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ORIGINAL ARTICLE

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Spontaneous healing of acute anterior cruciate ligament (ACL) injuries – conservative treatment using an extension block soft brace without anterior stabilization

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Abstract To evaluate the spontaneous healing capability of acute anterior cruciate ligament (ACL) injuries, conservative treatment was applied in a selected group of 31 patients, who had low athletic demands. Each patient demonstrated a continuous ACL on magnetic resonance imaging (MRI), from the original femoral attachment through the tibial attachment, and an area of high intensity was detected in the substance of the ACL. The injured knees were treated using an extension block soft brace without anterior stabilization for 2–3 months. KT-2000 and MRI examinations were carried out regularly during the follow-up. Twenty-three knees (74%) were revealed to be stable in the follow-up examination, with an average of 16.1 months elapsing since the initial injuries. The KT-2000 side-to-side differences of 20 knees were less than 3 mm, and those of the other 3 knees were more than 3 mm but less than 5 mm. MRI confirmed that 21 injured ACL out of 23 knees maintained a femoral to tibial attachment and showed gradual reductions in image intensity. The positions of the other 2 injured ACL femoral attachments were different from the original femoral attachment: one was attached to the posterior cruciate ligament, and the other was located at the lateral femoral condyle anterior to the original femoral attachment. Eight knees (26%) subsequently required ACL reconstructions due to instability. This study indicates that an acutely injured ACL has healing capability. It also suggests that conservative management of the acute ACL injury can yield satisfactory results in a group of individuals who have low athletic demands and continuous ACL on MRI, provided the patients are willing to accept the slight risk of late ACL reconstruction and meniscal injury.

Keywords Spontaneous healing · Acute anterior cruciate ligament injuries · Conservative treatment

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Introduction

Primary healing of the anterior cruciate ligament (ACL) has been reported to be extremely poor in both clinical and experimental studies [2, 8, 13, 16]. These inferior results have led surgeons to reconstruct the ACL rather than attempt conservative treatment involving bracing and muscle-strengthening exercises after acute injury in an athletically active patient [15].

The healing capability of injured ACLs has been reported both experimentally and clinically. The healing capability of human ACL tissue has been demonstrated using tissue culture [5], electron microscopy [14] and the reverse transcription-polymerase chain reaction [11]. Kurosaka reported two clinical cases of spontaneous healing of a tear in the ACL [10]. Several studies of the conservative treatment and a natural history of acute ACL injury have reported that some injured knees had decreased anterior instability based on the results of the Lachman test and KT-1000 measurements [3, 4]. The authors speculated that this decrease was secondary to healing of the injured ACL or the secondary stabilizing structures. However, arthoscopic or magnetic resonance imaging (MRI) examination was not utilized in all patients to detect healing of the disrupted ACL.

The purpose of the present study was to use MRI to evaluate prospectively the spontaneous healing capability of ACL injuries treated with only an extension block soft brace for 2–3 months. We hypothesized that a damaged ACL could heal spontaneously in a selected group of patients who were not athletically active and who showed a continuous ACL on MRI, from the original femoral at-

tachment site through to the tibial attachment site (high intensity area was detected in the ACL, indicating injury).

Patients and methods

All patients included in this report were seen in our department between April 1993 and March 1997. The diagnosis of acute ACL injury was established by physical examination and MRI (T2-weighted and proton-density images). Neither arthroscopic examination nor an arthrogram was done to aid the diagnosis. Anterior translation was defined using the Lachman test and KT-2000 measurement (MEDmetric, San Diego,Calif.). All patients were seen within 4 weeks of the initial consultation and had no history of a substantial injury to either the affected knee or the contralateral knee. A minimum follow-up period of 6 months was required.

The clinical criteria for inclusion in this study were one or more of the following: a sedentary occupation and low athletic demand, with an injured ACL showing a continuous MR image from the original femoral attachment through the tibial attachment with an area of high intensity detected in the substance of ACL (Fig. 1). Patients who had contralateral knee ligament injuries were eliminated.

The possibility of ACL healing with conservative treatment or delayed ACL reconstruction in the case of treatment failure was initially explained by the senior author (YS). All patients accepted our explanation and chose conservative treatment.

The present study consisted of 31 patients who met the criteria for inclusion. All of these patients were available for regular follow-up. Objective laxity measurements (KT-2000 arthrometer, MEDmetric) and MR images (T2-weighted and proton-density) were obtained during the follow-up (3, 6, 12, 24, and 36 months after the injury).

The average age at the time of injury was 33 years (range 15–56 years). Ten patients were men and 21 were women. All patients were athletically active before the injury, and 25 (81%) injured the knee during a sports activity. No meniscal injury requiring treatment was detected in association with the ACL tears by either physical examination or MRI.

Rehabilitation protocol

During the acute phase, patients were allowed early range of motion and quadriceps muscle strengthening exercises with a brace that had a 20-deg initial range of motion restriction (Fig. 2). The soft brace used had a single hinge without an anterior strap and is the brace traditionally used for patients after ACL reconstruction (Nakamura brace, Shimane, Japan). Weight-bearing was also allowed, as tolerated, with crutches initially. Full weight-bearing without the use of crutches was generally achieved within 4 weeks after the trauma. At 3 months after trauma, patients were evaluated by the authors and examined by KT-2000 measurements and MRI, and were allowed to take off the brace. Jogging was started 5 months after surgery.

Fig. 1 Magnetic resonance imaging (MRI), taken the 3rd day after injury, shows a continuous ACL from the original femoral attachment through the tibial attachment and high intensity in the substance of ACL

Fig. 2 This soft brace, which was applied for 2–3 months after the injury, had a 20-deg extension block without any prevention of anterior tibial displacement

Assessment of stability

The KT-2000 arthrometric laxity measurements were used to evaluate the objective and quantitative stability of the injured knee. The difference in the KT-2000 displacement values between the injured and the normal knee (side-to-side difference), with the knee in 30 deg of flexion at an anterior load of 134 N, was recorded and calculated by one author (EF).

Results

Successful conservative treatment cases

A total of 23 patients out of 31 regained stable knees, and the average follow-up period of these 23 patients was 16.1 months (range 6–36 months). The average age of these 23 patients was 33.5 years (range 15–56 years). All of these patients were involved in sedentary occupations and were able to return to work without difficulty. Twenty-one patients did not complain of pain in the affected knee nor episodes of giving way. Two patients had pain only upon athletic activities. No swelling or locking episodes were experienced.

At the time of the initial office presentation, 11 knees had a soft Lachman test and 12 knees had an end-point. At

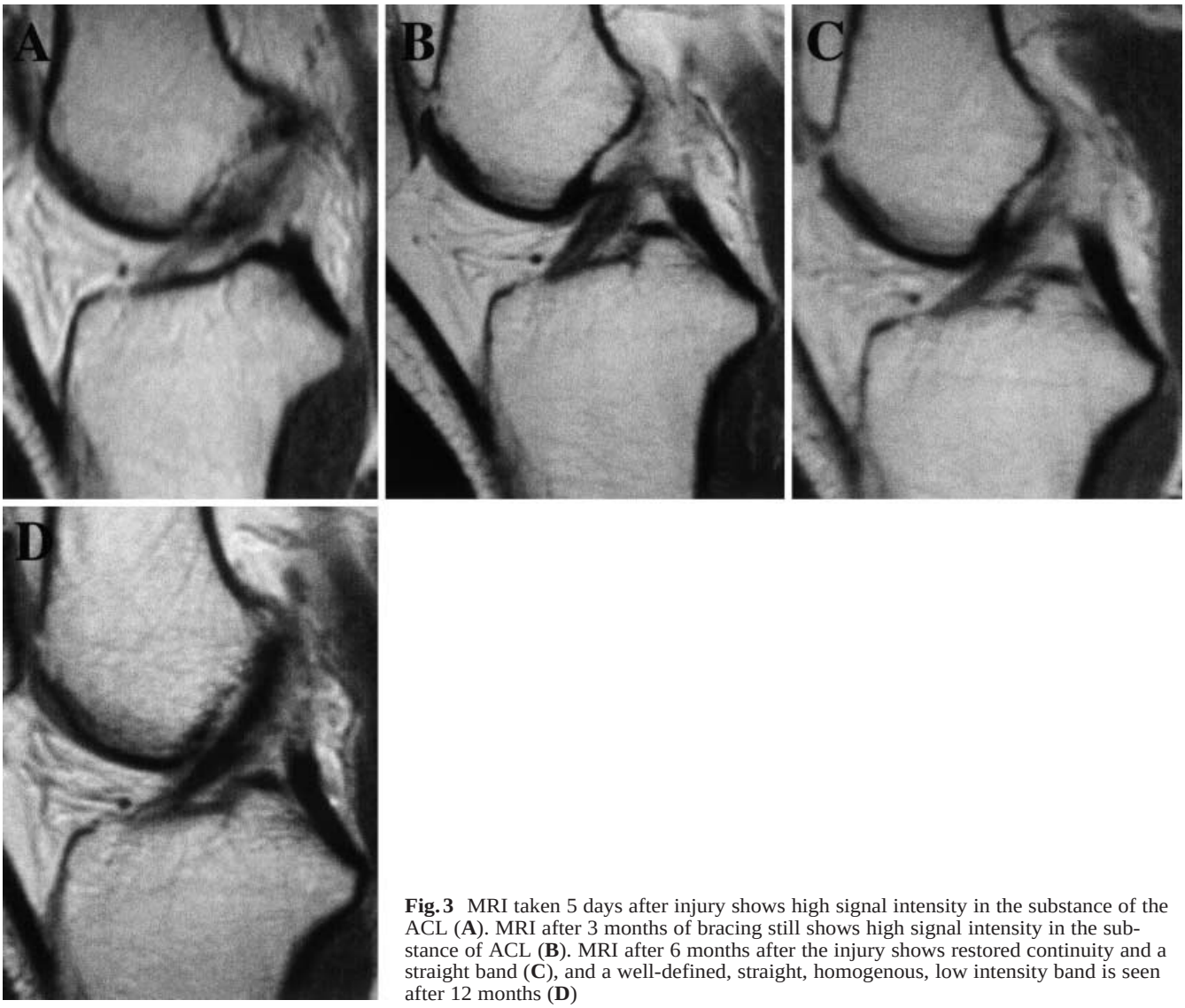

Fig. 3 MRI taken 5 days after injury shows high signal intensity in the substance of the ACL (**A**). MRI after 3 months of bracing still shows high signal intensity in the substance of ACL (**B**). MRI after 6 months after the injury shows restored continuity and a straight band (**C**), and a well-defined, straight, homogenous, low intensity band is seen after 12 months (**D**)

3 months after the trauma, all 23 knees regained an end-point. At the follow-up, 14 knees had an end-point like that of the contralateral knee, while 9 knees had an end-point with a displacement which was greater than that of the contralateral knee manually. A pivot shift test was also carried out, and 16 knees were classified as negative, while 7 knees showed gliding.

The KT-2000 arthrometric measurements at the time of the initial injury were not obtained for most patients because the equipment was not available during the initial painful phase after the injury. Follow-up KT-2000 arthrometric data were obtained for all 23 patients. The average side-to-side difference was 0.4 mm. The side-to-side differences of 20 knees were less than 3 mm, and those of the other 3 knees were more than 3 mm but less than 5 mm.

MRI revealed that 21 injured ACL out of 23 knees maintained a femoral to tibial attachment with a gradual reduction in MRI intensity (Fig. 3). On the other hand, the positions of the other 2 injured ACL femoral attachments were different from the original femoral attachment. One was attached to the posterior cruciate ligament and the other was attached at the lateral femoral condyle, anterior to the original femoral attachment.

Surgical reconstruction

Eight patients (26%) underwent a surgical ACL reconstruction in the follow-up period. All of the knees were reconstructed due to episodes of instability with daily or sport activities. The average age of these patients was 32.7 years (range 17–44 years). None of these patients regained an end-point on the Lachman test from the time of the initial injury to the time of the operation. Their MRI at the time of follow-up revealed the initially continuous injured ACL to have become unclear or to have disappeared (Fig. 4). None of the injured ACLs showed reductions in intensity on MRI after conservative treatment.

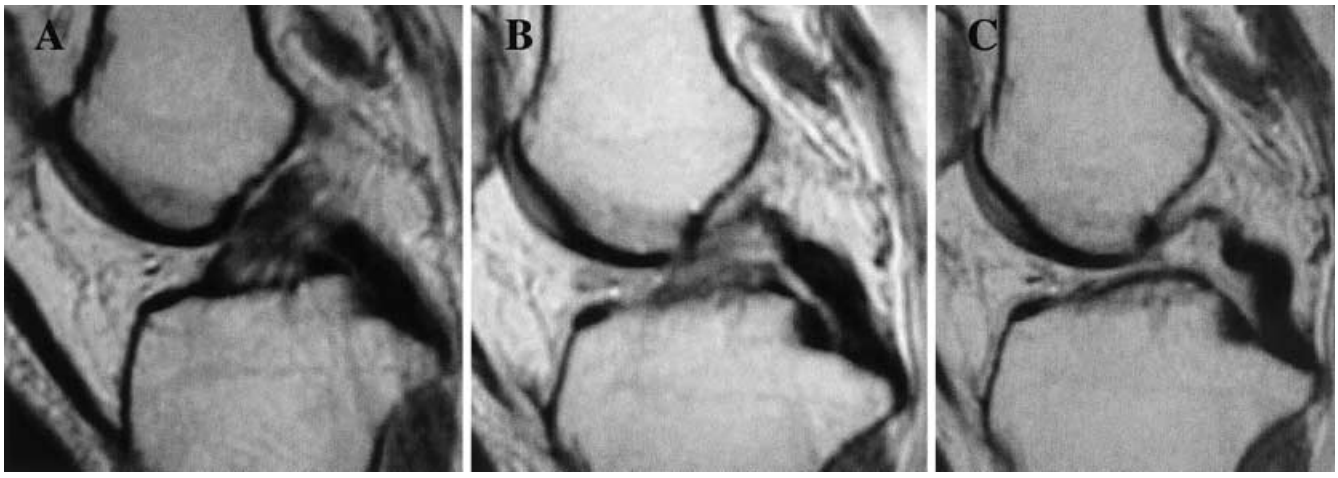

Fig. 4 MRI taken 26 days after injury shows high signal intensity in the substance of the ACL (**A**). After 3 months of bracing, the injured ACL became unclear (**B**). The injured ACL has disappeared, and a sigmoid PCL is seen at 12 months after the injury (**C**)

Discussion

Some papers have reported that conservative treatment can yield improvements in anterior stability. Buss et al. reported successful results after conservative treatment of acute injuries of the ACL using mainly the Lenox Hill braces in a group of patients who are older and relatively inactive [3]. At an average of 46 months after injury, 11 (20%) of 55 knees had a decrease of at least one grade on the Lachman test, and 7 knees (13%) had a difference of less than 3 mm between the injured and the normal knee. Daniel et al. reported in a prospective outcome study of acute traumatic hemarthrosis that patients who had instability immediately after the injury and did not undergo surgical treatment had a slight decrease in displacement of the joint over time [4]. They speculated that this decrease was secondary to healing of the disrupted ACL or the secondary stabilizing structures, or both. In these studies neither arthoscopic nor MRI examination was carried out, although MRI is a useful and non-invasive method of evaluating the condition of the ACL [12, 17].

To our knowledge, this prospective study reports the first serial MR images and KT-2000 evaluation of acute ACL injuries treated conservatively. Twenty-one ligaments of 23 successfully conservatively treated patients showed gradual reductions in intensity on MRI proton-density images at 3 and 6 months after treatment. The injured ligaments of 8 patients, followed-up for more than 2 years in the successful conservative treatment group, presented as a low signal intensity band on proton-density images extending from the femoral attachment site through the tibial attachment site. These results suggest that the injured ACL has healing potential, as supported by both physical examination and KT-2000 data.

This study also included 8 patients (26%) who underwent surgical reconstruction, resulting in anterior instability. None of these patients regained an end-point on the Lachman test from the time of the initial injury to the time of operation. None of their injured ACLs showed reductions in intensity on MRI at 3 months after conservative treatment. On the other hand, all of the 23 successfully conservatively treated patients regained an end-point and showed reductions in intensity on MRI at 3 months. These results indicate that both an end-point on the Lachman test and reduced intensity on MRI at 3 months after injury are decisive in the management of conservative treatment of acute ACL injury. This study also suggests that 3 months of conservative management of acute ACL injury can be applied in a group of individuals who have low athletic demand and a continuous ACL on MRI, if they are willing to accept the potential risk of delayed ACL reconstruction and meniscal injury.

Several authors have reported that the success rate of conservative treatment for athletic individuals is poor compared with surgical reconstruction [6, 7]. Recently, Ihara et al. reported that acute ACL injury can be treated successfully using his specially designed brace (Kyuro knee brace), even in athletic patients [9]. We do not recommend conservative treatment for every patient with acute tearing ACL showing a continuous ACL on MRI from the original femoral attachment through the tibial attachment, with a high intensity area detected in the substance of the ACL. We remain convinced that reconstruction or augmentation is necessary for athletic patients [1].

In conclusion, our study suggests that the ACL has healing potential and may heal under some conditions. This study also suggested that conservative management of acute ACL injury can be applied in a group of individuals who have low athletic demand and a continuous ACL on MRI.

References

1. Adachi N, Ochi M, Uchio Y, Sumen Y (2000) Anterior cruciate ligament augmentation under arthroscopy. A minimum 2-year follow-up in 40 patients. Arch Orthop Trauma Surg 120: 128–133
2. Andersson C, Odensten M, Good L, Gillquist J (1989) Surgical or non-surgical treatment of acute rupture of the anterior cruciate ligament. A randomized study with long-term follow-up. J Bone Joint Surg Am 71: 965–974

3. Buss DD, Min R, Skyhar M, Galinat B, Warren RF, Wickiewicz TL (1995) Nonoperative treatment of acute anterior cruciate ligament injuries in a selected group of patients. Am J Sports Med 23: 160–165
4. Daniel DM, Stone ML, Dobson BE, Fithian DC, Rossman DJ, Kaufman KR (1994) Fate of the ACL-injured patient. A prospective outcome study [see comments]. Am J Sports Med 22: 632–644
5. Deie M, Ochi M, Ikuta Y (1995) High intrinsic healing potential of human anterior cruciate ligament. Organ culture experiments. Acta Orthop Scand 66: 28–32
6. Fetto JF, Marshall JL (1980) The natural history and diagnosis of anterior cruciate ligament insufficiency. Clin Orthop 147: 29–38
7. Hawkins RJ, Misamore GW, Merritt TR (1986) Followup of the acute nonoperated isolated anterior cruciate ligament tear. Am J Sports Med 14: 205–210
8. Hefti FL, Kress A, Fasel J, Morscher EW (1991) Healing of the transected anterior cruciate ligament in the rabbit. J Bone Joint Surg Am 73: 373–383
9. Ihara H, Miwa M, Deya K, Torisu K (1996) MRI of anterior cruciate ligament healing. J Comput Assist Tomogr 20: 317–321
10. Kurosaka M, Yoshiya S, Mizuno T, Mizuno K (1998) Spontaneous healing of a tear of the anterior cruciate ligament. A report of two cases. J Bone Joint Surg Am 80: 1200–1203
11. Lo IK, Marchuk LL, Hart DA, Frank CB (1998) Comparison of mRNA levels for matrix molecules in normal and disrupted human anterior cruciate ligaments using reverse transcription-polymerase chain reaction. J Orthop Res 16: 421–428
12. Murakami Y, Sumen Y, Ochi M, Fujimoto E, Adachi N, Ikuta Y (1998) MR evaluation of human anterior cruciate ligament autograft on oblique axial imaging. J Comput Assist Tomogr 22: 270–275
13. Nagineni CN, Amiel D, Green MH, Berchuck M, Akeson WH (1992) Characterization of the intrinsic properties of the anterior cruciate and medial collateral ligament cells: an in vitro cell culture study. J Orthop Res 10: 465–475
14. Neurath MF, Printz H, Stofft E (1994) Cellular ultrastructure of the ruptured anterior cruciate ligament. A transmission electron microscopic and immunohistochemical study in 55 cases. Acta Orthop Scand 65: 71–76
15. Noyes FR, Matthews DS, Mooar PA, Grood ES (1983) The symptomatic anterior cruciate-deficient knee. Part II: the results of rehabilitation, activity modification, and counseling on functional disability. J Bone Joint Surg Am 65: 163–174
16. Noyes FR, Mooar PA, Matthews DS, Butler DL (1983) The symptomatic anterior cruciate-deficient knee. Part I: the long-term functional disability in athletically active individuals. J Bone Joint Surg Am 65: 154–162
17. Sumen Y, Ochi M, Adachi N, Urabe Y, Ikuta Y (1999) Anterior laxity and MR signals of the knee after exercise. A comparison of 9 normal knees and 6 anterior cruciate ligament reconstructed knees. Acta Orthop Scand 70: 256–260