

Meniscal Repair Compared with Meniscectomy for Bucket-Handle Medial Meniscal Tears in Anterior Cruciate Ligament-Reconstructed Knees

K. Donald Shelbourne,* MD, and Donald R. Carr, LCDR, MC, USN

From the Methodist Sports Medicine Center, Indianapolis, Indiana

Background: Repair of meniscal tears is generally preferred over meniscectomy.

Hypothesis: Repair of unstable bucket-handle tears of the medial meniscus leads to better outcomes than partial meniscectomy.

Study Design: Retrospective review of prospectively collected data.

Methods: We reviewed the records of 155 patients who had isolated bucket-handle medial meniscal tears and anterior cruciate ligament tears. Fifty-six menisci were repaired; 99 that were degenerative and crushed beyond repair were removed. Patients were evaluated at a mean follow-up of 6 to 8 years after surgery with the International Knee Documentation Committee examination and a modified Noyes questionnaire.

Results: The mean subjective scores were similar for patients in both the repair ($N = 51$) and meniscectomy ($N = 87$) groups. However, in the repair group, the mean subjective score of 93.9 for nondegenerative menisci was significantly better than the 87.1 for degenerative menisci. Objective grades for 25 patients in the repair group were normal or nearly normal in 22 patients (88%) and for 51 of 56 patients (91%) in the removal group. Radiographic subscores for the repair group were normal or nearly normal in 23 patients in the repair group and 49 in the removal group.

Conclusion: Outcomes from meniscal repair were not superior to those from partial removal. Patients with repaired degenerative tears had significantly lower subjective scores than those with nondegenerative tears.

© 2003 American Orthopaedic Society for Sports Medicine

Fairbank⁷ first described the accelerated development of arthrosis associated with loss of the meniscus in 1948. Over the last 50 years, the function of the meniscus in load transmission,³⁻⁵ shock absorption,²³ and in joint stability, specifically in the ACL-deficient knee,²¹ has been well documented. Because surgeons now have a better understanding of meniscal function and a desire to prevent progressive degenerative changes,⁹ the recommended treatment for pathologic conditions of the meniscus has changed from total meniscectomy to partial excision and now to salvage.⁴

O'Shea and Shelbourne¹³ evaluated the success of meniscal repair in 55 knees with chronic ACL deficiency, a

locked bucket-handle meniscal tear, and loss of extension. A second arthroscopic observation was possible because a two-staged approach to surgery was used. Meniscal repairs were performed at a mean of 10 ± 8 days after injury. The patients then underwent rehabilitation to regain full range of motion and good leg control before undergoing ACL reconstruction at a mean of 77 ± 58 days after meniscal repair. At that time, 30 menisci (55%) appeared healed, 19 menisci (34%) appeared partially healed, and 6 menisci (11%) showed no healing. Of 43 meniscal tears in the white-on-white zone, 21 appeared healed, 17 appeared partially healed, and 5 showed no healing. Of 11 meniscal tears in the red-on-white zone, 8 appeared healed, 2 appeared partially healed, and 1 showed no healing. One meniscal tear in the red-on-red zone appeared healed. Further follow-up evaluation at a mean of 4.3 ± 3.1 years after ACL reconstruction showed that 36 of 43 meniscal repairs in the white-on-white zone (83.7%) remained asymptomatic; all repairs in the red-on-

* Address correspondence and reprint requests to K. Donald Shelbourne, MD, 1815 North Capitol Avenue, Suite 530, Indianapolis, IN 46202.

No author or related institution has received any financial benefit from research in this study.

white zone and the red-on-red zone remained asymptomatic. The results showed that repaired locked bucket-handle meniscal tears, even in the white-on-white zone, can have a high rate of healing.

Shelbourne and Gray¹⁶ showed that meniscus salvage is possible in 85% of medial meniscal tears in patients with acute ACL injuries and in 55% of patients with chronic ACL injuries. We sought to evaluate the clinical results of repair of a subset of medial meniscal tears that were at the extreme of possible salvage, those tears equal to or greater than 50% of the circumference of the meniscus that were both degenerative and nondegenerative. These tears represented the worst tears we have repaired, with a retear rate of 13.6%.¹⁹ Our purpose was to document the superiority of meniscal repair over partial meniscectomy in the treatment of unstable bucket-handle medial meniscal tears in a young athletically active patient population undergoing ACL reconstruction.

MATERIALS AND METHODS

Between 1982 and 1995, the senior author (KDS) performed 2096 ACL reconstructions with use of patellar tendon autografts. We conducted a retrospective review of the prospectively collected data. One hundred fifty-five patients met the inclusion criteria of ACL deficiency with an isolated unstable bucket-handle medial meniscal tear involving 50% or more of the circumference of the meniscus. The tears were in the white-on-white zone in 124 patients (80%) and in the red-on-white zone in 31 patients (20%). Tears were further classified as either degenerative or nondegenerative (Figs. 1 and 2). A degenerative meniscal tear was defined as having both a vertical component and a horizontal cleavage tear or intrasubstance delamination. A nondegenerative meniscal tear was defined as having only a vertical component. Patients were excluded if they had associated articular cartilage damage of greater than Outerbridge¹⁴ grade 2 in any compartment, a lateral meniscal tear or degeneration, or additional liga-

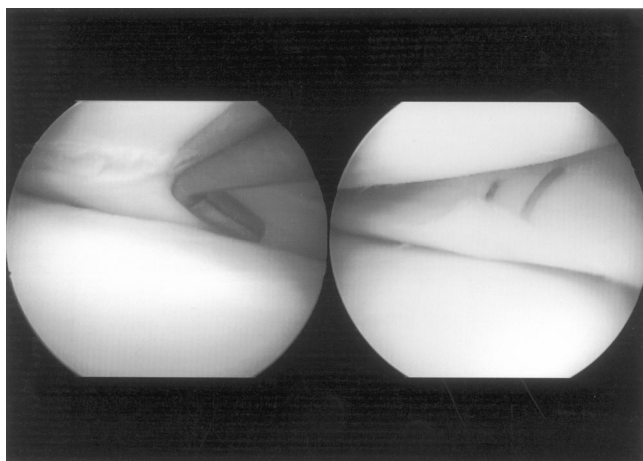


Figure 1. A nondegenerative bucket-handle meniscal tear. The undersurface side of the tear is shown on the left, and on the right is the meniscus after suture repair.

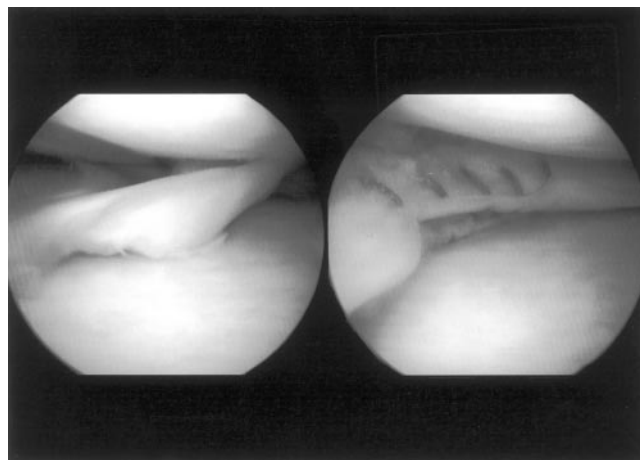


Figure 2. A degenerative bucket-handle medial meniscal tear in the avascular section. The left side view is of the meniscus slightly displaced, and the meniscus after suture repair is seen on the right.

ment injury. Fifty-six patients underwent medial meniscal repair with use of an inside-out technique; four to six vertical sutures were placed.¹⁸ Thirty of their meniscal tears were graded as nondegenerative and 26 were graded as degenerative. In 99 patients, the medial meniscal tear was thought to be nonsalvageable, and partial medial meniscectomy was performed. Their menisci were degenerative, had multiple horizontal and vertical tears, and appeared crushed beyond repair. The mean age of patients in the repair group was 21.5 ± 5.5 years (range, 15 to 37), and the mean age of patients in the partial meniscectomy group was 23.9 ± 8.9 years (range, 13 to 48).

After ACL reconstruction, the rehabilitation program was the same for all patients, regardless of whether they had meniscal repair or removal. Before 1987, patients were instructed to limit weightbearing for the first 2 to 4 weeks after surgery. Beginning in 1987, patients were allowed to bear weight as tolerated after surgery, although, beginning in 1990, patients were encouraged to limit activities out of bed for the 1st week after surgery as a means to keep swelling to a minimum.¹⁷ Full range of motion was allowed as soon as possible after surgery. Once full range of motion was achieved, patients began a strengthening program followed by a functional progression program until they could return to sports.

Patients were evaluated subjectively on a yearly basis with a modified Noyes knee questionnaire.²⁰ For research purposes, patients were asked to return for objective evaluation with the International Knee Documentation Committee (IKDC) protocol at 2, 5, 10, and 15 years after ACL reconstruction.²

Fisher's exact test was used to determine whether there was a statistically significant difference between groups for IKDC overall grade and radiographic subscores. The Mann-Whitney Wilcoxon test was used to determine whether there was a statistically significant difference between groups for the total subjective score. Statistical significance was determined at $P < 0.05$.

TABLE 1
Results of Objective Evaluation with International Knee Documentation Committee Criteria—Overall Grades

Group (N)	Normal		Nearly normal		Abnormal		Severely abnormal	
	N	(%)	N	(%)	N	(%)	N	(%)
Repair ^a (25)	13	(52)	9	(36)	3	(12)	0	(0)
Nondegenerative ^b (12)	5	(42)	5	(42)	2	(17)	0	(0)
Degenerative (13)	8	(62)	4	(31)	1	(8)	0	(0)
Removal (52)	26	(46)	25	(45)	5	(9)	0	(0)

^a No statistically significant difference in the distribution of grades between the repair and removal groups ($P = 0.7497$).

^b No statistically significant difference in the distribution of grades between the nondegenerative and degenerative meniscal repair groups ($P = 0.5774$).

TABLE 2
Results of Objective Evaluation with International Knee Documentation Committee Criteria—Radiographic Grades

Group (N)	Normal		Nearly normal		Abnormal		Severely abnormal	
	N	(%)	N	(%)	N	(%)	N	(%)
Repair ^a (24)	20	(83)	3	(13)	1	(4)	0	(0)
Nondegenerative ^b (12)	11	(92)	1	(8)	0	(0)	0	(0)
Degenerative (12)	9	(75)	2	(17)	1	(8)	0	(0)
Removal (52)	41	(79)	8	(15)	3	(6)	0	(0)

^a No statistically significant difference in the distribution of grades between the repair and removal groups ($P = 0.8977$).

^b No statistically significant difference in the distribution of grades between the nondegenerative and degenerative meniscal repair groups ($P = 0.4646$).

RESULTS

Subjective Results

Subjective follow-up results were available from 51 patients in the repair group at a mean of 8.9 ± 3.2 years (range, 3 to 15) after surgery and from 87 patients in the partial meniscectomy group at a mean of 7.8 ± 3.9 years (range, 2 to 19.1) after surgery. The mean subjective Noyes score was 90.9 ± 11.6 points in the repair group and 90.9 ± 16.7 in the partial meniscectomy group ($P = 0.634$). When the meniscal repair group was subdivided into nondegenerative tears ($N = 27$) and degenerative tears ($N = 24$), the mean modified Noyes total score was 93.9 ± 9.8 points for the nondegenerative group and 87.1 ± 12.9 for the degenerative group, which was statistically significantly different ($P = 0.02$). The mean subjective score of 87.1 points in the degenerative repair group was not statistically significantly lower than the mean of 90.9 points in the group of patients whose meniscus was removed ($P = 0.1377$).

IKDC Objective Evaluation

Objective evaluation was available for 25 patients in the repair group (mean time, 7.1 years after surgery) and 56 patients in the partial meniscectomy group (mean time 6.0 years after surgery). One patient with a meniscal repair of a nondegenerative tear refused radiographic evaluation. The distributions of overall grades or radiographic subscores were not statistically significantly different between groups ($P = 0.7467$, overall grade; $P = 0.8977$, radiographs) (Tables 1 and 2).

Subsequent Surgery

Five patients in the repair group and one patient in the partial meniscectomy group required a second surgical procedure for the medial meniscus at a mean of 3.8 years (range, 2.2 to 6.8) after ACL reconstruction. All of these patients had symptoms of painful catching or clicking that affected their everyday life. The medial meniscus was torn at the site of the original tear but also had a new degenerative radial flap tear. Of the five patients in the repair group who required subsequent meniscal surgery, four (80%) had a meniscus that was graded as degenerative at the time of the initial repair. There were no nerve injuries or deep vein thromboses. Two patients underwent subsequent arthroscopic surgery for a cyclops lesion that limited full hyperextension in the knee.

DISCUSSION

Our purpose was to document the subjective and objective superiority of meniscal repair over partial meniscectomy for treatment of large unstable bucket-handle meniscal tears in young athletically active patients undergoing ACL reconstruction. However, the results showed no statistically significant difference between subjective scores and objective IKDC grades for meniscal repair compared with removal of the torn menisci. Patients who underwent repair had statistically significantly lower subjective scores if their meniscal tears were degenerative compared with those patients who had nondegenerative meniscal tears.

Since Fairbank⁷ originally described the deleterious effects of meniscectomy on articular cartilage seen with long-term radiographic follow-up, many subsequent arti-

cles have documented the deterioration of the joint surface after meniscectomy and the possible protective function of the meniscus.^{1,3,8,10,11,22} In a cadaveric biomechanical model, Baratz et al.³ noted that after partial meniscectomy contact areas decreased 10% and contact stresses increased 65%. After total meniscectomy, contact areas decreased 75% and peak local contact pressure increased 235%. After meniscal repair, contact stresses and peak local contact pressures approached those of intact menisci. Their data suggested that contact stresses increase in proportion to the amount of meniscus removed.³

Several studies have compared the results of meniscal repair with those of meniscectomy or with the functional ability of knees with intact menisci. Lynch et al.¹⁰ found that the percentage of patients who had pain and more than two Fairbank changes at a mean of 3.8 years after ACL reconstruction was 90% of those who had total meniscectomies, 33% of those who had partial meniscectomies, 0% of those who had meniscal repairs, and 17% of those patients who had stable "leave alone" tears. The authors concluded that meniscal repair appeared to preserve the integrity of the meniscus in a stable ACL-reconstructed knee.¹⁰ DeHaven et al.⁶ found a higher rate of degenerative changes 10 years after surgery in patients whose meniscal repair was unsuccessful compared with patients who had successful meniscal repair. Neyret et al.¹¹ found that patients who underwent meniscectomy but had intact ACLs had a 35% increased risk of developing osteoarthritis, but this risk did not vary between 20 and 35 years after meniscectomy. Patients with ACL-deficient knees had an incidence of radiographic osteoarthritis of 86% at 30 years' follow-up. The authors concluded that the long-term outcome after rim-preserving meniscectomy depends mainly on the state of the ACL.¹¹ In a clinical and radiographic comparison between medial meniscal repair, partial meniscectomy, and intact meniscus in the ACL-reconstructed knee, Aglietti et al.¹ found that patients in the partial meniscectomy group had more pain and degenerative radiologic changes than did patients in the meniscal repair and meniscus intact groups ($P < 0.001$) at an average follow-up of 55 months. They concluded that medial meniscal repair offered the best chance to preserve the articular surface of the medial compartment.¹ Shelbourne and Gray¹⁶ found that, for patients who had undergone ACL reconstruction, both subjective and objective long-term outcomes were determined by the status of the meniscus and articular cartilage at the time of reconstruction. Patients with both menisci present and normal articular cartilage had a mean subjective score of 94 points. Patients who had undergone partial medial meniscectomy had a mean subjective score of 90 points. The overall IKDC rating was normal or nearly normal in 87% of patients with intact menisci; 70%, with partial or total lateral meniscectomy; 63%, with partial or total medial meniscectomy; and 60% of patients with both menisci removed.¹⁶ Our present study failed to support the findings of these previous studies and our initial belief that meniscal repair for unstable isolated bucket-handle medial meniscal tears in an ACL-reconstructed knee

would show superior subjective and objective scores when compared with partial meniscectomy.

Current recommendations include aggressive repair of meniscal tears in athletically active patients in association with ACL reconstruction because studies have shown that tears that extend into the avascular zone can heal and are potentially functional.^{12,13,15} O'Shea and Shelbourne¹³ showed that 84% of bucket-handle tears in the avascular zone have the potential to heal or partially heal. However, the data from our current study revealed that degenerative tears, although having the potential to heal, appear to remain nonfunctional, providing no advantage of repair over partial meniscectomy in improving postoperative scores. It is possible that many of these degenerative tears represent a nonfunctioning meniscus that does not provide the biomechanical advantage of a normally functioning meniscus. With that in mind, surgeons must consider the risks and benefits of meniscal repair in their own practice. Consideration should be given to technical difficulty, potential neurovascular injury, damage to articular surface, operative time, and the potential requirement of additional operations because of meniscal repair failure or a new meniscal tear.

The degenerative meniscal tears had a higher retear rate after repair; four of the five unsuccessful repairs were for a degenerative-type meniscal tear. The nondegenerative meniscal tears that were repaired appeared to function similarly to intact menisci, as indicated by the follow-up subjective score of 94 points, which is similar to that of patients with intact menisci and to the results of a group of athletes who have never injured their knee.¹⁶ These repaired menisci would be expected to provide protection to the articular surface.

The causes of degenerative changes in the knee after ACL reconstruction most likely are multifactorial. Patient age and activity level, associated injury, knee stability, meniscal function, and proper postoperative rehabilitation all contribute to the condition of the articular cartilage. In this study, we attempted to neutralize these multiple factors by excluding those patients with associated injury and comparing groups with similar age and activity levels and identical surgical procedures and rehabilitation protocols.

Potential weaknesses of this study included unequal numbers of patients in the groups, with the removal group almost twice the size of the repair group (99 versus 56). Additionally, only approximately 50% of patients in each group were available for objective follow-up, although subjective follow-up of the repair and removal groups was 91% and 87%, respectively. Our lack of statistical significance in IKDC scores between the degenerative and nondegenerative repair groups may reflect our small numbers, but we thought it was important to exclude patients with articular cartilage damage, lateral meniscal tears, and additional ligament injury to limit confounding variables. Also, the lack of statistical significance between groups may reflect insufficient time, still at a mean of only 7.8 to 8.9 years after surgery, to demonstrate the long-term effect of meniscectomy.

Severity of medial meniscus tears and their relationship to subjective scores

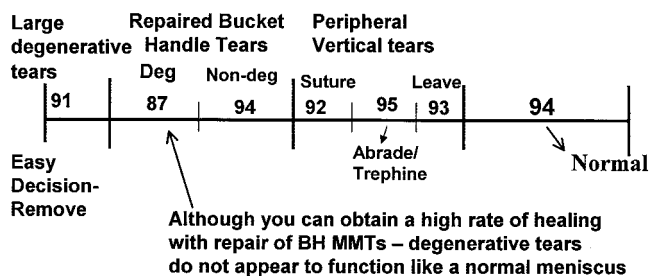


Figure 3. The continuum of severity of medial meniscal tears and recommended treatment as they relate to modified Noyes subjective scores after surgery. The score for patients with normal menisci is on the right (94 points), and the score of patients who had degenerative medial menisci removed is on the left (91 points). Although degenerative bucket-handle tears did have a fairly good subjective score (87), they do not appear to function like a normal meniscus. Data on peripheral vertical tears from Shelbourne and Rask.¹⁹ Deg, degenerative. BH MMTs, bucket-handle medial meniscal tear.

The continuum of subjective scores based on the severity of medial meniscal tear and treatment is shown in Figure 3. Patients who had undergone ACL reconstruction and who had no articular cartilage damage and both menisci intact had a mean modified Noyes subjective score of 94 points. Patients who underwent partial meniscectomy but had normal articular cartilage had a mean subjective score of 91 points, and the scores began to deteriorate slightly at 7 years after surgery.¹⁶ In a study that evaluated the clinical sequelae of nondegenerative peripheral vertical meniscal tears treated with abrasion and trephination alone (stable tears, $N = 372$) or suture repair (unstable tears, $N = 139$), these stable tears (<50% of the meniscal circumference and not displaceable) healed and functioned similarly to intact menisci, as indicated by subjective scores of 92 to 95.¹⁹ In the current study, we determined that repair of large nondegenerative bucket-handle tears can provide subjective results equal to those of patients with intact menisci. However, patients with large degenerative bucket-handle tears that are repaired do not have any better subjective results and, in fact, have lower subjective scores than patients whose meniscus was removed.

We emphasize that meniscal salvage still remains a viable and preferred method, in the proper setting, for treating bucket-handle medial meniscal tears in young athletically active patients undergoing ACL reconstruction. In the group with repaired degenerative bucket-handle medial meniscal tears, only 4 of 26 repairs (15%) clinically failed and required removal. Although the subjective scores indicated that these menisci were not functioning normally, the range of subjective scores was from 53 to 100 points. We do not believe that we can determine at the time of ACL reconstruction which of these repaired

degenerative menisci will be asymptomatic or which will cause painful symptoms in the future. Therefore, we continue to repair many degenerative bucket-handle medial meniscal tears with the knowledge that some patients might require subsequent surgery. Each surgeon must critically analyze the quality of tissue available for repair and the potential for functional healing, consider the long-term goals of the patient, and weigh the risks and benefits of meniscus salvage. Although our subjective follow-up was at a mean of 8.9 years in this study, we believe that even longer follow-up of this group may be required to determine the benefit of meniscus salvage over partial meniscectomy.

CONCLUSIONS

In patients with ACL-reconstructed knees with unstable and isolated bucket-handle medial meniscal tears, the results did not demonstrate superior subjective and objective outcomes for meniscal repair compared with partial removal. However, a subset of patients with degenerative tears at the time of repair had statistically significantly lower subjective scores at a mean of 8.9 years after surgery than did patients with nondegenerative tears. We believe this difference may be because the repaired degenerative meniscus may not be functioning. Longer follow-up is probably needed to detect a difference between the outcome of meniscal repair and meniscectomy.

REFERENCES

1. Aglietti P, Zuccherotti G, De Biase P, et al: A comparison between medial meniscus repair, partial meniscectomy, and normal meniscus in anterior cruciate ligament reconstructed knees. *Clin Orthop* 307: 165–173, 1994
2. Anderson AF: Rating scales, in Fu FH, Harner CD, Vince KG (eds): *Knee Surgery*. Baltimore, Williams & Wilkins, 1994, pp 275–297
3. Baratz ME, Fu FH, Mengato R: Meniscal tears: The effect of meniscectomy and of repair on intraarticular contact areas and stress in the human knee. A preliminary report. *Am J Sports Med* 14: 270–275, 1986
4. Bourne RB, Finlay JB, Papadopoulos P, et al: The effect of medial meniscectomy on strain distribution in the proximal part of the tibia. *J Bone Joint Surg* 66A: 1431–1437, 1984
5. Clatworthy M, Amendola A: The anterior cruciate ligament and arthritis. *Clin Sports Med* 18: 173–198, 1999
6. DeHaven KE, Lohrer WA, Lovelock JE: Long-term results of open meniscal repair. *Am J Sports Med* 23: 524–530, 1995
7. Fairbank TJ: Knee joint changes after meniscectomy. *J Bone Joint Surg* 30B: 664–670, 1948
8. Hazel WA, Rand JA, Morrey BF: Results of meniscectomy in the knee with anterior cruciate ligament deficiency. *Clin Orthop* 292: 232–238, 1993
9. Henning CE, Lynch MA: Current concepts of meniscal function and pathology. *Clin Sports Med* 4: 259–265, 1985
10. Lynch MA, Henning CE, Glick KR: Knee joint surface changes. Long-term follow-up meniscus tear treatment in stable anterior cruciate ligament reconstructions. *Clin Orthop* 172: 148–153, 1983
11. Neyret P, Donell ST, Dejour H: Results of partial meniscectomy related to the state of the anterior cruciate ligament: Review at 20 to 35 years. *J Bone Joint Surg* 75B: 36–40, 1993
12. Noyes FR, Barber-Westin SD: Arthroscopic repair of meniscus tears extending into the avascular zone with or without anterior cruciate reconstruction in patients 40 years of age and older. *Arthroscopy* 16: 822–829, 2000
13. O'Shea JJ, Shelbourne KD: Repair of locked bucket-handle meniscal tears in knees with chronic anterior cruciate ligament deficiency. *Am J Sports Med* 31: 216–220, 2003
14. Outerbridge RE: The etiology of chondromalacia patellae. *J Bone Joint Surg* 43B: 752–757, 1961
15. Rubman MH, Noyes FR, Barber-Westin SD: Arthroscopic repair of meniscal tears that extend into the avascular zone. A review of 198 single and complex tears. *Am J Sports Med* 26: 87–95, 1998

16. Shelbourne KD, Gray T: Results of anterior cruciate ligament reconstruction based on the meniscal and articular cartilage status at the time of surgery: Five- to fifteen-year evaluations. *Am J Sports Med* 28: 446–452, 2000
17. Shelbourne KD, Gray T: Anterior cruciate ligament reconstruction with autogenous patellar tendon graft followed by accelerated rehabilitation. A two- to nine-year followup. *Am J Sports Med* 25: 786–795, 1997
18. Shelbourne KD, Porter DA: Meniscal repair. Description of a surgical technique. *Am J Sports Med* 21: 870–873, 1993
19. Shelbourne KD, Rask BP: The sequelae of salvaged nondegenerative peripheral vertical medial meniscus tears with anterior cruciate ligament reconstruction. *Arthroscopy* 17: 270–274, 2001
20. Shelbourne KD, Whitaker HJ, McCarroll JR, et al: Anterior cruciate ligament injury: Evaluation of intraarticular reconstruction of acute tears without repair. Two- to seven-year followup of 155 athletes. *Am J Sports Med* 18: 484–489, 1990
21. Shoemaker SC, Markolf KL: The role of the meniscus in the anterior-posterior stability of the loaded anterior cruciate-deficient knee. Effects of partial versus total excision. *J Bone Joint Surg* 68A: 71–79, 1986
22. Sommerlath K, Lysholm J, Gillquist J: The long-term course after treatment of acute anterior cruciate ligament ruptures. A 9- to 16-year followup. *Am J Sports Med* 19: 156–162, 1991
23. Voloshin AS, Wosk J: Shock absorption of meniscectomized and painful knees: A comparative in vivo study. *J Biomed Eng* 5: 157–161, 1983