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Clinical and radiographic results of arthroscopic partial meniscectomy

Artroskopik parsiyel menisektominin klinik ve radyografik sonuçları

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Objectives: The purpose of this study was to evaluate the results of the arthroscopic partial meniscectomy and to investigate correlations between preoperative findings and the clinical and radiographic results.

Patients and methods: The study included 49 patients (49 knees; 28 females, 21 males; mean age 42 years; range 16 to 68 years) who underwent arthroscopic partial meniscectomy for medial (n=39) or lateral (n=10) meniscus tears. Thirty patients (61.2%) were over 40 years of age at the time of surgery. Final evaluations were made at the end of a mean follow-up of 62.7 months (range 31 to 109 months) with preoperative and postoperative Lysholm scores, Tegner activity scores, standing anteroposterior x-rays of both knees, and subjective evaluation of the patients. Radiographic evaluations were made separately for medial and lateral meniscectomy groups. The femorotibial axis, medial and lateral clear spaces, and the degree of degeneration according to the Fairbank criteria were determined and compared with the contralateral side.

Results: Functional results were excellent in 29 knees (59.2%), good in 17 knees (34.7%), and poor in three knees (6.1%). The mean Lysholm score showed a significant improvement from 52.4 to 94.5 postoperatively ($p<0.01$). The results were better in patients under 40 years of age and in those without articular cartilage damage. Final radiographs showed a trend to varus and valgus in the medial and lateral meniscectomy groups, respectively. Compared with the contralateral side, significant narrowing of the medial joint space was detected in the operated knees after medial meniscectomy ($p<0.05$).

Conclusion: Early functional and subjective results of arthroscopic partial meniscectomy are satisfactory. However, radiographic narrowing of the joint space and angulation to the varus may pose further problems in the long-term.

Key words: Arthroscopy; knee injuries/surgery; knee joint/radiography; menisci, tibial/injuries/surgery.

Amaç: Artroskopik parsiyel menisektomi yapılan hastalarda tedavi sonuçları değerlendirildi ve ameliyat öncesi bulgular ve klinik ve radyografik sonuçlar arasındaki ilişkiler araştırıldı.

Hastalar ve yöntemler: Çalışmaya, artroskopik parsiyel menisektomi uygulanan 49 hasta (49 diz; 28 kadın, 21 erkek; ort. yaş 42; dağılım 16-68) alındı. Otuz dokuz hastaya medial, 10 hastaya lateral menisektomi yapıldı. Parsiyel menisektomi sırasında 30 hasta (%61.2) 40 yaşından büyüktü. Değerlendirmeler ameliyat öncesi ve sonrası Lysholm skorları, Tegner aktivite skoru, her iki dizin ayakta çekilen ön-arka radyografileri ve subjektif değerlendirme ile yapıldı. Radyografik değerlendirmeler medial ve lateral menisektomi gruplarında ayrı ayrı yapıldı. Ameliyat edilen dizlerde femorotibial eksen, medial ve lateral eklem aralıkları ve Fairbank ölçütlerine göre dejenerasyon miktarı belirlendi ve diğer taraf ile karşılaştırıldı. Ortalama takip süresi 62.7 ay (dağılım 11-109 ay) idi.

Bulgular: Fonksiyonel sonuçlar 29 dizde (%59.2) mükemmel, 17 dizde (%34.7) iyi, üç dizde (%6.1) kötü bulundu. Ortalama Lysholm skoru ameliyat sonrasında anlamlı bir düzelme ile 52.4'ten to 94.5'e çıktı ($p<0.01$). Kırk yaşın altındaki hastaların ve kıkırdak lezyonu bulunmayan olguların sonuçlarının daha iyi olduğu gözlendi. Radyografik olarak, medial menisektomi grubunda varus, lateral menisektomi grubunda ise valgus eğilimi gözlendi. Ayrıca, medial menisektomi grubunda, medial eklem aralıklarında karşı dize oranla anlamlı derecede daralma saptandı ($p<0.05$).

Sonuç: Artroskopik parsiyel menisektominin erken dönemdeki fonksiyonel ve subjektif sonuçları başarılıdır. Ancak, medial eklem aralığında gözlenen daralma ve varus açılanması uzun dönemde başka sorunlara neden olabilir.

Anahtar sözcükler: Artroskopi; diz yaralanması/cerrahi; diz eklemi/radyografi; menisküs, tibial/yaralanma/cerrahi.

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Since long-term follow-up studies of open total meniscectomy demonstrated poor results and serious degeneration of the knee joint, arthroscopic partial resection has become a common surgical procedure. Although repair of the meniscus, another alternative treatment, seems to be more popular, it is impossible for many types of tears which can be treated by arthroscopic partial meniscectomy. Several studies[1-5] reported good functional and subjective results, allowing early weight-bearing, return to function, and reduction of the cost of care. However, radiographic changes were detected in mid- to long-term follow-up studies.[2,4,6,7] An increased degree of degeneration was shown and radiographic results were poorer in knees with a femorotibial anatomic varus alignment.[2,6]

The purpose of this study was to assess functional results and early radiographic features following arthroscopic partial meniscectomy.

PATIENTS AND METHODS

A total of 229 patients with medial or lateral meniscus tears and a stable knee underwent arthroscopic partial meniscectomy between 1993 and 1999 at the author's institution. All the procedures were performed by the senior author. Of these, 52 patients (54 knees) were eligible for postoperative evaluation. Two patients with bilateral involvement were excluded due to the lack of comparison with the control knee. One patient who underwent total knee arthroplasty in another medical center for serious degeneration that had formerly existed at the time of arthroscopic meniscectomy was also left out of the series. The remaining 49 patients (49 knees; 28 females, 21 males) formed the study group. Five patients who were unable to return were not included in radiographic evaluations, but they were questioned on the telephone for functional results. The mean age at the time of operation was 42 years (range 16 to 68 years). Thirty patients (61.2%; 21 females, 9 males) were over 40 years of age at the time of surgery.

Involvement was in the left knee in 30 patients (61.2%), and in the right in 19 patients (38.8%). Medial and lateral meniscectomies were performed in 39 patients (79.6%) and 10 patients (20.4%), respectively. The type of meniscus tears was vertical-longitudinal in 18 knees (36.7%), bucket-handle in nine knees (18.4%), and radial in six knees (12.2%). Degenerative tears were found in 25 patients, with horizontal tears in 13 knees (26.5%), and complex tears in 12 knees (24.5%). Most of the tears (n=27, 55.1%) occurred in the posterior horn of the menisci. Serious cartilage lesions (grade 3 or 4 according to the criteria of Outerbridge[8]) were present in 12 patients (24.5%), 11 of whom were females. The mean age of this group was 55 years (range 43 to 68 years). In addition, 14 knees (28.6%) showed chondral degeneration of grade 1 or 2. Focal full-thickness cartilage defect was observed in four patients (8.2%).

Final evaluations were made at the end of a mean follow-up of 62.7 months (range 31 to 109 months). Preoperative and postoperative Lysholm scores[9] were compared. Preoperative and postoperative activity levels of the patients were evaluated using the Tegner activity scores.[10] For subjective evaluation, the patients were asked to define their results by one of the following: excellent, better, same, or worse. Physical examination included evaluations for muscle atrophy, effusion, crepitus, stability of the knee, range of motion, joint space tenderness, and provocative tests for meniscal pathology. The result was graded as excellent if the Lysholm score exceeded 95, good if it was 85 to 94, and poor if it was below 84.

For radiographic assessment, standing anteroposterior x-rays of both knees were obtained in each patient except for five patients who were only available by telephone interviews. Evaluations were made separately for medial and lateral meniscectomy groups. The contralateral knees were evaluated as controls. The femorotibial axis, medial and lateral clear spaces, and the degree of degeneration according to the Fairbank criteria[11] were determined and compared with the contralateral side.

Clear spaces were measured in millimeters at the midpoint of each compartment and compared with the other side. The femorotibial anatomic angle was measured between the distal third line of the femur and the proximal third one of the tibia. Orthoroentgenograms of the patients to evaluate the hip-knee-ankle angle were not obtained. Differences in the joint spaces and angles of both knees were evaluated for any relationship with the meniscectomy.

Statistical analyses of functional and radiographic data were performed using Student's t-

test, paired t-test, and Wilcoxon signed-rank test. P values of less than 0.05 were considered to be statistically significant.

RESULTS

Functional results were excellent in 29 knees (59.2%), good in 17 knees (34.7%), and poor in three knees (6.1%). The mean Lysholm score showed a significant improvement at the last follow-up (52.4±18.2 *vs.* 94.5±6.7; p<0.01).

There were no significant differences between the operated and nonoperated knees in terms of range of motion and stability. Eight patients complained of joint line tenderness and the provocative meniscus test was positive in six patients. Quadriceps atrophy was detected in 11 knees and eight patients had minimal joint effusion.

Activity levels improved postoperatively. Level 1 or level 2 activities were performed by 42 patients (85.7%) and 16 patients (32.7%) before surgery and at the last follow-up, respectively (Table I). Forty-three patients (87.8%) improved to a higher level of activity compared to the preoperative status.

In the subjective evaluation, 23 patients (46.9%) rated their knees as excellent, 22 patients (44.9%) as better, whereas four patients (8.2%) reported no difference after surgery.

Distribution of the results between males and females were as follows, respectively: excellent, 16 (76.2%) *vs.* 14 (50.0%); good, 4 (19.1%) *vs.* 12 (42.9%); and poor, 1 (4.8%) *vs.* 2 (7.1%). The mean Lysholm scores did not differ significantly between males and females (95.5±7.9 *vs.* 93.5±5.4; p=0.31). Subjective evaluations of males and females were similar. However, compared to females, males had higher levels of activity both preoperatively and postoperatively, with final activity level scores of 3.48 *vs.* 2.42, respectively.

The mean postoperative Lysholm score of the medial meniscectomy group was significantly higher than that of the lateral meniscectomy group (95.6±5.2 *vs.* 90.7±10.3; p<0.05).

There were no significant differences between younger patients and those over 40 years of age with regard to the mean Lysholm score (96.3±5.5 *vs.* 93.3±7.3; p=0.13) and the degree of patient satisfaction.

Analyses of the results according to the type and localization of meniscal tears showed no significant differences with respect to the Lysholm and Tegner activity scores. However, patients with posterior horn tears or longitudinal tears were more satisfied with their results.

TABLE I

Postoperative changes in Tegner activity levels[10]

	Activity level							
	1	2	3	4	5	6	7	8
Preoperative	26	16	5	2	0	0	0	0
Follow-up	6	10	23	5	3	1	1	0

The presence of a focal chondral defect was associated with a less favorable outcome. The mean Lysholm score of four knees with a full-thickness chondral defect was 85.0±11.8 compared to 95.3±5.6 of the knees without a defect. However, the degree of chondromalacia did not have a significant influence on the functional outcome, grade 1-2 and grade 3-4 chondral lesions were associated with similar mean Lysholm scores (94.8±18.5 *vs.* 93.5±5.7) and patient satisfaction.

Radiographically, 44 patients were evaluated, of which medial meniscectomy was performed in 34 patients. In this group, Fairbank changes were assessed in both knees. For the contralateral knees, 17 patients (50%) had no radiographic evidence for osteoarthritis at the last follow-up, while one patient showed grade 4 osteoarthritis. For the operated knees, 13 (38.2%) were classified as having a higher grade of osteoarthritis according to Fairbank changes. Twelve knees (35.3%) were found to be normal and four knees (11.8%) were classified as grade 4 (Table II). Radiographic deterioration was also detected in the operated knees in the lateral meniscectomy group. Two operated knees and seven contralateral knees showed no signs of osteoarthritis (Table II).

In the medial meniscectomy group, the medial joint space was measured as a mean of 4.5 mm (range 1 to 7 mm) in the operated knees and 4.9 mm (range 2 to 8 mm) in the contralateral knees (p<0.05). The lateral joint space in the operated knees was wider compared to the contralateral knees; however, this was not statistically significant (p>0.05).

The femorotibial anatomic alignment exhibited a mean valgus of 1.7° on the operated side, and 3.2° on the contralateral side, the difference being

TABLE II

Comparison of degenerative changes in the operated and contralateral knees in the medial and lateral meniscectomy groups according to the Fairbank criteria[11]

	Grade 0		Grade 1		Grade 2		Grade 3		Grade 4	
	n	%	n	%	n	%	n	%	n	%
Medial meniscectomy										
Operated knees (n=34)	12	35.3	11	32.4	4	11.8	4	11.8	3	8.8
Contralateral knees	17	50.0	9	26.5	5	14.7	2	5.9	1	2.9
Lateral meniscectomy										
Operated knees (n=10)	2	20.0	4	40.0	2	20.0	2	20.0	–	
Contralateral knees	7	70.0	1	10.0	2	20.0	–		–	

statistically significant ($p<0.05$; Table III). Eight operated knees (23.5%) had a varus alignment compared to four varus knees of the control side. In the lateral meniscectomy group, there were no significant differences between the two knees with respect to the medial and lateral joint spaces and anatomic alignment ($p>0.05$; Table III).

DISCUSSION

Although many previous studies on arthroscopic partial meniscectomies showed satisfactory early and mid-term results,[2,6,7,12-14] deterioration in the success rates was also reported during the further course of follow-up.[5] Radiographic changes, albeit less severe compared to open total meniscectomies, were also observed.[1]

The rates of good and excellent clinical outcomes after 10 years of follow-up were reported to be 62% to 88% in different series.[2,5,6] Several studies found no differences in the results with respect to age and gender.[2,6] Partial medial meniscectomy resulted in slightly better results than did partial lateral meniscectomy, but this difference was not significant.[2] Clinically, our patients showed higher Lysholm scores in the medial meniscectomy group compared to the lateral group; however, the two treatment groups did not differ significantly with respect to activity levels and patient satisfaction.

Many studies have demonstrated that accompanying cartilage lesions have a negative influence on the results of meniscal resection.[5,15,16] Bonanomo et al.[15] observed decreasing success rates in patients with higher grades of cartilage degeneration. Schimmer et al.[5] showed that patients with degenerative chondral changes did not achieve preinjury levels of activity, and that the effect of this degeneration became evident with increasing time after surgery. Other studies also emphasized the adverse effect of cartilage

TABLE III

Comparison of the femorotibial anatomic alignment and the size of medial and lateral joint spaces between the operated and contralateral knees

	Operated side (mean±SD)	Contralateral side (mean±SD)	*p*
Medial meniscectomy (n=34)			
Anatomic axis (° of valgus)	1.7±3.9	3.2±2.9	**0.033**
Medial joint space (mm)	4.5±1.5	4.9±1.4	**0.048**
Lateral joint space (mm)	5.6±1.4	5.4±1.4	0.121
Lateral meniscectomy (n=10)			
Anatomic axis (° of valgus)	4.0±2.2	2.7±2.7	0.151
Medial joint space (mm)	4.6±0.9	4.7±0.4	0.796
Lateral joint space (mm)	5.0±0.9	5.3±0.6	0.168

degeneration at the time of surgery on the outcome of partial meniscectomy.[13,17] Our early results showed no remarkable differences related to the effect of chondral degeneration, but a possible effect of chondral defects was observed on clinical outcomes.

Despite satisfactory functional outcomes, radiographic changes also occur in the course of follow-up. It is well-known that open total meniscectomy is associated with a high frequency of arthrosis,[11,18] and meniscus surgery has become more conservative, preserving as much functional meniscal tissue as possible. However, arthroscopic partial meniscectomy, which is a more benign procedure than open total meniscectomy, also affects radiographic features of the knee, especially following medial meniscectomies. Radiographic evaluations of our patients showed that there was narrowing of the medial joint space and a tendency to varus alignment in the medial meniscectomy group even five years after surgery.

Hulet et al.[4] reported that, following arthroscopic medial meniscectomy, narrowing of the medial joint space was found in 21% of the knees, which was in remarkable contrast with only 11% of the nonoperated knees. Andersson-Molina et al.[1] compared long-term results of arthroscopic partial and total meniscectomies and found narrowing of the medial joint space in 24% of the knees. They also noted that these radiographic changes had no influence on activity and little influence on knee function. We found significant narrowing of the medial joint space in the medial meniscectomy group compared to minimal changes in the lateral meniscectomy group. However, it should be noted that our follow-up period was a mean of 5.2 years (62.7 months; range 31 to 109 months). Burks et al.,[2] after a 15-year follow-up, reported 0.7 mm and 0.8 mm of narrowing in the medial and lateral joint spaces following medial and lateral meniscectomies, respectively.

In a rabbit model of total meniscectomy, Messner et al.[19] observed significant decreases in the size of the medial joint space. However, there was no correlation between this narrowing and histologic cartilage changes. They stated that removal of the medial meniscus led to a permanent narrowing without resulting in any cartilage changes. However, formation of marginal osteophytes and simultaneous cartilage changes noted 40 weeks after meniscectomy were interpreted as some degree of cartilage degeneration, which might result in a decrease in cartilage thickness with time.[19]

Limb malalignment was reported as an adverse result in several studies.[2,11,18,20,21] Fairbank[11] described varus alignment on radiographs following open meniscectomy. Similar findings were reported by Jones et al.[22] in patients older than 40 years. Burks et al.[2] noted a significantly increased degeneration in the varus knees compared with valgus knees, without any statistically significant difference between the mean Lysholm scores. On the other hand, McBride et al.[14] did not observe any relationship between medial meniscectomy and the varus of the knee. In our study, we found a significant increase in the varus of the knees following arthroscopic partial meniscectomy, but this did not affect early clinical results.

Any medial displacement occurring in the gravity center of the body results in an increased stress in the medial compartment, which is known to be a major factor of medial gonarthrosis.[18,23,24] Removing any meniscal tissue would inevitably lead to some degree of disruption in load transmission, shock absorption, and stability of the joint. It has been shown that 50% of the load in the medial compartment and more than 50% of the load in the lateral compartment are transmitted through the respective menisci.[25] Seedhom and Hargreaves[26] demonstrated that removing even as little as 30% of the meniscus increased joint surface contact forces by approximately 300%. Moreover, significant degeneration was demonstrated after removal of the meniscus resulting from significant decreases in the compressive, shear, and tensile properties of the articular cartilage.[27] These two factors, the lack of meniscal tissue and malalignment, lead to an abnormal loading to the cartilages of the medial femoral condyle and tibial plateau, triggering early degenerative changes in the medial compartment. Therefore, patients should be followed not only clinically, but also with regard to the lower limb axis for a possible high tibial osteotomy in the future. Our early results showed a tendency to valgus in the lateral meniscectomy group, although the difference was not statisti-

cally significant. Barret et al.[28] showed that clinical results were adversely affected in patients with a valgus alignment compared to those with a neutral alignment. Higuchi et al.,[6] detected signs of arthrosis in the valgus knees, but this was not statistically significant. Hoser et al.[12] analyzed the results of lateral meniscectomy after 10 years of follow-up and found that 39% of the knees exhibited narrowing of the lateral compartment joint space. This was found to be %55 by Jaureguito et al.[29] after a follow-up of eight years.

In conclusion, early clinical and radiographic results of arthroscopic partial meniscectomy are excellent and good. However, considering the fact that most of the patients were young, our findings of narrowing of the medial joint space and a tendency to varus alignment after five years of partial medial meniscectomy are somewhat suggestive of a possible high tibial osteotomy in the long-term follow-up of younger patients.

REFERENCES

1. Andersson-Molina H, Karlsson H, Rockborn P. Arthroscopic partial and total meniscectomy: A long-term follow-up study with matched controls. Arthroscopy 2002;18:183-9.
2. Burks RT, Metcalf MH, Metcalf RW. Fifteen-year follow-up of arthroscopic partial meniscectomy. Arthroscopy 1997;13:673-9.
3. Chatain F, Robinson AH, Adeleine P, Chambat P, Neyret P. The natural history of the knee following arthroscopic medial meniscectomy. Knee Surg Sports Traumatol Arthrosc 2001;9:15-8.
4. Hulet CH, Locker BG, Schiltz D, Texier A, Tallier E, Vielpeau CH. Arthroscopic medial meniscectomy on stable knees. J Bone Joint Surg [Br] 2001;83:29-32.
5. Schimmer RC, Brulhart KB, Duff C, Glinz W. Arthroscopic partial meniscectomy: a 12-year follow-up and two-step evaluation of the long-term course. Arthroscopy 1998;14:136-42.
6. Higuchi H, Kimura M, Shirakura K, Terauchi M, Takagishi K. Factors affecting long-term results after arthroscopic partial meniscectomy. Clin Orthop Relat Res 2000;(377):161-8.
7. Rockborn P, Gillquist J. Outcome of arthroscopic meniscectomy. A 13-year physical and radiographic follow-up of 43 patients under 23 years of age. Acta Orthop Scand 1995;66:113-7.
8. Outerbridge RE. The etiology of chondromalacia patellae. J Bone Joint Surg [Br] 1961;43:752-7.
9. Lysholm J, Gillquist J. Evaluation of knee ligament surgery results with special emphasis on use of a scoring scale. Am J Sports Med 1982;10:150-4.
10. Tegner Y, Lysholm J. Rating systems in the evaluation of knee ligament injuries. Clin Orthop Relat Res 1985;(198):43-9.
11. Fairbank TJ. Knee joint changes after meniscectomy. J Bone Joint Surg [Br] 1948;30:664-70.
12. Hoser C, Fink C, Brown C, Reichkendler M, Hackl W, Bartlett J. Long-term results of arthroscopic partial lateral meniscectomy in knees without associated damage. J Bone Joint Surg [Br] 2001;83:513-6.
13. Jackson RW, Rouse DW. The results of partial arthroscopic meniscectomy in patients over 40 years of age. J Bone Joint Surg [Br] 1982;64:481-5.
14. McBride GG, Constine RM, Hofmann AA, Carson RW. Arthroscopic partial medial meniscectomy in the older patient. J Bone Joint Surg [Am] 1984;66:547-51.
15. Bonamo JJ, Kessler KJ, Noah J. Arthroscopic meniscectomy in patients over the age of 40. Am J Sports Med 1992;20:422-9.
16. Matsusue Y, Thomson NL. Arthroscopic partial medial meniscectomy in patients over 40 years old: a 5- to 11-year follow-up study. Arthroscopy 1996;12:39-44.
17. Gillquist J, Oretorp N. Arthroscopic partial meniscectomy. Technique and long-term results. Clin Orthop Relat Res 1982;(167):29-33.
18. Allen PR, Denham RA, Swan AV. Late degenerative changes after meniscectomy. Factors affecting the knee after operation. J Bone Joint Surg [Br] 1984;66:666-71.
19. Messner K, Fahlgren A, Persliden J, Andersson BM. Radiographic joint space narrowing and histologic changes in a rabbit meniscectomy model of early knee osteoarthrosis. Am J Sports Med 2001;29:151-60.
20. Fauno P, Nielsen AB. Arthroscopic partial meniscectomy: a long-term follow-up. Arthroscopy 1992;8:345-9.
21. Maletius W, Messner K. The effect of partial meniscectomy on the long-term prognosis of knees with localized, severe chondral damage. A twelve- to fifteen-year followup. Am J Sports Med 1996;24:258-62.
22. Jones RE, Smith EC, Reisch JS. Effects of medial meniscectomy in patients older than forty years. J Bone Joint Surg [Am] 1978;60:783-6.
23. Maquet P. The treatment of choice in osteoarthritis of the knee. Clin Orthop Relat Res 1985;(192):108-12.
24. Odenbring S, Lindstrand A, Egund N, Larsson J, Heddson B. Prognosis for patients with medial gonarthrosis. A 16-year follow-up study of 189 knees. Clin Orthop Relat Res 1991;(266):152-5.
25. Walker PS, Erkman MJ. The role of the menisci in force transmission across the knee. Clin Orthop Relat Res 1975;(109):184-92.
26. Seedhom BB, Hargreaves DJ. Transmission of the load in the knee joint with special reference to the role of the menisci, Part II: experimental results, discussion, and conclusions. Eng Med 1979;8:220-8.

27. LeRoux MA, Arokoski J, Vail TP, Guilak F, Hyttinen MM, Kiviranta I, et al. Simultaneous changes in the mechanical properties, quantitative collagen organization, and proteoglycan concentration of articular cartilage following canine meniscectomy. J Orthop Res 2000;18:383-92.
28. Barrett GR, Treacy SH, Ruff CG. The effect of partial lateral meniscectomy in patients > or = 60 years. Orthopedics 1998;21:251-7.
29. Jaureguito JW, Elliot JS, Lietner T, Dixon LB, Reider B. The effects of arthroscopic partial lateral meniscectomy in an otherwise normal knee: a retrospective review of functional, clinical, and radiographic results. Arthroscopy 1995;11:29-36.