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Augmented repair with early mobilization of acute anterior cruciate ligament injuries

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Akut ön çapraz bağ yaralanmalarında erken mobilizasyonla ogmantasyon tamiri

Doğal izometrik pozisyonu ve ÖÇB'in mekanik ve proprioseptif fonksiyonu korumak için başarılı bir cerrahi girişimle ÖÇB yırtığını onarmak gerekirse de cerrahi onarım girişimleri genel olarak başarısız sonuçlar vermiştir. Bu bildiride onarım sonrasında koruma amacı güden sentetik güçlendirici aracın kullanıldığı bir teknik anlatılmaktadır. Bu teknik propriseptif elemanlara zararı minumuma indirger, çok ufak bir artrotomiyle yapılabilir ve postoperatif immobilizasyonun yan etkilerini ortadan kaldırır. Ayrıca stabilizasyon yeniden hemen sağlanmasıyla grade III yan bağ yaralanmaları grade II konumunu koruyan ve böylece eşlik eden yan bağ lezyonunun nonoperatif tedavisi mümkün olur. Aşağıda tekniğimizi uyguladığımız serimizi ve sonuçlarımızı göreceksiniz.

Anahtar kelimeler: *Ön çapraz bağ tamiri, ogmentasyon*

Although a succesful method for repairing the ruptured anterior cruciate ligament (ACL) would seem desirable in order to preserve the naturel isometric position and the mechanical and proprioceptive function of the ACL, attempts to achieve surgical repair have generally yielded poor results. This paper describes a technique for repair of the ACL with protection of that repair by a synhetic augmentation device. This technique minimizes damage to proprioceptive elements, can be carried out with a "mini arthrotomy" and eliminates the adverse effects of postoperative immobilization. In addition, the immediate restabilization of the joint provided by the augmentation device converts "grade III" collateral ligament injuries to a "grade II" condition and thus allows nonoperative treatment of concomitant collateral ligament injuries.

Of 61 patients operated 24 to 57 months (mean 38. 3 months) prior to data accumulation, 57 returned for follow up. Subjectively, 93 % of all patients reported a good or excellent functional result, however only 50. 9 % of the patients returned to their preinjury sports level. Objectively, a radiographic Lachman test was performed on both the injured and the noninjured knee of all 57 patients. The preoperative mean difference between the kness was 8. 6 mm (range 4. 6 to 17. 2 mm) and of follow up was 2. 4 mm (range 0. 9 to 11. 8 mm). Radiographic abduction and adduction stress test demonstrated stable healing of the (unrepaired) collateral ligament lesions (varus stress 0. 1 mm and valgus stress 0. 4 mm mean side-to-side difference), indication that suture of ruptured collateral ligaments is not necessary when the knee is centrally stabilized with the augmentation device. These results indicate that succesful repair of the anterior cruciate ligament is frequently possible when enhanced by an augmentation device. We feel that a successful repair with preservation of the normal structures is distinctly preferable to reconstruction.

Key words: *ACL reconstrvation, augumentation*

Lesions of the cruciate ligaments are not a recently recognized entity, in 1879, Paul Segond (54) raported extensive investigations and described many of the "modern" diagnostic signs. The first succesful suture of a cruciate ligament was reported by A. Mayo Robson (51) in 1903. The disappointing results of primary anterior cruciate ligament (ACL) repairs in some studies (4, 17, 26, 54) led us to wonder whether there might be technical causes for these failures. Review and consideration of the literature led us to believe that the reasons for failure might be:

1. Insufficient protection of the repair
2. Damage to the proprioceptors
3. Damage to the joint by a "large artrotomy" and
4. Extended postoperative immobilization.

We also concluded that operative repair of concomitant extraarticular ligament injuries might not be necessary if the "central pivot" were restored. Our thought process is summarized as follows.

Insufficient protection of the repair

Yasuda and Sasaki (68) demonstrated that in 30° flexion, contraction of the quadriceps muscle exerted a force of 7 kp to 15 kp of the reconstructed ACL. As

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these forces are sufficient to cause rupture of a sutured ligament in the early phase of postoperative treatment, it was felt that fresh repairs of the cruciate ligament should be protected and it was our opinion that sufficient protection cannot be provided by an external device. This protection may be accomplished by an extraarticular iliotibial band tenodesis (32, 24, 39) but in our opinion, may be better accomplished by intraarticular augmentation of the cruciate repair as proposed recently (2, 3, 5, 23, 31, 36, 42, 52, 57, 60, 64).

Damage to the proprioceptors

As early as 1879, Segond (54) noted significant numbers of sensory nerve endings in the cruciate ligament. Since then considerable evidence of cruciate mechanoreceptors has been developed (45, 49, 50, 66, 69), and according to Schultz et al (52), these mechanoreceptors play a decisive role in the proprioceptive reflex arc that safeguards the knee from deformation beyond the anatomic boundaries. The menisci also have (in addition to their passive function as pressure absorbing buffers) a proprioceptive function (8, 12, 64) Weaver (64) reported a much higher failure rate among 302 patients with ACL rupture when the meniscus was removed instead of being preserved. Thus it would seem that salvage of meniscal tissue is desirable when possible.

Damage by "Large arthrotomy"

Many reconstruction procedures performed today use a large arthrotomy of the joint which we feel may have several disadvantages:

1. The large medial parapatellar incision injures the distal vastus medialis and results in additional atrophy (besides the atrophy caused by pain and immobilization).

2. The intraoperative dislocations of the patella causes damage to the articular cartilage.

3. It impaire the anterior mechanism for a prolonged period and proeduces parapatellar pain which may be persistant.

4. The raising of flaps damages proprioceptors. This occurs especially during exposure of the lateral ligaments, requiring the detachment and preparation of fascia and retinacula.

5. Extensive adhesions can results.

These saquelae of an operation can be greatly diminished by use of a mini-incision or arthroscopic techniques.

Damage by immobilization

In 1874, Carl Reyher (50) documented in animal experiments that morphological lesions of cartilage followed prolonged immobilization. In recent years, the decrimental effects of immobilization of injured and unjured joints and ligaments have been increasingly documented (5, 6, 15, 18, 19, 21, 30, 41, 46, 59).

Operative reconstruction of collateral ligaments

In recent animal studies (22, 65) it has been demonstrated that early motion is more important than surgical repair in enhancing MCL healing. Sailer et al (55) as well as Lundberg et al (33) have recently reported that (provided the cruciate ligaments are intact) injuries of the peripheral capsuloligamentous structures will heal with functional treatment. In a prospective study, Holden et al (25) carried out functional treatment in 51 patients with grade I and grade II collateral ligament injuries of the knee. In 42 of the patients the injuries healed with complete stability. The followup showed that in 7 of the 9 patients with instability, an ACL disruption and in the other 2 cases, a meniscus lesion had escaped notice.

In a panel discussion of the Americal Journal of Sports Medicine, Jack C. Hughston remarked; "I just wish somebody doing anterior cruciates and talking about them so much had guts enough to do the anterior cruciate and leave the rest of it alone, like we have the guts to do the peripheral and leave the anterior cruciate ligaments alone and let's see what will happen" (26). As this study demonstrates, for 4 years, we have acted upon this principle. Therefore, we have proceded according to the following concept: In all anterior cruciate injuries the ligament is sutured and then augmented with a synthetic augmentation device. The augmentation is performed in a manner intended to cause the least possible damage of the proprioceptors through a small arthrotomy. Functional mobilization of the joint is carried out immediately. As implantation of the augmentation device restabilizes the "central pivot" of the knee joint, it converts grade III collateral ligament injuries to grade II injuries and operative repair of the collateral ligament is not undertaken.

Material and method

From 1985-1987, 61 patients with a fresh rupture of the anterior cruciate ligament underwent surgery in the Bopfingen Hospital. 57 patients were followed for 24-57 months (mean 38. 3 months). Of the four patients who could not be re-examined, one died of cancer, two moved to a foreign country and one entered a convent. 91 % of the injuries (52 / 57) were sports related. 7 % of the injuries (4 / 57) occurred at work and 2 % (1 / 57) occured in a motor vehicle accident.

The ages ranged from 14-59 years (average 27. 1) and 70 % of the patients were male. On admissions, after excluding a fracture, a radiographic Lach-

man test (47, 48, 61) was performed in all patients in whom the history and clinical examination were suggestive of a cruciate injury. The indication for arthroscopy and subsequent surgical repair was a radiographic Lachman test with a side to side difference of more than 2 mm.

Localisation of ACL rupture

72 % (41, 57) of the ACL tears were near femoral avulsions with sufficient tissue for repair. 25 % (14, 57) had a midsubstance tear and 3 % (2, 57) were classified as multiple level tears of the ACL.

Associated lesions

At arthroscopy associated lesions were verified. In 18 patients (32 %) we observed an isolated tear of the ACL without any associated lesions of other intra-articular structures. The rest presented with accompanying lesions, 40 % had meniscal lesions, 36 % had peripheral ligamentous injuries, 21 % had articular cartilage lesions and 3 % had a rupture of the patellar tendon (Table I).

	N	%
Medial meniscous	14	18
Lateral meniscus	17	22
Posteromedial structures	18	23
Posterolateral structures	10	13
Patellar tendon	2	3
Articular cartilage	16	21
Total	77	100

Table I: Associated lesions in 57 patients with ACL rupture

Operative technique

All surgical procedures were performed by the same surgeon (HHP). Before inflating the tourniquet, every knee was examined under anesthesia. This was followed by arthroscopic examination. Large peripheral meniscal tears were sutured arthroscopically with an outside-inside technique and smaller peripheral tears were not treated. Partial resections of non-peripheral tears were also performed. Then a 3-4 cm medial parapatellar "mini" arthrotomy was made. The disrupted ends of the tibial stump of proximally ruptured cruciate ligaments were identified and 8-10 absorbable sutures (4-5 sutures each, into the anteromedial and posterolateral bundle) were inserted according to the technique of Marshall. Next a 2 cm incision was made medial to the tibial tuberosity and a 3. 2 mm bone tunnel was drilled into the center of the tibial insertion of the anterior cruciate ligament using a drill guide. A 3 cm longitudinal incision was made just proximal to the lateral femoral condyle and blunt dissection used to expose the posterolateral capsule through a split in the iliotibial band. A holding suture was inserted from the lateral condyle through the dorsal capsule into the intercondylar notch ("over the top") with an angled clamp. In 100° flexion, a 2 mm bone tunnel was drilled through the anatomic center of the femoral insertion of the anterior cruciate ligamen from the lateral condyle again using a drill guide. Then the augmenting synhetic device (6x1 mm woven polyester Trevira, maximum load 2100 Newton (TELOS Co., 6303 Hungen, Germany) was pulled through the tibial drill hole and the dorsal capsule "over the top". The augmentation device was fixed to the lateral femoral condyle with a staple. The holding sutures of the anteromedial bundle were brought "over the top", and those of the posterolateral bundle were pulled through the femoral bone tunnel. In 5° flexion, a pre-load of 50 Newtons was applied to augmentation device and it was fixed to the tibia with a staple. Finally the Marshall sutures were tied under slight tension over the lateral condyle with the knee in 20°-30° flexion.

In interstitial tears the proximal ligament stumps were sutured in an analogous way with Marshall sutures, and the ends brought through the tibial drill hole and sutured to the augmentation device beyond the staple. At the end of the procedure, the knee was taken through 0°-130° range of motion to confirm isometry of suture and augmentation placement.

Postoperative rehabilitation

Immediately following ACL repair, the patients were immobilized in a removable plastic splint in 10° flexion. Quad sets, straight leg raises and gait training were begun on the first postoperative day as well as continuous passive motion (CPM). Muscular exercises against resistance were used for the hamstring muscles only.

The splint was removed frequently throughout the day for rehabilitation exercises. After 4 weeks, it was used only for ambulation outside the home and it was discontinued after 6 weeks. Because the augmented ACL was mechanically stable, the patients were allowed to put full weight without crutches upon their operated leg as early as pain allowed (usually between the 5th and 8th postoperative day). During early gait training they were taught to contract the hamstrings and the quadriceps simultanaously during the entire gait cycla, a technique that we call "controlled coactivated gait" (CCG) (13, 67, 68). Functional braces were not used in these patients.

To diminish atrophy of the quadriceps muscle, the patients were encouraged to perform half squat exercises frequently, as the squat does not produce anterior translation (35, 37, 43, 67, 68).

After 6 weeks, swimming (only the crawl) was started. As soon as the patient was able to flex the knee at least 100° (8th to 9th week) stationary cycling with a high seat position was started and balancing exercises on special unstable boards were added to stimulate proprioception. At the time of this study, isokinetic exercises were not included because we did not have isokinetic equipment available.

Data collection

At the time of operation the results of the examination under anesthesia (regarding injuries to other ligament), arthroscopy (regarding articular or meniscal cartilage damage) and the location of the injury of the anterior cruciate were recorded on a data sheet and are described in our materials section. Subjective evaluation included the Lysholm knee score system (34) (maximum 100 points) and a determination of activity level according to Tegner's classification (62). Physical examination included crepitus, range of motion (ROM), abduction and adduction stress tests, a Lachman test and a pivot shift test. The hop ratio (the distance of a one leg hop of the injured knee divided by that of the uninjured knee) was measured with the one-leg hop test (11).

To objectively evaluate the mechanical anterior translation stability, a radiographic Lachman test (47, 48, 61) was again performed on both knees using the TELOS stress apparatus (TELOS Co., 6303 Hungen, Germany) with an applied force of 15 kp. The preoperative and final followup radiographs were measured with a special template. The same apparatus was used for standardized varus and valgus stress x-rays, also with an applied force of 15 kp. The varus/valgus measurements were made according to the technique of Kennedy and Fowler (29). All charts were reviewed for early complications and late reoperations.

Results

Subjective data

At last follow up, subjectively, 53 of the 57 patients (%" %) had good or excellent function of the repaired knee (a Lysholm score of more than 84 points, Table II).

Points	0ualification	No	Pat.
0 - 64	poor	1	1. 8%
65 - 83	fair	3	5. 3%
84 - 90	good	5	8. 8%
91 - 100	excellent	48	84. 2%

Tabla II: LYSHOLM-SCORE (max. 100, N=57)

Only one case had a poor functional result (less than 64 points) and this patient had a ruptured augmentation device which had displaced into the joint. After arthrroscopic removal of the augmentation device this knee regained good function. 65 % patients, (37/ 57) reported no pain on or after severe exertion, 7 % (4/ 57) had pain on or after severe exertion and 1 patient reported pain on moderate exertion. No swelling was reported by 89 % (51/ 57), and swelling on severe exertion was reported by 9 % (5/57). The pationt with the ruptured augmentation device (displaced into the joint) reported constant swelling which resolved after arthroscopic removel of the device. On the Tegner scole the average preinjury level of sports activity for all 57 patients was 7. 0 (max possible level 10) and on follow up it was 5. 7 (Table III).

Group	Tegner level	Description	preinjury		postop	
			N	%	N	%
I	8 - 10	Competitive and professional sport partici pation	2239		14	24
II	5 - 7	Recreational and comptetive sports, heavy labor	2849		25	44
III	3 - 4	Recreational sports competitive swiming light work	712		16	28
IV	0 - 2	Light or sedentary work, sick leave or disability pension	0	0	2	4

Table III: Sports participation and work levels before and after injury, according to the Tegner activity score

51 % (29/ 57) of all patients raturned to their preinjury level of sport activity, whereas 42 % (21/ 57) reduced activity to a lower level and 7 % (4/57) gave up sports completely (all but 1 attributed giving up sports to a change in lifestyle rather than their knee injury).

Physical examination

There was patellofemoral crepitus, in 37 % (21, 57) of all repaired knees. 79 % (45, 57) had a füll ROM. 2 % (1 / 57) lacked more than 10° extension. This patient had the ruptured/displaced augmentation device, and achieved full extension after arthroscopic removal of the device.5 % (3/ 57) had an extension loss of 10° or less. In 5 % (3 / 57) flexion was decreased more than 10°, another 5% (3 / 57) lost 10° less of flexion. In 4 % (2 / 57) we observed loss of both flexion and extension (Table IV).

ROM	N	%
Full	45	78. 9
Loss of flexion < 10°	3	5. 3
Loss of flexion > 10°	3	5. 3
Loss of extension < 10°	3	5. 3
Loss of extension > 10°	1	1. 8*
Loss of both	2	3. 5

* This patient achieved full extension after removal of the augmentation device.

Table IV: Range of motion at follow up

On clinical examination, in full extension, no patient had laxity on abduction or adduction testing. In slight flexion 93 % (53/57) had no clinical laxity to either abduction or adduction, 3 % (2/ 57) had slight laxity (1+) to abduction, 32 % (1/ 57) had slight laxity (1+) to adduction and another 2 % (1/ 57) had 2+ laxity. None of the patients had 2+ or 3+ laxity on abduction or 3+ laxity on adduction. At physical examination we observed a negative clinical Lachman test

in 63 % (36/ 57) of the patients, a trace Lachman test in 23 % (13/ 57), a moderate one in 9 % (5/ 57) and a severe one in 5 % (3/ 57). There was no pivot shift in 58 % (33/ 57) of the patients, a trace one in 28 % (16, 57), a moderate one in 11 % (6/ 57) and a severe one in only 3 % (2 / 57). The hop ratio (injured to uninjured leg) average 0. 98 for all patients.

Radiographic Lachman

We regarded the radiographic Lachman test to be the decisive criterium of a successful repair of the cruciate ligament. Preoperatively the mean side-to-side difference of our 57 patients was 8. 6 mm (range 4. 6 to 17. 2). At the time of the most recent follow up the mean side-to-side difference was 2. 4 mm (range -0. 9 to 11. 8). 67 % (38, 57) were considered stable with a side-to-side difference of 0 to 2. 9 mm. 18 % (10 /57) had a side-to-side difference of 3 to 4. 9 mm and were considered to be only partially stable. 16 % (9 /57) had a side-to-side difference of 5 mm or more and were considered to be failures. When the two different rupture locations (proximal / midsubstance) were compared, knees with a proximal rupture tended to have better stability (mean side to side difference 1. 93 mm, SD + 1. 79 mm) than mid substance lesions (mean side to side difference 4. 53 mm, SD ± 3. 03 mm), but the difference was not statistically significant.

Radiographic adduction and abduction test

All tests were performed in 20° of knee flexion with a stress of 15 kp. The mean side to side difference for varus (adduction) stress was 0. 1 mm (SD ± 1. 6 mm) and for valgus (abduction) stress 0. 4 mm (SD± 1. 2 mm) demonstrating stable healing of the injured, unrepaired, collateral and capsuloligamentous structures. The lowest valgus stress values (mean 0. 3 mm) were obtained in the stable group (radiographic Lachman test values 0 to 2. 9 mm), whereas the average valgus stress value was 0. 9 mm in the unstable group (5 mm and more).

Early complications

All complications were minor and were readily resolved. In the 4 knees the femoral staple was poorly placed and had to be revised in an early reoperation. Postoperative synovitis occurred in 2 patients (3. 5%). They were treated by needle aspiration (1-3 x), NSAIDS (nonsteroidal antiinflammatory drugs), ice packs, and rest. No incompatibility or allergic reactions to the augmentation devices were evident. In one of the two patients with a simultaneous repair of a ruptured patellar tendon a small area of skin necrosis with superficial infection occurred which healed after local debridement.

Late reoperations

A total of 12 late reoperations were performed during the follow up period. In two patients the distal staple was painful during kneeling and had to be removed. Second look arthroscopy was performed on 4 knees because of unexplained pain, and showed only articular lesions. Partial meniscectomy was performed in 4 patients, and incidental removal of a broken synhetic augmentation device was performed in 3 of knees. One patient had removal of his augmentation device at his request and one patient had ramoval of a broken augmentation device which had displaced into the joint. No patient had requested a secondary ACL reconstruction at the last follow up.

At each reoperation synovial samples were from at least 5 different locations including the area of the ACL. Only one case (the one with the broken device which displaced into the joint) showed pathologic evidence of foreign body reaction and abrasion synovitis. As can be seen at reoperation the healed ACL's generally appeared to be nearly normal and the augmentation device was not visible.

Discussion

In our opinion, this study demonstrates that a satisfactory repair of the ACL can frequently be achieved using a minimal traumatic technique and a concomitant augmentation sufficiently strong for physical therapy. Subjectively, in the Lysholm knee score, 86 % (49 / 57) of the patients reported never giving way, 9 % (5 / 57) had occasional giving way on vigorous exercises and only 4 % (2 / 57) had frequent giving way on vigorous exercise. Only 1 patient reported giving way in daily activity.

The objective data provided by the radiographic Lachman test documented stable ACL healing in 67 %, healing with some laxity in 18 % and failure in only 16 %. Note that 84 % had some ACL healing, a similar figure to the 86 % without giving way on the Lysholm score.

It should be recognized that the radiographic Lachman test is a much more sensitive measure of ACL instability than KT-1000 data. Moyen et al (38) demonstrated in a comparative study of ACL deficient knees measured with both devices an average value of 7. 6 mm with the radiologic Lachman and 4. 5 mm with the KT-1000 at 89N of force. If a factor of 0. 59 (4. 5 mm / 7. 6 mm) were applied to our radiologic Lachman data, to provide data similar to that which could be expected from a KT-1000 85 % of these patients would have been rated as objectively stable (0- 2. 9 mm displacement). Again this is similar to the 86 % with no giving way on the Lysholm score.

The disappointing results of many authors (4, 12, 14, 16, 17, 27, 28, 64) with a nonaugmented repair of fresh ACL ruptures are in contrast to the good results of this study and others (2, 3, 23, 24, 31, 40, 42) that augmented their repair by extraarticular tenodesis

(24), or intraarticularly using autologous tissue (2, 3, 40, 44, 56, 57, 63) or the Kennedy LAD. (31).

Kwasny et al (31) found that of 88 repaired knees only 3 knees were unstable 11 months after surgery (when arthroscopy was performed to remove their staples). At arthroscopy, sutured ACL's appeared to have a normal structure, excepting those in which the repair failed. 9 of the LAD's were ruptured causing slight synovitis in one patient. The operative technique used by Kwasny et al was similar to ours ("over the top" LAD, with both ends fixed by staples).

In contrast to others (23) our own previous (unpublished) studies with resorbable PDS-ribbons as an augmentation material in a small series (n=10) were disappointing. We attributed this to rapid resorption of the PDS material and its high elasticity.

For the implantation of the (relatively small) trevira augmentation device only a 3 mm tibial bone tunnel is necessary, and significant portions of the natural fibers of the cruciate ligaments including the mechanoreceptors (which have been detected close to the sites of insertion by Zimmy (69) and Schultz (53) are preserved. The use of autologous material (semitendinosus, gracilis or patellar tendon) requires that a large portion of the cruciate fibers must be sacriflced due to the relatively large diameter of these grafts (5, 57). In this study we found only one patient with a foreign body reaction, demonstrating good tolerance for the Trevira augmentation device. In contrast to other synhetic ligaments which fray upon rupture the Trevira augmentation device develops a clean break without evidence of abrasion. Because the rupture strength of the original 6 mm Trevira device seemed unnecessarily high (2100 N) a 5 mm augmentation device (1700 N) was developed (SUNAD, SAMO Inc. 40100 Bologna, Italy) and has been used for the last 2 years,the surface area became about 20 % smaller. The over the top position of the synhetic augmentation device, which is preloaded in extension with 50 Newtons, produces dynamic loading of the sutured ligament (52). In the extended position of the knee the augmentation device is loaded more heavily and thus protects the suture from the strong anterior translation forces produced by the quadriceps muscle (67). With progressive flexion of the knee, the tension in the augmentation device decreases, but at the same time the anterior translation force from the quadriceps muscle diminishes. Capsuloligamentous lesions can also heal with the advantage of mobilization while protected by the augmentation device. As Dahners (9, 10, 22) and Woo (65) have demonstrated in animal experiments, suture of peripheral capsuloligamentous structures such as the medial collateral ligament is not necessary if the ACL is intact or stabilized. Our varus/valgus strage results confirm that in cases of combined ACL injuries additional surgery on the collateral ligaments (which may damage propioceptors) is unnecessary. Motion has been shown to increases the strengh of healing ligament structures (9, 15). Early in ligament healing tension and mobilization promote better mechanical properties and better organization of the collagenous structure (9, 20). In a rat model enforced rehabilitation (by swimming exercises) resulted in greater tensile strength of the healing MCL as long as the ACL was stable (7, 9). On the other hand the detrimental effects of immobilization have been extensively documented (5, 6, 9, 10, 15, 18, 19, 21, 30, 41, 50, 59, 65).

Our study indicates that mobilization and early weighbearing did not stretch out the ligament repair and we feel it resulted in a shortened and more comfortable rehabilitation. Previous studies (1) have shown that not only the instability due to the ruptured ACL, but also the operation itself causes degeneration of the hyaline cartilage and so leads to premature arthrosis of the knee. We believe that the use of smal incisions and avoidance of the harvest of the patellar tendon when possible may diminish this cartilage damage. Although there was not a statistically significant difference in laxity (by the radiographic Lachman test) between the midsubstance rupture group and the proximal rupture group, we observed a strong trend that midsubstance lesions had more laxity. For this reason we have abandoned repair of midsubstance ruptures and now perform primary reconstruction with patellar tendon in these patients. Note, however, that in this unselected series of ACL injuries 72 % were proximal "repairable" ruptures.

Refereces

1. Aglietti, P., Buzzi, R., D'Andria S. et al: Patello-femoral problems after anterior cruciate ligament (ACL)reconstruction. Presented at 4th Congress of European Sociely of Knee Surgery and Arthroccopy, Stockholm.
2. Andersson, C., Gillquist, J.: Treatment of acute isolated and combined ruptures of the anterior cruciate ligament. Presented at 4th Congress of European Society of Knee Society of Knee Surgery and Arthroscopy, Stockholm.
3. Andersson, C., Odsten, M., Good, L. et al: Surgical or non surgical treatment of acute rupture of the anteriorcruciate ligament. J. Bone Joint Surg. 71-A: 965-974, 1989.
4. Arnold, JA., Coker, TP., Heaton, LM., Park, JP., Hanes, WD.: Naturel history of anterior cruciate tears. Am J Sports Med 7: 305-313, 1979.
5. Bernett, P., Seesko, H., Feldmeire, CH.: Die versorgung der fristchen und der veralteten Kruzbandruptur mit kombiniertem autologam und alloplastish verstarktem Sehnenstransplantat (Polypropylen-Band). Unfallchirurgie 11: 251-258, 1985.
6. Burri, C., Hutschenreuter, P., Passler, HH. et al: Functional postoperative care after reconstruction of knee ligaments. An experimental study. In: Ingwerson DS (Ed) The knee joint. Amsterdam, Excerpta Medica, pp 108-112, 1974.
7. Burroughs, P., Dahners, LE.: The effect of enforced exercise on the healing of ligament injuries. Am J Sports Med 18 (4): 376-378, 1990.
8. Cerulli, G., Cecarini, A., Alberti, P.: Neuromorphological studies proprioceptivity of the human anterior cruciate ligament.I J Sports Traumatology 1: 49-52, 1986.

9. Dehners, LE., Padgett, L.: The effect of joint motion on collagen organization in healing ligaments. Trans ORS 15: 511, 1990.
10. Dehners, L., Torke, M., Gilbert, J. et al: The effect of motion on collagen synthesis, DNA synthesis and fiber orientation during ligament healing. Trans ORS 14: 299, 1989.
11. Daniel, D., Malcom, L., Stone, MD. et al: Quantification of knee stability and function con Orthop. 5-8, 1982.
12. Dejour, H.: Analysia critique des resultars du traitement des laxites fraiches. Deduction therapeutique, conclusion indication dans les laxites fraiches. Rev Chir Orthop. 69: 269-270, 1983.
13. Draganich, LF., Vahey, JR.: An in vitro study of anterior cruciate ligament strain induced by quadriceps and hemstrings forces. J Orthop Res 8: 57-63, 1990.
14. Driessen, M., Nollen, J., Marti, K: Suture or resection of ACL Abstract, Presentation at the 6th Congress of the International Society of the knee, Rom 1989.
15. El Saman, Moukthar: Der einflub von funktioneller Bewegung und Gipsruhigstellung auf die heilung partiell durchtrennter medialer Seitenbander beim Kaninchen. Thesis experimentalle Chirurgie Uni Ulm 1978.
16. Engebretsan, L., Svenningsen, S., Benum, P.: Poor results of anterior cruciate ligament repair in adolescance. Acta Orthop Scand 59 (6): 684-686, 1988.
17. Feagin, JA., Curl, WW.: Isolated tear of the anterior cruciate ligament: 5-year follow-up study. Am J Sports Med 4: 95-100, 1976.
18. Finsterbush, AMD., Friedmen, MD.: Early changes in immobilized rabbits knee joints: A light and electron microscopic study. Clin. Orthop. an related research 1973.
19. Gamble, JG., Edwards, CHC., Max, Str.: Enzymatic adaptation in ligaments during immobilization. Am J Sports med 12: 221-228, 1984.
20. Gomez, M., Woo L-Y: The advantages of applied tension on healing medial collateral ligament. 35th annual meeting ORS, Fab 6-9, 1989.
21. Grüber, J., Wolter, D., Lierse, W.: Der vordere Kreuzbandreflex (LCA-Reflex): Unfallchir 89: 551-554, 1986.
22. Hart, DP., Dahners, LE.: Healing of the collateral ligament in rats. J Bone Joint Surg 69-A: 1194-1199, 1987.
23. Haupt, PR., Duspiva, W.: PDS-Augmentations plastik bei Kreuzbandverletzungen, Unfallchirurg 91: 97-105. 1988.
24. Higgins, RW., Steadman, JR.: Anterior cruciate ligament repairs in world clase skiers. Am J Sports Med 15: 439-447, 1987.
25. Holden, DL., Eggert, AW., Butler, JE.: The nonoperative treatment of grade I and II medial collateral ligament injuries of the knee. Am J Sports Med 11: 340-344, 1983.
26. Hughston, JC.: In "presidential guest panel". Am J Sports Med 10: 32326.
27. Jarvinen, M., Kannus, P.: Clinical and radiological long-term results after primary knee ligament surgery. Acta Orthop. Truma Surg. 104: 1-6, 1985.
28. Kaplan, N., Wickiewicz, T., Warren, R.: Primary ssurgical treatment of anterior cruciate ligament ruptures. A long-term follow-up study. Am J Sports Med 18: 354-358, 1990.
29. Kennedy, J., Fowler, P.: Medial an anterior instability of the knee. An anatomical and clinical study using stress machines J Bone Joint Surg. 53-A: 1257-1270, 1971.
30. Kipfer, W., Ballmer, P., Grünig, B. et al: Late results after primary repair of anterior cruciate ligament tears. Presented at the 2cn Congress of European Society of knee Surgery and Arthroscopy, Basel, 1986.
31. Kwasny, O., Schabus, R., Wuppinger, G. et al: Ergebnisse der kontrollarrtroskopie nach reinsertion des vorderen Kreuzbandes und alloplastischer Verstarkung. Arthroskopie 2: 58-62, 1989.
32. Lemaire, M., Combelles, F., Miramed, C. et al: Les desinsertions menisco-capsulaires posteriointernes associees aux instabilites chroniques par rupture du ligament croise anterieur Rev Chir Orthop. 70: 613-623, 1984.
33. Lundberg, M., Hamberg, P.: Early mobilization of isolated partiel ruptures of the medial collateral lig. A randomized comparison of bracing VS elastic wrapping. Presented at 2nd Congress of European Society of Knee Surgery and Arthroscopy Basel, 1986.
34. 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.
35. Lysholm, M., Gillquist, J.: Effect of differant knee rehabilitation exercises on tibial translation. Presented at the 4th Congress of duropean USociety of knee Surgery and Arthroscopy, Stockholm, 1990.
36. Maunier, C., Moiner, PH., Maller, F.: Reperation des lesions recented du ligament croise anterieur. Sport et Medio Act. 3: 21-24, 1988.
37. More, RC., Daniel, DM., Harris, S.: Quadriceps rehabilitation after ACL reconstruction a comparison of two types of exercise. Trs ORS 15, 1990.
38. Moyen, B., Lerat, J., Jenny, J., Brunet-Guedi, E.: A comparison of the pre-operative evaluation of the anterior knee play by passive dynamic rays and by arthrometer KT 1000. Presented at 4th Congress of European Society of knee Surgery and arthroscopy. Stockholm 1990.
39. Müller, W.: Knia. Form, funktion und ligamentare Wiederher stellungschirurgie. Springer-Verlag, Heidelberg, 1982.
40. Noack, W., Scharf, HP.: Aktueller Stant in der therapie der vorderen Kreuzbandvarletzungen. Sportverl Sportsch 1: 13-19, 1987.
41. Noyes, FR.: Functional properaties of knee ligaments and alternations induced by immobilisation. A correlative biomechanical and histological study in primates. Clin Orthop. 123: 210-242, 1977.
42. Mangine, RE., Barber, S.: Arthroscopic anterior cruciate ligament reconstruction. Am J Sports Med. 15: 149-160, 1987.
43. Ohkoshi, Y., Yasuda, K.: Biomechanical analysis of shear force exerted on anterior cruciate ligament during half squat exercise. Trs ORS 14: 192, 1989.
44. Paar, O.: Verstarkung der frisch geklebten oder genahten ruptur des vorderen Kreuzbandes durch die Semitendinosuschanne indikation und Frühergebnisse. Chirurg 56: 728-734, 1985.
45. Palmer, J.: Injuries to the crucial ligaments of the knee joint as a surgical problem. Reconstr Surg. Traum 4: 181-196, S Karger, Basel / NewYork, 1957.
46. Passler, HH., Henkameyer, H., Burri, C.: Funktionelle Behandlung nach Bandnaht und-plastik am Kniegelenk.
47. Paessler, HH., Lanzetta, A., Rettagliate, F.: The radiological Lachmantest, I J Sports Traumatology 2; 85-95, 1987.
48. Paessler, HH., Harz, S. Der radiologische Lachman-Test eine einfache und sichere methode zum Nechweis von Kreuzbandschaden. Unfallchirurgie 12: 295-300, 1986.
49. Pitaan, M., Nainzadeh, N., Menche, D. et al: Intraoperative evaluation of the neurosensory function of the anterior cruciate ligament in humans utilizing somato-sensory evoked potentials. Presented at 4th Congress of European society of knee Surgery and Arthroscopy, Stockholm 1990.
50. Reyher, C.: Ober die Veranderungen der Gelenke bei dauernder Ruhe. Dtsch Z Chir 3: 189-200, 1974.
51. Robson, AW Mayo: Ruptured crucial ligaments and their repair by operation. Ann of Surgery 715-716, 1903.
52. Schabus, R.: Die Bedautung der Augmentation für die rekonstruktion des vorderen Treuzbandes. Acta Chirurg Austrica Supp 76: 1-48, 1988.
53. Schultz, RA., Müller, DC., Kerr, CS: Mechanoreceptors in human cruciate ligaments. An histological study. J Bone Jt Surg. (AM) 66: 12072-1076, 1984.
54. Sagond, P.: Recherches cliniques et experimentales sur les epanchements sanguins du genou par entorse. Le progress Medical (Paris) 7: 297-299, 319-321, 340-341, 379-381, 400-401, 419-421, 1879.
55. Sailer, H., Kayser, M., Niemeyer, H. et al: Isolated tears of medial collateral ligament of the knee operative or conservative treatment. Presented at 2nd Congress of European Society of knee Surgery and arthroscopy, Basel 1986.
56. Scaglione, N., Warren, R., Wickiewicz,T. et al: Primary repair with semitendinosus tendon augmentation of acute anterior cruciate ligament injuries. Am J Sport Med 18 (8): 64-73, 1990.

57. Shields, C., Stevenson, D: Acute anterior cruciate ligament tear: Primary repair with and without patellar tendon augmentation presentation at the 6th Congress of the International Sociaty of the knee, Rom 1989.
58. Solomonow, M., Baratte, R., Zhov, Bh. et al: The spnergistic action of the anterior cruciate ligament and thigh muscles in maintaining joint stability. Am J Sports Med 15: 207-213, 1987.
59. Stanitzki, CL.: Rehabilitation following knee injury. Clin Sports Med-Vol 4 No. 3, Juli 1985.
60. Straub, T., Hunter, R.: Acute anterior cruciate ligament repair. Clin Orthop. Rel Res 227: 238-249, 1988.
61. Strobel, M., Stedtfeld, H.: Diagnostic evaluation of the knee Springer Verlag Heidelberg, 1990.
62. Tegner, Y., Lysholm, J.: Rating systems in the evaluation of knee ligament injuries. Clin Orthop. 198: 43-49, 1985.
63. Tiling, Th., Schmid, A., Edelmann, M. et al: Therapie der ligamentaren vorderen Kreuzbandruptur Nachuntersuchungs-ergebnisse in Abhangigkeit von der Riblokalisation und Versorgung. Hefte zur Unfallheilkunde 189: 1089-1105, 1987.
64. Weaver, JK., Derkash, RS., Freeman, JR., et al: Primary ligament repair-revisted. Clin Orthop. 199: 185-191, 1985.
65. Woo, SLY., Gomez, MA., Sites, TJ., et al: The biomechanical and morphological changes in the medial collateral ligament of the rabbit after immobilization and remobilization. J Bone Joint Surg. 69 A: 1200-1211, 1987.
66. Wyko, BD.: Structurel and functional charectoristies of articular receptor system. Acta Chirurg Orthop. et Traumatologiae Chezhoslavace 40: 489-497, 1973.
67. Yasuda, K., Sasaki, T.: Exercise after anterior cruciate ligament reconstruction. Clin Orthop. 220: 275-282, 1987.
68. Yasuda, K., Sasaki, T.: Muscle exercise after anterior cruciate ligament reconstruction. Clin Orthop. 220: 266-274, 1987.
69. Zimmy, ML., Schutte, M., Debezies, E.: Mechanoreceptors in the human anterior cruciate ligament. Anat Rec 214: 204-209, 1986.

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