

Ipsi- or Contralateral Patellar Tendon Graft in Anterior Cruciate Ligament Revision Surgery

A Comparison of Two Methods*

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ABSTRACT

Twenty-four patients who underwent anterior cruciate ligament revision surgery were studied postoperatively (12 with reharvested ipsilateral patellar tendon grafts and 12 with contralateral patellar tendon grafts). For comparison purposes, 12 matched patients with primary anterior cruciate ligament reconstruction, who had been operated on using the same technique by the same surgeons, were chosen. The median time since the first reconstruction was 57 months (range, 15 to 132) in the ipsilateral tendon group and 54 months (range, 20 to 108) in the contralateral tendon group. Follow-up examination showed that there were no significant differences in total KT-1000 arthrometer side-to-side measurements between the groups, but the Lysholm score was higher for patients with contralateral tendon grafts than for patients with ipsilateral grafts. Only two patients with ipsilateral grafts were classified as having excellent or good results. Functional testing outcomes were similar for all groups, and magnetic resonance imaging screening showed no differences between the reharvest and primary harvest groups in terms of length, width, thickness, or donor site gap of the patellar tendon. However, there were two major complications in the group with revision surgery with the ipsilateral reharvested patellar tendon. Reharvesting the ipsilateral patellar tendon resulted in

lower functional scores and a higher rate of complications than revision with the contralateral patellar tendon or primary anterior cruciate ligament reconstruction.

With the increasing number of primary ACL reconstructions, the need for revision surgery will certainly also increase, even if the correct anatomic and isometric results are produced by the primary operation.²³ In primary ACL reconstruction, the use of the patellar tendon is considered to be the most suitable option.^{7,9,10,13} There are, however, well-known postoperative problems and complications, such as donor site morbidity and patellofemoral pain, which are found in 20% to 60% of patients.^{2,4,15} There are also more serious but less frequent complications, such as patellar tendon rupture^{3,16} and patellar fracture.⁹ Revision surgery after failed ACL reconstruction is a great challenge and lacks a standard procedure at the present time. Even though it is now understood that the most common reason for failed primary ACL reconstruction is the incorrect placement of either the femoral or tibial drill holes or insufficient notchplasty (Refs. 12, 20, 23, 28-30; H. H. Paessler, unpublished data, 1996), one of the as yet unsolved problems in ACL revision surgery is the optimal choice of graft for the revision operation. The options include the quadriceps tendon,^{20,29} the contralateral patellar tendon (Refs. 20, 22; H. H. Paessler, unpublished data, 1996), reharvesting of the ipsilateral patellar tendon (Refs. 14, 20; H. H. Paessler, unpublished data, 1996), or a free hamstring graft.²⁰ Other authors have advocated allograft material.^{20,24}

Until recently, only a few reports on the results after ACL revision when reharvesting of the ipsilateral patellar tendon or the contralateral tendon is used have been found in the literature (Refs. 14, 22; H. H. Paessler, un-

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published data, 1996). One of the main advantages of using the ipsilateral patellar tendon is the absence of surgical trauma to the contralateral knee. There is also no risk of disease transmission as there is with allografts. Adriani et al.¹ used ultrasonograph evaluation to show that healing of the patellar tendon defect after harvesting a free graft can be expected to take place with tendon-like scar tissue, and the healing time is approximately 1 year. Cerullo et al.⁵ have used computed tomography to demonstrate that scarring of the open patellar tendon defect takes place within 6 months postoperatively. Reharvesting of the ipsilateral tendon therefore appears theoretically to be a valid alternative. On the other hand, animal studies have shown a strength decrease of approximately 50% after 12 months in both the reharvested central third of the patellar tendon¹⁷ and the remaining two-thirds of the patellar tendon after the first harvest.²⁶ Neither of these studies therefore recommends reharvesting of the patellar tendon.

The aim of this study was to assess knee function after ACL revision reconstruction involving either the reharvesting of the ipsilateral patellar tendon or the harvesting of the contralateral patellar tendon graft and to compare the findings with the results from primary ACL reconstructions in a matched group of patients.

MATERIALS AND METHODS

Patients

Twenty-four consecutive patients in need of ACL revision reconstructions underwent surgery involving either the central third of the ipsilateral patellar tendon (group A, $N = 12$) or a contralateral patellar tendon graft (group B, $N = 12$), depending on the choice of the surgeon. For purposes of comparison, a group C—12 age- and sex-matched patients with primary ACL reconstruction operated on with a free ipsilateral bone-patellar tendon-bone graft by the same surgeons—were chosen. The median time since the first reconstruction was 57 months (range, 15 to 132) in group A, and 54 months (range, 20 to 108) in group B (no significant difference).

In group A, all the previous reconstructions were performed using an open technique. Six patients underwent reconstruction involving the medial third of the patellar tendon and six involving the central third. The cause of failure in 10 patients was nonisometric placing of the drill holes too anterior on the tibial side, femoral side, or both sides, causing graft elongation by notch roof impingement in extension and overloading in flexion. A new trauma was the cause of failure in two patients. At the time of the revision operation, all patients but one had concomitant medial or lateral meniscus injuries. Six patients had both lateral and medial meniscus injuries, and five patients had a medial meniscus injury. Seven patients had mild degenerative changes of the cartilage in the knee (damage down to subchondral bone with a maximal size of 5×5 mm, Outerbridge grades II or III).

In group B, all the primary operations were performed using an open technique. All these patients had previously

undergone reconstruction involving the medial third of the patellar tendon. The cause of failure was a new trauma in four patients and nonisometric placing of the drill holes, failure of graft incorporation, or both in eight patients. There were no concomitant PCL injuries. Eleven patients had concomitant meniscus injuries: five on the medial side, four on the lateral side, and two on both the medial and lateral sides. Six patients had mild degenerative changes of the cartilage of the knee (Outerbridge grades II or III).

The median time since the injury in group C was 18 months (range, 3 to 90). The median age of the patients at the time of revision surgery was 27 years (range, 23 to 33) in group A and 27 years (range, 24 to 33) in group B (no significant difference). In group C, the median age at the time of primary reconstruction was 27 years (range, 19 to 32). There were five men and seven women in each group. All the patients were reexamined by an independent observer at 26 months (range, 20 to 33) postoperatively in group A, at 24 months (range, 22 to 30) in group B, and at 24 months (range, 23 to 26) in group C.

Follow-up Examination

The follow-up examination was based on a KT-1000 arthrometer (MedMetric, San Diego, California) Lachman test to evaluate the total sagittal stability of the knee and Lysholm,¹⁸ Tegner,²⁷ and International Knee Documentation Committee (IKDC) scores,¹¹ as well as MRI screening⁸ of the knees focused on the donor site. All the subjective scores were patient-administered, which means that the patients completed the score sheet without the presence or guidance of the observer. In the case of the Lysholm score, the stability and pain subscores were also registered by the patient.

Functional performance was evaluated with the single-legged hop test to calculate a quotient between the injured and noninjured legs. In all three groups, the donor site was palpated for tenderness and the patient was asked to kneel to assess discomfort compared with the other knee.

Eleven patients in group A and 12 in group C underwent MRI screening of both knees and the ratios of the length, width, and thickness of the patellar tendon in the injured and noninjured knees were evaluated (Fig. 1). The gap in the donor site that did not correspond to normal tendon signal was measured in millimeters (Fig. 2).

The MRI examination was performed with a Siemens Magnetom 1.0-T magnet (Siemens, Erlangen, Germany) using a flexible knee coil method. A three-dimensional dual echo steady state sequence was used, with a repetition time of 26.8 ms and an echo time of 9.0 ms. A 200×200 field of view was used, with a matrix of 256×256 . A three-dimensional reconstruction program was then used for axial reconstructions from which a mean average value for the width and thickness of the patellar tendon was calculated using three different levels through the upper midthird and lower third of the patellar tendon. The midpoint of the patellar tendon on the donor side was then evaluated for the gap size in the axial dimension.

The length of the patellar tendon from the apex of the

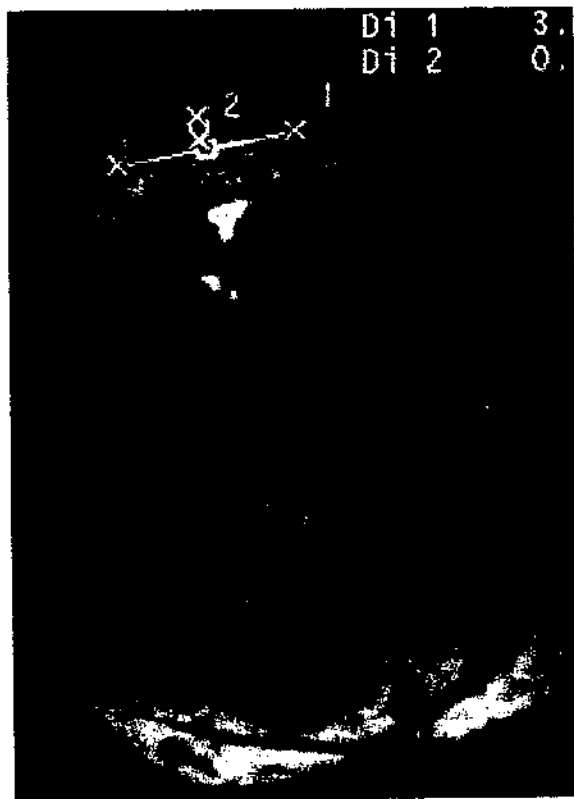
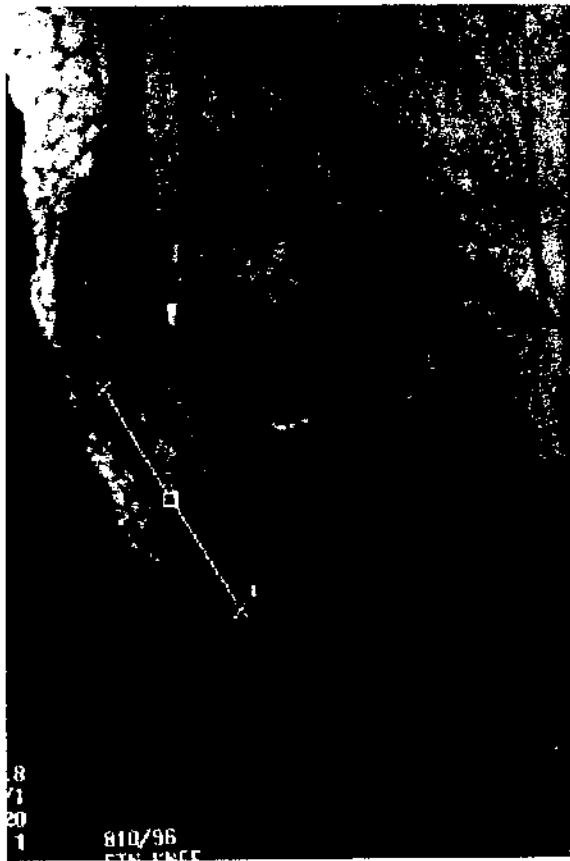


Figure 1. The measurement of the length (top), width (bottom, 1), and thickness (bottom, 2) of the patellar tendon.

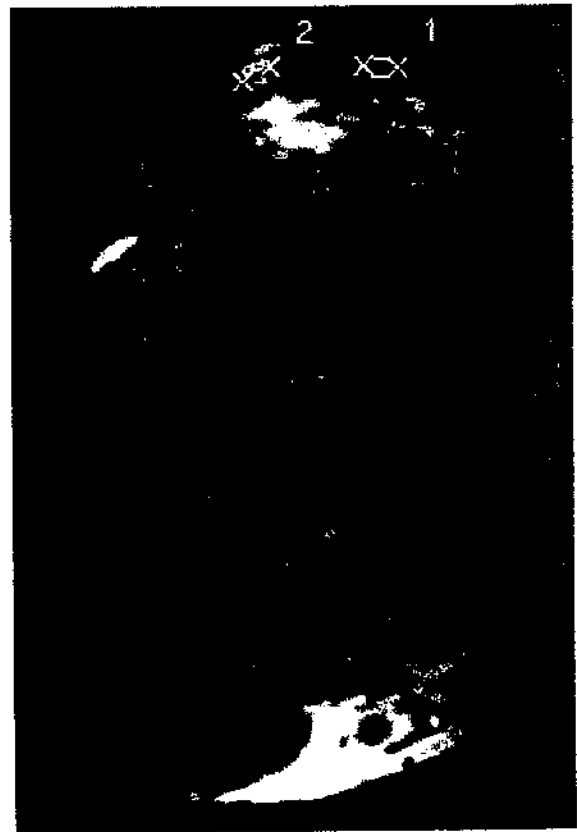


Figure 2. Magnetic resonance imaging scan of the knee in the axial plane. Top, a 7-mm central slit in the central part of the patellar tendon. Bottom, two 5-mm slits after reharvesting of a free patellar tendon graft.

patella to the insertion at the tibial tuberosity was calculated (Fig. 1). All measurements were made with a Siemens evaluation unit with the aid of computerized distance measurements during the standardized setting of window level and window center.

Surgical Procedures

All the patients were operated on by one of three experienced surgeons (without any surgeon-method bias) using the all-inside one-incision arthroscopic technique, patellar tendon autograft, and interference screw fixation at both ends (except in one patient in group A who had staple fixation on the tibial side). The graft was reharvested from the central third of the remaining ipsilateral patellar tendon (group A), harvested from the contralateral patellar tendon (group B), or primarily harvested from the ipsilateral patellar tendon (group C). A 7- to 8-cm long single vertical incision was used and, at the completion of surgery, the tendon defect was left open and the paratenon was carefully sutured. All associated meniscus injuries were addressed at the time of the operation described here. We treated the minor meniscus injuries with debridement and the major injuries with partial resection. No meniscal sutures were used in this study. At the end of the operation, a miniarthrotomy was performed in one patient in group A because of technical difficulties.

Rehabilitation

All patients underwent rehabilitation following a standard protocol. A knee brace was used for 4 weeks (range, 3 to 6). Early weightbearing with crutches was encouraged, as well as early range of motion training. Closed kinetic chain exercises were started at 3 weeks. Three patients in group C did not use a brace during the postoperative period. Otherwise, there were no differences between the groups in terms of the rehabilitation protocol.

Statistics

All the results are given as median values (with range). The Mann-Whitney nonparametric two-tailed test and the chi-square test were used for comparisons of the two treatment groups. A *P* value less than 0.05 was regarded as statistically significant. Group A and group B were included in the primary analysis and all statistical calculations were based on this cohort. Group C was included as a reference group.

RESULTS

In group A, the median total KT-1000 arthrometer side-to-side difference was 3 mm (range, -0.5 to 8.5). Seven of 12 patients had an anterior side-to-side difference between the injured and noninjured leg of 3 mm or more and 6 of 12 had a total anteroposterior side-to-side difference of 3 mm or more. The median Lysholm score was 62 points (range, 25 to 89). Two patients were classified as having excellent or good results (Lysholm score more than 84

points). The stability and pain subscores were 10 points (range, 5 to 25) and 10 points (range, 0 to 20), respectively. The median Tegner activity level was 5 (range, 1 to 7). The single-legged hop quotient was 88% (range, 0% to 118%) of the uninjured side. There was no difference in terms of subjective and objective function or stability and MRI findings between the patients who had previously undergone reconstruction with the medial or central third of the patellar tendon.

In group B, the median total KT-1000 arthrometer side-to-side difference was 2 mm (range, 0 to 5.5) (*P* = 0.11, group A compared with group B). Two of 12 patients had an anterior side-to-side difference of 3 mm or more and 3 of 12 had a total side-to-side differences of 3 mm or more. The median Lysholm score was 84 points (range, 55 to 95) (*P* = 0.002, group A compared with group B). Eight patients were classified as having excellent or good results. The stability and pain subscores were 20 points (range, 10 to 25) (*P* = 0.02) and 20 points (range, 5 to 25) (*P* = 0.006), respectively (*P* values for group A compared with group B). The Tegner activity level was 5 (range, 2 to 7) (*P* = 0.3, group A compared with group B). The single-legged hop quotient was 88 (range, 62 to 120) (*P* = 0.4, group A compared with group B).

In group C, the median total KT-1000 arthrometer side-to-side difference was 3 mm (range, -7 to 6.5). Four of 12 patients had an anterior side-to-side difference of 3 mm or more and 3 of 12 had a total side-to-side difference of 3 mm or more. The median Lysholm score was 90 points (range, 38 to 99), and the stability and pain subscores were 25 points (range, 10 to 25) and 20 points (range, 5 to 25), respectively. Nine patients were classified as having excellent or good results. The Tegner activity level was 6 (range, 1 to 9). The single-legged hop quotient was 87% (range, 50% to 104%).

Eleven patients in group A and 12 in group B underwent MRI screening of both knees. In terms of the patellar tendon length, thickness, and width, the ratios between the harvested and nonharvested sides revealed no significant difference between the patients in each group (Table 1).

In group A, 11 of 12 patients had discomfort at the donor site, problems kneeling, or both, compared with 7 of 12 in the reconstructed knee in group B and 4 of 12 in the contralateral knee. In group C, 9 of 12 patients had discomfort at the donor site.

Using the IKDC final evaluation classification,¹¹ no patient in group A was classified as having a normal knee (IKDC grade A), three were classified as nearly normal (IKDC grade B), seven as abnormal (IKDC grade C), and two as severely abnormal (IKDC grade D). In group B, no patient was classified as having a normal knee, seven as nearly normal, four as abnormal, and one as severely abnormal. In group C, five patients were classified as having a normal knee, five as nearly normal, and two as abnormal.

No major complications were registered in patients in groups B and C. In group A, one patient suffered a dislocated patellar fracture 2 weeks postoperatively and one patient suffered a patellar tendon rupture 6 months post-

TABLE 1

Magnetic Resonance Imaging Findings of the Donor Site in Patients with Reharvest of the Ipsilateral Patellar Tendon (Group A) and Primary Reconstruction (Group C)

Measurement	Group A	Group C	Significance ^a
Gap (mm)	7 (3-15)	5 (2-11)	NS
Length (% of noninjured side)	97 (71-120)	100 (87-121)	NS
Width (% of noninjured side)	113 (82-129)	104 (93-113)	NS
Thickness (% of noninjured side)	117 (57-250)	117 (83-233)	NS

^a There was no significant difference in terms of the residual donor site gap as well as the length, width, and thickness ratios between the reharvested and primary harvested patellar tendons as assessed with MRI at the 2-year follow-up.

operatively. The patient with the patellar fracture was operated on with internal fixation using longitudinal K-wires and tension banding²⁵ and had a total Lysholm score of 25 points and severe discomfort from the knee at follow-up. The patient with patellar tendon rupture required three more operations, was not able to walk without pain, and had a total Lysholm score of 36 at follow-up.

In group A, apart from the patients who experienced serious complications, two patients were reoperated on during the follow-up period. One patient was operated on because of meniscus symptoms, one had staples on the tibial side removed because of pain. In group B, 4 of 12 patients were reoperated on, two because of meniscus symptoms and two with extended notchplasty because of extension deficits. In group C, 5 of 12 patients were reoperated on during the follow-up period. Two patients had the tibial interference screw removed because of pain. One patient underwent arthroscopic procedures on two occasions because of an extension deficit, and two patients underwent arthroscopic procedures because of meniscus symptoms.

DISCUSSION

The principal finding in this study was that objective stability can be restored in most patients by either reharvesting the ipsilateral tendon or harvesting the contralateral patellar tendon in patients in whom ACL revision surgery is required. However, the use of the ipsilateral patellar tendon produced inferior functional results, even though the MRI screening revealed no significant difference between patellar tendons that were harvested once or twice. There were also major complications in 2 of 12 patients in whom the ipsilateral patellar tendon was reharvested.

There were no significant differences in total sagittal laxity between the groups (3 mm in groups A and C and 2 mm in group B) as measured by the KT-1000 arthrometer, and this indicates that objective stability can be restored by reharvesting the patellar tendon as well as by primary harvesting. There were significant differences in the subjective rating of the Lysholm score between patients in group A (62 points) and those in group B (84 points). This difference was fully explained by the differences in the most important subscores, that is, stability and pain, where the cumulative median difference was 18 points between groups A and B. This difference indicates that, even though KT-1000 arthrometer measurements displayed acceptable stability values in many patients, reharvesting the ipsilateral patellar tendon did not produce

a subjectively stable and pain-free knee. Only two patients in group A were classified as having excellent or good results on the subjective Lysholm rating scale. The median Tegner activity level was similar in the three groups (5 in group A, 5 in group B, and 6 in group C).

The functional performance as assessed by the single-legged hop quotient revealed no differences in median values between the groups. Two patients in group A could not jump at all because of pain, and three patients had a hop quotient of over 100%. In both groups B and C, all the patients were able to jump.

Eleven of 12 patients in group A, 7 of 12 in group B, and 9 of 12 in group C had donor site discomfort on the operated side. One interesting finding is that only four patients in group B had donor site discomfort from the contralateral side, which indicates that there are factors that have a major influence on the donor site morbidity other than harvesting the patellar tendon. In a 2-year (range, 0.5 to 5) follow-up study of 20 patients, Rubinstein et al.²² found that none of their patients had patellofemoral pain from the donor site when the contralateral patellar tendon was harvested, that patellar tendinitis resolved after 1 year, and that 95% of the quadriceps muscle strength had returned.

Magnetic resonance imaging screening revealed no difference between primary harvest or reharvesting of the patellar tendon in terms of length, width, thickness, and donor site gap. This shows that reharvesting is possible because the gap (not normal tendon-like fibrous scar tissue signal) does not differ after being harvested once or twice. This finding indicates that the patellar tendon has the potential to regenerate, even though the gap is still visible. However, we are aware of the fact that MRI does not describe the quality of the tissue in the gap or in the tendon. Previous animal studies have shown a decrease in strength of approximately 50% in both the remaining two-thirds and in the reharvested middle one-third of the patellar tendon.^{17,26}

On the other hand, Nixon et al.¹⁹ have shown normal tissue and no gap in an MRI study of two patients 24 months after harvesting the middle third of the patellar tendon and no tendon suture. They also saw almost normal tendon in a histologic and microscopic investigation in a biopsy taken from the donor site 24 months after harvest.

Contrary to the findings of Nixon et al.¹⁹ and previous ultrasonography studies,¹ the present study revealed fibrous scar tissue formation in the gap, and in none of our patients was there a regeneration of completely normal tendon-like tissue on the MRI signal for at least the first

2 years after harvesting and reharvesting of the central part of the patellar tendon for ACL reconstruction. This is in line with the results of Rosenberg et al.,²¹ who saw persistent defects at the harvest site and significant anterior knee scar formation in both MRI and computed tomography imaging after 12 to 24 months. We also saw that, after 2 years, the median thickness was still 17% higher in both group A and group C compared with the uninjured side. The same phenomenon was found by Coupens et al.,⁸ who showed a significant increase in the thickness of the donor site using MRI up to 18 months after surgery. In their study, however, the gap in the patellar tendon had been closed at the time of the operation.

There were two major complications in the present study, both in patients in group A. One patient had a patellar fracture and one a patellar tendon rupture. In this small series of 12 patients, this must be regarded as an exceptionally high rate of major complications. There are only a few reports in the literature on patellar tendon ruptures,^{3,16} and Christen and Jakob⁶ found only three patellar fractures in a follow-up of 490 patients where the central third of the patellar tendon was used as a free graft.

CONCLUSIONS

Magnetic resonance imaging revealed that reharvested patellar tendons did not differ from primary-harvest tendons 2 years after the revision reconstruction in terms of length, thickness, width, and the size of the gap. We therefore conclude that reharvesting the ipsilateral patellar tendon is technically possible, even though MRI revealed a remaining donor site gap 2 years after primary harvest in every case. Objective knee stability can be recovered with ipsilateral patellar tendon as a graft during ACL revision surgery.

Reharvesting the ipsilateral patellar tendon for revision ACL surgery resulted in a significantly lower functional score (Lysholm) than both primary reconstruction and revision surgery involving harvest of the contralateral patellar tendon. This study indicates that there is an unacceptably high risk of major complications after reharvest of the ipsilateral patellar tendon. When ACL revision surgery is required, graft options other than reharvesting the ipsilateral patellar tendon should be considered.

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REFERENCES

- Adriani E, Mariani PP, Maresca G, et al: Healing of the patellar tendon after harvesting of its mid-third for anterior cruciate ligament reconstruction and evolution of the unclosed donor site defect. *Knee Surg Sports Traumatol Arthrosc* 3: 138-143, 1995
- Almekinders LC, Moore T, Freedman D, et al: Post-operative problems following anterior cruciate ligament reconstruction. *Knee Surg Sports Traumatol Arthrosc* 3: 78-82, 1995
- Bonamo JJ, Krinick RM, Sporn AA: Rupture of the patellar ligament after use of its central third for anterior cruciate reconstruction. A report of two cases. *J Bone Joint Surg* 66A: 1294-1297, 1984
- Breitfuss H, Fröhlich R, Povacz P, et al: The tendon defect after anterior cruciate ligament reconstruction using the midthird patellar tendon—a problem for the patellofemoral joint? *Knee Surg Sports Traumatol Arthrosc* 3: 194-198, 1996
- Cerullo G, Puddu G, Gianni E, et al: Anterior cruciate ligament patellar tendon reconstruction: It is probably better to leave the tendon defect open! *Knee Surg Sports Traumatol Arthrosc* 3: 14-17, 1995
- Christen B, Jakob RP: Fractures associated with patellar ligament grafts in cruciate ligament surgery. *J Bone Joint Surg* 74B: 617-619, 1992
- Giancy WJ Jr: Arthroscopic anterior cruciate ligament reconstruction with patellar tendon. *Techn Orthop* 2(4): 13-22, 1988
- Coupens SD, Yates CK, Sheldon C, et al: Magnetic resonance imaging evaluation of the patellar tendon after use of its central one-third for anterior cruciate ligament reconstruction. *Am J Sports Med* 20: 332-335, 1992
- Eriksson E: Reconstruction of the anterior cruciate ligament. *Orthop Clin North Am* 7: 167-179, 1976
- Fu FH, Schulte KR: Anterior cruciate ligament surgery 1996. State of the art? *Clin Orthop* 325: 19-24, 1996
- Hefli F, Müller W, Jakob RP, et al: Evaluation of knee ligament injuries with the IKDC form. *Knee Surg Sports Traumatol Arthrosc* 1: 226-234, 1993
- Johnson DL, Swenson TM, Irrgang JJ, et al: Revision anterior cruciate ligament surgery: Experience from Pittsburgh. *Clin Orthop* 325: 100-109, 1996
- Johnson RJ, Beynon BD, Nichols CE, et al: The treatment of injuries to the anterior cruciate ligament [Current concepts review]. *J Bone Joint Surg* 74A: 140-151, 1992
- Kams DJ, Heidt RS Jr, Holladay BR, et al: Case report: Revision anterior cruciate ligament reconstruction. *Arthroscopy* 10: 148-151, 1994
- Kohn D, Sander-Bauer A: Donor-site morbidity after harvest of a bone-tendon-bone patellar tendon autograft. *Knee Surg Sports Traumatol Arthrosc* 2: 219-223, 1994
- Langan P, Fontanelletta AP: Rupture of the patellar tendon after use of its central third. *Orthop Rev* 16: 317-321, 1987
- LaPrade RF, Hamilton CD, Montgomery RD, et al: The reharvested central third of the patellar tendon: A histologic and biomechanical analysis. *Am J Sports Med* 25: 779-785, 1996
- Lysholm J, Gillquist J: Evaluation of knee ligament surgery results with special emphasis on use of a scoring scale. *Am J Sports Med* 10: 150-154, 1982
- Nixon RG, SeGall GK, Sax SL, et al: Reconstitution of the patellar tendon donor site after graft harvest. *Clin Orthop* 317: 162-171, 1995
- Ritchie JR, Parker RD: Graft selection in anterior cruciate ligament revision surgery. *Clin Orthop* 325: 65-77, 1996
- Rosenberg TD, Franklin JL, Baldwin GN, et al: Extensor mechanism function after patellar tendon graft harvest for anterior cruciate ligament reconstruction. *Am J Sports Med* 20: 519-526, 1992
- Rubinstein RA Jr, Shelbourne KD, VanMeter CD, et al: Isolated autogenous bone-patellar tendon-bone graft site morbidity. *Am J Sports Med* 22: 324-327, 1994
- Safran MR, Harner CD: Technical considerations of revision anterior cruciate ligament surgery. *Clin Orthop* 325: 50-64, 1996
- Safran MR, Harner CD: Revision ACL surgery: Technique and results utilizing allografts. *Instr Course Lect* 44: 407-415, 1995
- Schatzker J, Tile M: *The Rationale of Operative Fracture Care*. Berlin, Springer-Verlag, 1987, p 277
- Scherer MA, Früh HJ, Ascherl R, et al: Biomechanische Untersuchung zur Veränderung der Patellarsene nach Transplantatentnahme. *Aktuelle Traumatol* 23: 129-132, 1993
- Tegner Y, Lysholm J: Rating systems in the evaluation of knee ligament injuries. *Clin Orthop* 198: 43-49, 1985
- Uribe JW, Hechtman KS, Zvijac JE, et al: Revision anterior cruciate ligament surgery: Experience from Miami. *Clin Orthop* 325: 91-99, 1996
- Vergis A, Gillquist J: Graft failure in intra-articular anterior cruciate ligament reconstructions: A review of the literature [Current concepts]. *Arthroscopy* 17: 312-321, 1995
- Wirth CJ, Kohn D: Revisionseingriff nach fehlgeschlagener vorderer Kreuzbandsplastik. *Ortopäde* 22: 399-404, 1976