Return to High-Level Sport After Meniscal Allograft Transplantation

Peter N. Chalmers, M.D., Vasili Karas, B.S., Seth L. Sherman, M.D., and Brian J. Cole, M.D., M.B.A.

Purpose: Our purpose was to determine the results of meniscal allograft transplantation (MAT) in high school and higher-level athletes, specifically with respect to return to their preinjury level of play. **Methods:** This is a retrospective case series of prospectively collected data from a single surgeon, evaluating athletes who underwent MAT. Each patient participated in either high school, collegiate, or professional athletics before injury, with a mean preinjury Tegner score of 8. In addition, patients were only included if one of their stated preoperative goals was to return to their previous level of activity. Patients completed preoperative and postoperative validated knee surveys (Knee Injury and Osteoarthritis Outcome Score, International Knee Documentation Committee score, Lysholm score, and Tegner score) and underwent physical examinations. **Results:** The mean age of the 13 included patients was 19.8 years, with a mean follow-up of 3.3 years (range, 1.9 to 5.7 years). After MAT, 10 of 13 patients (77%) returned to sporting activity. The mean Knee Injury and Osteoarthritis Outcome Score for the sport subset was 76 (SD, 18), the mean International Knee Documentation Committee score was 77 (SD, 14), and the mean Lysholm score was 81 (SD, 13). Of the 13 patients, 3 (23%) required further surgery, comprising one revision MAT, one partial meniscectomy, and one meniscal repair. **Conclusions:** In this small retrospective series, 77% of high school and higher-level athletes with meniscal deficiency and symptomatic "post-meniscectomy syndrome" returned to their desired level of play after MAT. These athletes also had significant improvements in most outcome measures. **Level of Evidence:** Level IV, therapeutic case series.

Meniscal pathology is the most commonly treated knee injury, with an incidence rate of 61 cases per 100,000 person-years.[1] The knee menisci have critically important roles including load transmission, stabilization,[2] shock absorption, joint lubrication, and articular cartilage nutrition.[3,4] Because of this critical function, every attempt should be made to repair meniscal tears in young patients. However, some meniscal tears are not reparable, leaving the surgeon few options other than partial or subtotal meniscectomy.[5-9] Outcomes are particularly poor in athletes after meniscectomy.[10-13] After meniscal removal, "post-meniscectomy syndrome," consisting of recurrent joint effusions, pain, and symptomatic "giving way," may develop in athletes. This constellation of symptoms may limit or prevent the athlete from returning to play after meniscal injury and surgery.[5-9]

Meniscal allograft transplantation (MAT) is a surgical procedure indicated for patients with symptomatic meniscal deficiency.[14] Past series on MAT show successful improvement in quality of life and activities of daily living in a slightly older, less active patient population.[15] These series are deficient in that they do not address the young athlete with post-meniscectomy syndrome. The purpose of this study was to determine the outcome of MAT in high school and higher-level athletes, specifically with regard to ability to return to play. Our hypothesis was that the significant pain relief and functional gains that follow MAT would reliably allow athletes to return to their previous level of activity.

Methods

Between 2004 and 2009, 166 consecutive patients underwent MAT. After institutional review board

From the Department of Orthopedic Surgery (P.N.C.) and Sports Medicine Program (B.J.C.), Rush University Medical Center, Rush University Medical College (V.K.), Chicago, Illinois; and Division of Sports Medicine, Department of Orthopaedic Surgery (S.L.S.), University of Missouri-Columbia, Columbia, Missouri, U.S.A.

The authors report that they have no conflicts of interest in the authorship and publication of this article.

Received April 5, 2012; accepted October 23, 2012.

Address correspondence to Peter N. Chalmers, M.D., Department of Orthopedic Surgery, Rush University Medical Center, 1611 W Harrison, Ste 300, Chicago, IL 60612, U.S.A. E-mail: p.n.chalmers@gmail.com

0749-8063/12228/$36.00

http://dx.doi.org/10.1016/j.arthro.2012.10.027

approval, these patients underwent an informed consent process and were followed up as part of a prospective database of cartilage restoration procedures. Clinical criteria used for MAT include persistent symptoms after meniscectomy, normal alignment or correction to normal alignment, and a stable ligamentous knee condition or correction to a stable ligamentous knee condition. Prospectively collected preoperative data included level and type of preinjury athletic activity. Patients were asked their motivation for seeking treatment in a multiple choice format with one possible answer being returning to preinjury athletic activity. The inclusion criteria were (1) preoperative participation in high school, collegiate, semiprofessional, or professional athletics as specified on our preoperative specific sport/activity survey and (2) preoperative self-selected motivation of returning to preinjury athletic activity as specified on our preoperative sport/activity survey (Table 1). Of our 166 patients, 14 met these criteria, of whom one was lost to follow-up.

Surgical Planning, Technique, and Rehabilitation

Of the transplants, 11 were performed with a bridge-in-slot technique[16] (10 patients) and 3 were performed with a double–bone plug technique[17] to accommodate concomitant anterior cruciate ligament reconstruction. The sizing protocol[18,19] and operative technique are described elsewhere.[16] In all cases fresh-frozen, nonirradiated menisci were used.

The postoperative rehabilitation protocol has been described elsewhere, with a 2-week period of protected weight bearing and immobilization, followed by full weight bearing, range of motion, strengthening, and closed-chain strengthening, progressing to sport-specific activities by 3 months and full training by 4 months postoperatively.[7]

Patient evaluations were performed preoperatively and at greater than 2 years postoperatively (except for the patient evaluated at 1.9 years) with the Knee Injury and Osteoarthritis Outcome Score (KOOS) and International Knee Documentation Committee (IKDC), Lysholm, and Tegner validated scoring questionnaires in addition to a sport-specific questionnaire (Table 1) and physical examination. Standing radiographs in full extension were obtained preoperatively and at final follow-up and graded by use of the Kellgren-Lawrence system.[20] Subsequent procedures were also recorded.

Statistical analysis was performed with SPSS software for Windows (version 8.0; SPSS, Chicago, IL), and groups were analyzed with the Student t test, as well as descriptive statistics. For this study, $P < .05$ was deemed significant.

Results

Table 2 shows demographic characteristics of the 13 included patients. The mean preinjury Tegner score was 8, with an SD of 2. Of the patients, 5 (38%) had previous surgical procedures performed concomitantly with meniscectomy, including 5 anterior cruciate ligament reconstructions, 2 microfracture procedures, and 1 osteoarticular autografting procedure. Of the patients, 4 (31%) had prior total meniscectomies and 9 (69%) had subtotal meniscectomies. Pain and swelling developed after meniscectomy in all patients, 7 (54%) with activities of daily living, and all with attempted athletic activity, at a mean (± SD) of 23.9 ± 23.5 months after the index meniscectomy. Although 8 of these patients (62%)

Table 1. Specific Sport/Activity-Related Questionnaire Completed by Patients Who Met Criteria After Secondary Survey of Clinical Data (n = 25)

Question	Response
1. What was your goal in having meniscal allograft transplantation?	Improve activities of daily living* Pain relief* Return to athletics or previous level of activity Other _____
2. What sport/activity did you participate in prior to injury or onset of symptoms?	Sport/activity _____
3. What was your highest level attained in that sport/activity prior to injury?	Recreational* High school varsity Collegiate Minors Professional
4. How many hours per week did you train/play/participate at the above level after/during injury/symptoms?	Hours per week _____
5. How many hours per week did you train/play/participate at the above level after surgery and rehabilitation?	Hours per week _____
6. How long after surgery did it take you to reach your previous level of activity?	Months _____
7. Were you able to return to your previous level of activity?	Yes/no Comment _____
8. Based on your experience, if you have the same problem on the opposite knee, would you have this surgery again?	Yes/no Comment _____

*Patients who responded in this manner met the exclusion criteria for this study.

Table 2. Patient Demographic Characteristics

Patient No.	Side	Medial/ Lateral	Procedures Concomitant to Initial MAT	Sex	Age at Surgery (yr)	Follow-up (yr)	Athletics	Initial Procedure	Subsequent Procedures
1	Right	Medial	ACL reconstruction	F	19.4	2.3	Collegiate track and field	DBP	None
2	Right	Lateral	None	M	20.4	3.2	Collegiate basketball	BIS	Partial Mtx at 1 yr
3	Left	Medial	ACL reconstruction	F	23.8	3.0	Collegiate track	DBP	Arthroscopy
4	Left	Lateral	None	F	19.8	4.4	Collegiate soccer	BIS	Revision at 1 yr
5	Left	Lateral	None	F	17.1	2.5	Collegiate basketball	BIS	None
6	Right	Lateral	None	M	20.9	2.0	Professional baseball	BIS	PTMR
7	Right	Lateral	OA graft	F	18.8	3.4	Collegiate softball	BIS	None
8	Left	Lateral	None	F	20.4	3.6	Collegiate basketball	BIS	None
9	Left	Lateral	None	M	17.5	3.9	HS varsity wrestling	BIS	None
10	Left	Lateral	OA graft, DFO	F	18.9	5.7	Collegiate basketball	BIS	None
11	Right	Lateral	MxFx	F	17.5	5.5	HS varsity soccer	BIS	None
12	Left	Medial	ACL reconstruction	M	16.5	2.0	HS varsity football	DBP	None
13	Right	Lateral	OA graft	F	19.8	1.9	Collegiate basketball	BIS	None
Total	6 right and 7 left	10 lateral and 3 medial	8 procedures in 7 patients	9 F and 4 M	19.3 (17-24)	3.3 (1.9-5.7)		10 BIS and 3 DBP	3 procedures in 3 patients

ACL, anterior cruciate ligament; BIS, bone in slot; DBP, double bone plug; DFO, distal femoral osteotomy; HS, high school; Mtx, meniscectomy; MxFx, microfracture; OA, osteochondral; PTMR, post-traumatic meniscal repair.

attempted to return to sports, none were able to return to their preinjury level of play. Table 3 shows Outerbridge grading[21] of the articular cartilage at the time of MAT.

Of the 13 study participants, 10 (77%) returned to their previous level of activity. Of the 13 patients, 9 (70%) returned to their desired level of play. Patients spent a mean of 25.4 hours per week (range, 10 to 56 hours per week; SD, 12.6) before injury or symptoms participating in their respective activities, a mean of 8.9 hours per week (range, 0 to 25 hours per week; SD, 8.9) while injured, and finally, a mean of 13.3 hours per week (range, 10 to 56 hours per week; SD, 6.5) after surgery and rehabilitation. Whether they returned to their desired level or not, the mean time to return to their previous athletic level was 16.5 months (range, 8 to 24 months; SD, 6.5).

Overall, there were significant improvements ($P < .05$) from preoperative scores to most recent follow-up in IKDC score, Lysholm score, and overall satisfaction, as well as the KOOS pain, symptoms, activity of daily living, and sport subscores (Figs 1 and 2). The mean overall satisfaction score increased from 5.4 (SD, 2.1) to 8.7 (SD, 1.3) out of 10. The mean IKDC score increased from 43 (SD, 15) to 77 (SD, 14) at most recent follow-up. The mean Lysholm score increased from 55 (SD, 16) to 81 (SD, 13). The KOOS method for following outcomes is broken down into 5 specific subsets, with 4 (pain, symptoms, activities, and sport) showing significant improvement. The Tegner scores were not significantly different, with the mean being slightly improved from 8 preoperatively to 9 postoperatively ($P > .05$).

Radiographic follow-up was available for 10 of 13 patients. At final follow-up, one patient was classified as

Table 3. Status of Articular Cartilage at Time of MAT, Graded by Outerbridge System[21]

	No. of Patients
Normal cartilage	4
Outerbridge grade I	3
Outerbridge grade II	1
Outerbridge grade III	1
Outerbridge grade IV	4

NOTE. All patients with grade IV changes underwent concomitant osteoarticular allografting.

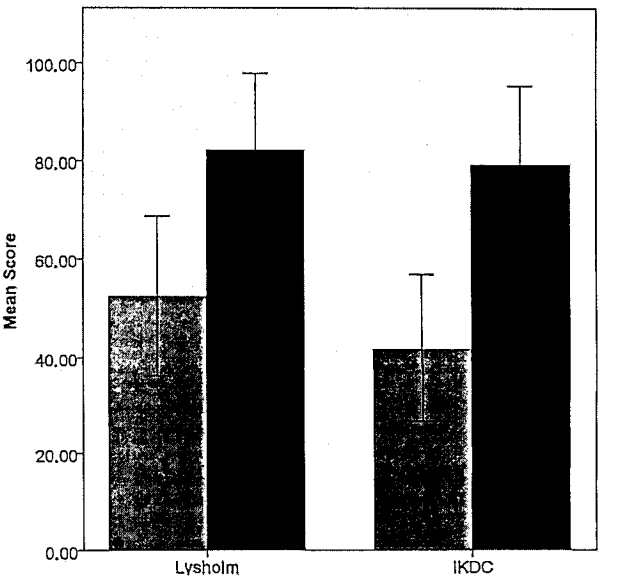

Fig 1. Preoperative (light gray) and postoperative (dark gray) (final follow-up) Lysholm and IKDC scores. Error bars show standard deviations. Both Lysholm and IKDC scores were significantly improved ($P < .05$).

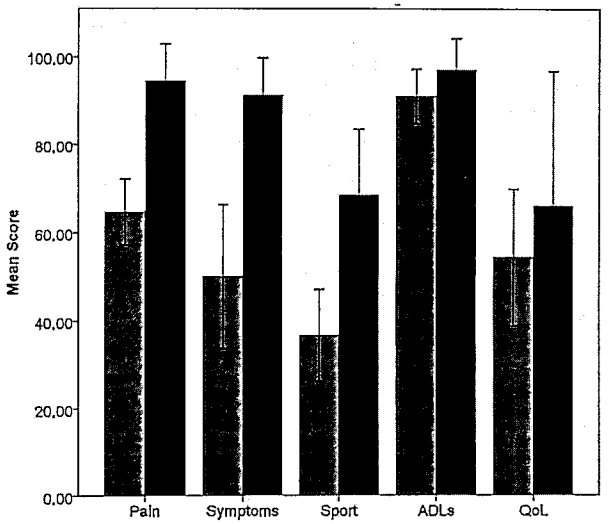

Fig 2. Preoperative (light gray) and postoperative (dark gray) (final follow-up) KOOS subset scores. Error bars show standard deviations. Significant ($P < .05$) improvements were seen in pain, symptom, activities of daily living (ADLs), and sport subscores. Although the quality-of-life (QoL) score trended toward improvement, the change was not significant ($P = .11$).

Kellgren-Lawrence stage 0, 4 were classified as stage 1, one was classified as stage 2, and 3 were classified as stage 3. Of the 10 patients, 5 had progressed by one or more Kellgren-Lawrence stages and 5 were unchanged.

When the cohort was split into patients who underwent concomitant reconstruction of meniscal, cartilaginous, and/or ligamentous pathology and those who underwent MAT alone, no significant differences were seen in age (19.4 years *v* 19.3 years, $P = .93$), length of follow-up (3.4 years *v* 3.3 years, $P = .89$), mean overall satisfaction score at final follow-up (9 *v* 7, $P = .23$), mean IKDC score at final follow-up (54 *v* 61, $P = .73$), mean Lysholm score at final follow-up (63 *v* 71, $P = .58$), or mean Tegner score at final follow-up (9 *v* 9, $P > .99$).

Subsequent Procedures

Of the 13 patients, 4 (30%) underwent subsequent procedures. One patient each underwent plica excision, partial graft meniscectomy, revision MAT, and posttraumatic meniscal repair. These patients' data were included in the statistical analysis, because despite failing to reach their preoperative goal, they were all symptomatically improved. In the patient who underwent partial meniscectomy, zones 1 and 2 of the lateral meniscus were debrided to the middle third of the meniscus. In the patient who underwent revision MAT, allograft shrinkage and degeneration were noted 1 year postoperatively. The patient underwent revision and, despite never returning to preoperative activity (collegiate soccer), became a triathlete. Finally, one allograft had to be repaired after a traumatic tear during sport 1 year postoperatively. A tear of the anterior horn was found and repaired, and the patient is currently at his desired level of play as a Major League Baseball player 2 years after MAT and 1 year after meniscal repair.

Discussion

This retrospective case series of prospectively collected data describes 13 athletes with symptomatic postmeniscectomy syndrome who underwent MAT. At a minimum of 1.9-year follow-up, 77% of patients were able to return to their previous level of activity and 70% were able to return to their desired level of play. These patients reported improved Lysholm and IKDC scores, as well as KOOS pain, symptoms, activity of daily living, and sport subscores. Of the patients, 78% reported that the condition of the knee was 8 of 10 or greater and 93% reported satisfaction scores of 8 of 10 or greater. Of the 13 MAT patients, 3 (23%) required revision surgery on the allograft, consisting of one revision MAT, one partial allograft meniscectomy, and one meniscal repair. It is unclear whether graft damage and the need for revision surgery arose from traumatic injury to the graft, immunohistologic reaction to the graft, or graft degeneration. Unfortunately, because of the mobility of the patient population, we were unable to obtain complete radiographic imaging series including preoperative and postoperative imaging. In the 10 patients with imaging available, 5 had no increase in degenerative changes at final follow-up.

Several series on MAT have shown successful improvement in quality of life and activities of daily living in a slightly older, less active patient population than our series.[14] In a recent meta-analysis of 44 available case series, the mean patient age at the time of MAT was 34.8 years.[15] The mean time between injury and MAT in this same meta-analysis was almost 11 years.[15] Since the initial series by Milachowski et al.[22] in 1989, numerous authors have reported on over 1,000 cases of MAT. The clinical results in our study of athletes mirror those of previous series, which showed overall excellent symptomatic and functional results after MAT in nonathletic populations.[7,15,23-32]

To our knowledge, our study is the first to report the outcomes of MAT in high school and higher-level athletes with the specific intention of returning to their preinjury level of play.[14] In this small series, we have shown that most patients return to their desired level of play after this procedure. As with most procedures, management of patient expectations is paramount and is a critical component of postoperative satisfaction.[6] These athletes need to understand that a successful return to play may take up to 2 years after surgery. In addition, they must be made fully aware of the uncertain effect of MAT, as well as athletics after MAT, on the eventual progression of articular cartilage degeneration and deterioration or

traumatic disruption of their meniscus implant.[7,8,15,22-38] Longer-term follow-up will continue to provide information on the safety, efficacy, and longevity of MAT in the young, athletic patient population.

Limitations

There are several limitations to our series. Our small sample size and the broad range of concomitant knee pathology within our cohort may limit the generalizability of our results. Unfortunately, it is inevitable that this complex patient population has multiple and varied knee comorbidities that require intervention at the time of MAT. This limitation is found in much of the recent literature surrounding complex knee reconstruction.[25,28,32] Our study is also limited by relatively short-term follow-up. This limitation raises the question of whether degradation of outcomes will be seen with time, as has been shown in other series.[23,30,36] This limitation is amplified by the lengthy rehabilitation often needed in the athlete after MAT. Moreover, our study is limited by the lack of follow-up with either advanced imaging or second-look arthroscopy. As a result, we are unable to comment on the pathologic status of the transplanted menisci in these cases and are able to comment only on clinical symptoms and activity level.

Conclusions

In this small retrospective series, 77% of high school and higher-level athletes with meniscal deficiency and symptomatic post-meniscectomy syndrome returned to their desired level of play after MAT. These athletes also had significant improvements in most outcome measures.

References

1. Baker BE, Peckham AC, Pupparo F, Sanborn JC. Review of meniscal injury and associated sports. *Am J Sports Med* 1985;13:1-4.
2. Spang JT, Dang AB, Mazzocca A, et al. The effect of medial meniscectomy and meniscal allograft transplantation on knee and anterior cruciate ligament biomechanics. *Arthroscopy* 2010;26:192-201.
3. Ahmed AM, Burke DL. In-vitro measurement of static pressure distribution in synovial joints—Part I: Tibial surface of the knee. *J Biomech Eng* 1983;105:216-225.
4. Walker PS, Erkman MJ. The role of the menisci in force transmission across the knee. *Clin Orthop Relat Res* 1975: 184-192.
5. Sekiya JK, Ellingson CI. Meniscal allograft transplantation. *J Am Acad Orthop Surg* 2006;14:164-174.
6. Alford W, Cole BJ. The indications and technique for meniscal transplant. *Orthop Clin North Am* 2005;36: 469-484.
7. Cole BJ, Carter TR, Rodeo SA. Allograft meniscal transplantation: Background, techniques, and results. *Instr Course Lect* 2003;52:383-396.
8. Rodeo SA. Meniscal allografts—Where do we stand? *Am J Sports Med* 2001;29:246-261.
9. Packer JD, Rodeo SA. Meniscal allograft transplantation. *Clin Sports Med* 2009;28:259-283; viii.
10. Jorgensen U, Sonne-Holm S, Lauridsen F, Rosenklint A. Long-term follow-up of meniscectomy in athletes. A prospective longitudinal study. *J Bone Joint Surg Br* 1987;69:80-83.
11. Brophy RH, Gill CS, Lyman S, Barnes RP, Rodeo SA, Warren RF. Effect of anterior cruciate ligament reconstruction and meniscectomy on length of career in National Football League athletes: A case control study. *Am J Sports Med* 2009;37:2102-2107.
12. Giuliani JR, Burns TC, Svoboda SJ, Cameron KL, Owens BD. Treatment of meniscal injuries in young athletes. *J Knee Surg* 2011;24:93-100.
13. Stein T, Mehling AP, Welsch F, von Eisenhart-Rothe R, Jager A. Long-term outcome after arthroscopic meniscal repair versus arthroscopic partial meniscectomy for traumatic meniscal tears. *Am J Sports Med* 2010;38:1542-1548.
14. Hergan D, Thut D, Sherman O, Day MS. Meniscal allograft transplantation. *Arthroscopy* 2011;27:101-112.
15. Elattar M, Dhollander A, Verdonk R, Almqvist KF, Verdonk P. Twenty-six years of meniscal allograft transplantation: Is it still experimental? A meta-analysis of 44 trials. *Knee Surg Sports Traumatol Arthrosc* 2011;19:147-157.
16. Cole B, Fox JA, Lee SJ, et al. Bone bridge in slot technique for meniscal transplantation. *Oper Tech Sports Med* 2003;11:144-155.
17. Fox J, Lee SJ, Cole BJ. Bone plug technique for meniscal transplantation. *Oper Tech Sports Med* 2003;11:161-169.
18. Pollard ME, Kang Q, Berg EE. Radiographic sizing for meniscal transplantation. *Arthroscopy* 1995;11:684-687.
19. Van Thiel GS, Verma N, Yanke A, Basu S, Farr J, Cole B. Meniscal allograft size can be predicted by height, weight, and gender. *Arthroscopy* 2009;25:722-727.
20. Kellgren JH, Lawrence JS. Radiological assessment of osteo-arthrosis. *Ann Rheum Dis* 1957;16:494-502.
21. Outerbridge RE. The etiology of chondromalacia patellae. *J Bone Joint Surg Br* 1961;43:752-757.
22. Milachowski KA, Weismeier K, Wirth CJ. Homologous meniscus transplantation. Experimental and clinical results. *Int Orthop* 1989;13:1-11.
23. van der Wal RJ, Thomassen BJ, van Arkel ER. Long-term clinical outcome of open meniscal allograft transplantation. *Am J Sports Med* 2009;37:2134-2139.
24. Gonzalez-Lucena G, Gelber PE, Pelfort X, Tey M, Monllau JC. Meniscal allograft transplantation without bone blocks: A 5- to 8-year follow-up of 33 patients. *Arthroscopy* 2010;26:1633-1640.
25. LaPrade RF, Wills NJ, Spiridonov SI, Perkinson S. A prospective outcomes study of meniscal allograft transplantation. *Am J Sports Med* 2010;38:1804-1812.
26. Rue JP, Yanke AB, Busam ML, McNickle AG, Cole BJ. Prospective evaluation of concurrent meniscus transplantation and articular cartilage repair: Minimum 2-year follow-up. *Am J Sports Med* 2008;36:1770-1778.
27. Cole BJ, Dennis MG, Lee SJ, et al. Prospective evaluation of allograft meniscus transplantation: A minimum 2-year follow-up. *Am J Sports Med* 2006;34:919-927.
28. Noyes FR, Barber-Westin SD, Rankin M. Meniscal transplantation in symptomatic patients less than fifty years old. *J Bone Joint Surg Am* 2004;86:1392-1404.

29. Stone KR, Adelson WS, Pelsis JR, Walgenbach AW, Turek TJ. Long-term survival of concurrent meniscus allograft transplantation and repair of the articular cartilage: A prospective two- to 12-year follow-up report. *J Bone Joint Surg Br* 2010;92:941-948.
30. von Lewinski G, Milachowski KA, Weismeier K, Kohn D, Wirth CJ. Twenty-year results of combined meniscal allograft transplantation, anterior cruciate ligament reconstruction and advancement of the medial collateral ligament. *Knee Surg Sports Traumatol Arthrosc* 2007;15: 1072-1082.
31. Rodeo SA, Seneviratne A, Suzuki K, Felker K, Wickiewicz TL, Warren RF. Histological analysis of human meniscal allografts. A preliminary report. *J Bone Joint Surg Am* 2000;82:1071-1082.
32. Gomoll AH, Kang RW, Chen AL, Cole BJ. Triad of cartilage restoration for unicompartmental arthritis treatment in young patients: Meniscus allograft transplantation, cartilage repair and osteotomy. *J Knee Surg* 2009;22: 137-141.
33. Cummins JF, Mansour JN, Howe Z, Allan DG. Meniscal transplantation and degenerative articular change: An experimental study in the rabbit. *Arthroscopy* 1997;13: 485-491.
34. Aagaard H, Jorgensen U, Bojsen-Moller F. Immediate versus delayed meniscal allograft transplantation in sheep. *Clin Orthop Relat Res* 2003:218-227.
35. Szomor ZL, Martin TE, Bonar F, Murrell GA. The protective effects of meniscal transplantation on cartilage. An experimental study in sheep. *J Bone Joint Surg Am* 2000;82:80-88.
36. Goble EM, Kohn D, Verdonk R, Kane SM. Meniscal substitutes—Human experience. *Scand J Med Sci Sports* 1999;9: 146-157.
37. Rath E, Richmond JC, Yassir W, Albright JD, Gundogan F. Meniscal allograft transplantation. Two- to eight-year results. *Am J Sports Med* 2001;29:410-414.
38. van Arkel ER, de Boer HH. Human meniscal transplantation. Preliminary results at 2- to 5-year follow-up. *J Bone Joint Surg Br* 1995;77:589-595.