 80 N, with the knee fully extended.10

Postoperatively, the knee was braced (Donjoy Smith & Nephew, Carlsbad, CA) at 20° for the first 5 days after which free range of motion was encouraged. Continuous passive motion (50°-0°-90°) was performed starting from the first postoperative day for 4 to 6 hours per day. Weight bearing was allowed as tolerated. Local cryotherapy with cool-packs and non-steroidal anti-inflammatory drugs were prescribed. Patients were discharged from the hospital on the fourth or fifth postoperative day. Training for competitive sports was allowed after 3 to 4 months, when the thigh regained its normal circumference.

Patients were asked to come in for a follow-up investigation approximately 1 year after the ACL reconstruction. The investigations performed included clinical examination, subjective symptoms, and radiographic control. Range of motion was measured with an international standard goniometer. Passive sagittal knee laxity was measured with the KT 1000 (MEDmetric, San Diego, CA), as described by Daniel et al.11 Preoperatively and at follow-up, radiographs were taken as described by Merchant et al.12 except that the knee was flexed to 25°, not 45°. Care was taken to keep the axis of the patient’s forefoot vertical. On these radiographs, the sulcus angle, the lateral patellofemoral angle (α),13 and the Merchant congruence angle (β)12 were measured (Fig 1). The length of the patella and the patellar tendon were measured, as described by Insall and Salvati,14 on lateral radiographs taken in the supine position with the knee flexed to 60°. The patellar vertical height ratio was then calculated by dividing the length of the patellar tendon by the length of the patella (Fig 2). The recorded angles and the patella height were statistically compared using analysis of covariance; P < .05 was considered statistically significant.

**RESULTS**

In group A there were 13 men and 10 women, in group B, 12 men and 11 women. The mean age was 26.1 years (±7.8 years) with no significant difference between the two groups. All patients had stable knees with a free range of motion at follow-up.

There were no significant differences, either preoperatively or postoperatively, between sulcus angles or between the lateral patellofemoral angles (α) of both groups (Table 1).

For the Merchant congruence angle (β), significant differences were observed between the preoperatively and the postoperatively recorded values, as well as between group A and B postoperatively. The mean difference between the preoperatively and postoperatively recorded angles was −1.7° ± 0.9° in group A, and −4.7° ± 0.7° in group B (P = .001) (Table 2).

No significant difference was detected between the groups for the alterations of the patellar tendon length (P = .09). However, there was a significant decrease from the preoperative measurements to the follow-up investigation (P = .04) (Table 3).

**FIGURE 1.** The lateral patellofemoral angle (α) is determined by the junction of a line across the femoral condyles and another line drawn across the lateral patellar facet. The congruence angle (β) is determined by bisecting the sulcus angle, projecting a second line from the apex of sulcus to the lowest point of the patellar ridge; the angle is formed between this line and the bisecting line.
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DISCUSSION

The authors investigated the influence of ACL surgery on the patellofemoral joint. Two techniques for ACL reconstruction, the patellar tendon grafting and the multiple suture repair, were compared to measure the patellar alignment on radiographs. Despite the advantages of the use of the central third of the patellar tendon, there are also some drawbacks. In conjunction with donor-site morbidity, another possible major risk is an increase of the incidence of patellofemoral arthrosis. The high occurrence of anterior knee pain cannot be explained solely by donor-site morbidity because it occurs in a comparable percentage even after the use of hamstring tendons for ACL reconstruction.15

Recently, Hsieh et al.6 reported a cadaver study with significant effects of the removal of the ACL on patellar kinematics, which returned to normal after ACL reconstruction. They stated that one limitation was that their study could not address the healing process, which could alter the pressure distribution as a result of scarring and contracture of the patellar tendon. Our results indicate a definite influence of the graft harvest on the patellofemoral joint. Care was taken to use the same anatomic landmarks when taking the measurements. Because no significant differences were recorded for the sulcus angle between the preoperative and follow-up radiographs, it can be assumed that the radiographs were taken very carefully and constantly in the same position. The lateral patellofemoral angle did not differ after the ACL reconstruction. However, the Merchant’s angle showed a significant decrease on the follow-up radiographs. One could argue that these changes are minimal. Although no pathological angles were measured, either preoperatively or at follow-up, the exactness of the measurements give reason to believe that a change of approximately 5° cannot be explained by inaccuracy. This change is a hint of a distinct alteration in the patellofemoral alignment. However, the ACL deficiency could have caused a change of the patellofemoral alignment by itself, but the authors do not believe that the preoperative ACL deficiency significantly influenced the results, because in group A no significant change of the measured angles occurred at follow-up and all knees included were stable.

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<th>Table 1. Lateral Patellofemoral Angle (mean ± SD)</th>
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NOTE. No statistically significant difference was found for the lateral patellofemoral (LPF) angle between groups A and B pre- and postoperatively.

*P values obtained for the comparison of preoperative and postoperative values.
†P values obtained for the comparison of group A and group B values preoperatively and postoperatively.

<table>
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<th>Table 2. Merchant’s Angle (mean ± SD)</th>
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NOTE. Although the preoperative and postoperative differences in group A were minimal, they were statistically significant. On the other hand, in group B the differences were distinct. Postoperatively, a significant difference was found between the two groups that was not present preoperatively.

*P values obtained for the comparison of preoperative and postoperative values.
†P values obtained for the comparison of group A and group B values preoperatively and postoperatively.
Changes in the patellar height result in different mechanical forces acting on the patellofemoral joint. The change of the patella height cannot be the only explanation for significant differences of the Merchant angle between groups A and B because this study as well as an investigation with more than 100 patients showed that changes of the patella height were the same regardless of the operative procedure (ACL repair vs ACL grafting). The extracted patellar tendon graft, not located exactly in the center, or the scar formation, not conducting forces as the original tendon, could be an explanation for the medial migration of the patella.

This study was performed without the benefit of accelerated rehabilitation. Those cited above, which describe high rates of anterior knee pain, were also performed without accelerated rehabilitation. When we began to accelerate the rehabilitation program, the rate of anterior knee pain in our patients dropped, and even without postoperative fixation no adverse effects were seen. This also supports the contention that patellar tendon shrinkage is one major responsible factor for the changes in the patellofemoral alignment and subsequent anterior knee pain.

Donor site morbidity cannot be the only explanation for the arthroscopic finding of deterioration around the central ridge of the patella and the frequent occurrence of anterior knee pain after ACL reconstruction. Furthermore, it is probably justifiable to hypothesize that graft harvest and/or scar formations influence the patellar alignment. Because the scarring might not be limited to the site of the graft harvest, but may also be generalized, as in infrapatellar contracture syndrome, these distinct aspects must likewise be taken into consideration when the patient complains about anterior knee pain after ACL reconstruction, without presenting a completely infrapatellar contracture syndrome.

REFERENCES