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The Effect of Knee Bracing After Anterior Cruciate Ligament Reconstruction

A Prospective, Randomized Study with Two Years' Follow-up

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ABSTRACT

The purpose of this prospective, randomized, clinical trial was to evaluate the effect of knee bracing after anterior cruciate ligament reconstruction. Sixty patients were randomized into one of two groups: Patients in the braced group wore rehabilitative braces for 2 weeks, followed by functional braces for 10 weeks, and patients in the nonbraced group did not wear braces. Data were recorded preoperatively, and postoperatively after 6 weeks, 3 and 6 months, and 1 and 2 years. The following outcome measures were used: KT-1000 arthrometry, the Cincinnati knee score, goniometry to record range of motion, computed tomography to determine thigh atrophy, Cybex 6000 isokinetic testing to evaluate muscle strength, three functional knee tests, and a visual analog scale to evaluate pain. At all follow-up times there were no significant differences between the two groups with regard to knee joint laxity, range of motion, muscle strength, functional knee tests, or pain. However, the Cincinnati knee score showed that patients in the braced group had significantly improved knee function compared with patients in the nonbraced group at the 3-month follow-up, even though the braced group showed significantly increased thigh atrophy compared with the nonbraced group at 3 months.

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Knee braces have been included in the rehabilitation program after ACL reconstruction for many years.[22,30,43] These braces have been designed to allow protected motion and prevent excessive loading on an injured ACL or healing ACL graft.[6]

Several biomechanical studies have evaluated the effect of different types of braces.[2,11,15,49,50] Many of these studies used cadaveric models and concluded that some of the braces are effective in reducing anterior tibial displacement under low loading conditions, but provide little or no resistance to anterior tibial translation under loading conditions equivalent to those associated with normal activities.

Functional analyses have provided data about the effect of braces during performance testing.[1,9,10,18] Some investigations of subjects with ACL-deficient knees have demonstrated that the application of knee braces increases performance in those with functional disabilities, whereas asymptomatic subjects are not affected by bracing.[1,10,18] Many review articles on rehabilitative and functional braces have supported the view that bracing should be used during rehabilitation,[13,14,24,32] but these reports also indicate that further scientific studies are required because of the inconsistency in the literature.[28]

Previous studies of bracing have reported improvement as subjectively rated by the patients.[17,31] Colville et al.[17] reported that of those subjects who used braces, more than 90% believed that the braces were beneficial and reduced the frequency and severity of giving-way episodes. Decoster et al.[21] reported that while most physicians prescribe braces after ACL surgery, 36% of the physicians they surveyed had recently changed their brace prescription practices, including using braces less often.

The aims of this study were to determine whether knee bracing after ACL reconstruction alters knee joint laxity, influences lower limb function (as measured by the Cincinnati knee score, range of motion, muscle strength, functional knee tests, patient perception of knee function, and pain), affects the cross-sectional area of the thigh, and reduces the incidence of further intraarticular injury (that is, meniscus and cartilage lesions).

MATERIALS AND METHODS

Subjects were included if they were between 15 and 50 years of age, had an ACL injury (either isolated or combined with meniscus or medial collateral ligament injuries), and were candidates for a bone-patellar tendon-bone ACL reconstruction. Subjects were excluded if they were skeletally immature, if they had a fracture or other major injuries to the lower extremity less than 1 year before surgery, if they had an ACL or PCL injury to the contralateral leg, if they did not speak Norwegian, or if they had substance abuse problems. Each subject gave his or her written consent before participation.

Knee joint laxity was used as the primary outcome measure to determine the number of patients required in each group. The study was planned to detect a difference in knee joint laxity of 3 mm between the two groups.[3] The standard deviation for the KT-1000 arthrometry performed on patients with ACL reconstructions was set to 3 mm. With alpha set to 0.05 (type I error) and beta to 0.10 (type II error), a power analysis demonstrated that a minimum of 22 patients was required in each group to complete the trial. Therefore, 60 patients were enrolled with 30 randomized to each group to account for possible dropouts.

The sixty patients included in this study had a mean age of 28 years (range, 15 to 47). There were 28 women (47%) and 32 men (53%). The mean time from injury to operation was 31 months (range, 0 to 263). Forty-three patients (72%) had chronic ACL injuries (more than 6 months from the time of injury to surgery), and 17 of the patients (28%) had acute ACL injuries (less than 6 months from injury to surgery). Fifty-five (92%) of the injuries were sports related (20 soccer [36%], 14 handball [25%], 9 alpine skiing [16%], and 12 other sports [22%]). Twenty-six (44%) of the injuries were isolated ACL ruptures. Among the 34 patients (56%) with combined injuries, 28 patients (82%) had meniscus injuries, and 6 patients (18%) had collateral ligament injuries that did not require repair. Of those patients with meniscus injuries, 8 (29%) had partial tears that did not require resection, 18 (64%) had partial tears that required resection, and 2 (7%) underwent meniscus repair.

The patients were block randomized (using blocks of 6) into 2 groups with 30 subjects in each group. The brace group (group B) used the DonJoy rehabilitative range of motion brace (DonJoy, Smith & Nephew, Carlsbad, California) the first 2 weeks after surgery and were instructed to wear the DonJoy Gold Point functional knee brace (DonJoy, Smith & Nephew) for the next 10 weeks (total brace time, 3 months) and then as needed for sports activities thereafter. The nonbraced group (group NB) did not use any brace or external support from the time of operation through the duration of the study (2 years). All patients returned to the clinic 2 weeks after surgery for routine follow-up and instructions regarding the study. At this time, patients in the brace group were given their functional knee braces. Data were recorded preoperatively (0 to 2 days before surgery) and postoperatively at 6 weeks, 3 and 6 months, and 1 and 2 years. The patients were clinically evaluated by the same orthopaedic surgeon (AE) and the same physical therapist (MAR) at all follow-up times (using KT-1000 arthrometry, the Cincinnati knee score, range of motion, the Tegner activity level, and the functional knee tests). Isokinetic muscle strength testing was performed by one physical therapist (IH), and the CT measurements were recorded by one radiologist (JE). The same examiner recorded the same measurements at all follow-up times to prevent interobserver variability of the measurements. This study was a single-blinded study.

Rehabilitation and Bracing

All patients used a continuous passive motion device (Kinetec, Smith & Nephew) immediately after surgery until the time of discharge from the hospital. Isometric and passive extension exercises were started the first postoperative day. Immediately after discharge from the hospital, all subjects followed the same rehabilitation program based on closed kinetic chain principles.[37] Partial weightbearing (20 kg) was allowed during the first 4 weeks, with progression to full weightbearing between 4 and 6 weeks after surgery. All the patients started at an outpatient clinic with a rehabilitation program no later than 2 weeks after surgery. The first part of the rehabilitation program included bicycling, and exercises with partial weightbearing, full range of motion, and swelling reduction were emphasized. After 4 to 6 weeks the program consisted of exercises with full weightbearing, functional activities, muscle strength training, and proprioceptive training. After 9 to 12 weeks the program emphasized progressive muscle strength training, proprioceptive training, and running. All the exercises were performed according to the patient's individual symptoms and tolerance. The patients were not encouraged to return to active, competitive sports before 8 to 12 months after surgery.

For the first 6 weeks after surgery the brace was set to range between 0° and 90° of knee flexion. After 6 weeks the brace was adjusted to allow full range of motion. Group B patients were asked to use the brace continuously (24 hours per day) for 8 weeks, followed by 4 weeks of brace use during waking hours. After 3 months the patients in group B were instructed to use the brace during strenuous activities, but otherwise to discontinue its use. Brace compliance in group B was documented through the use of a questionnaire. This allowed us to document the amount of time during which the brace was worn, as well as any problems with the brace and the

TABLE 1
Results of KT-1000 Arthrometry, the Cincinnati Knee Score, the Knee Extension Deficit Test, and the Knee Flexion Test (Mean [SD]) for the Two Groups Preoperatively and at all Follow-up Times[a]

Test	Preoperatively		6 weeks		3 months	
	B	NB	B	NB	B	NB
KT-1000 (mm difference)	6.2 (4.2)	6.6 (5.3)	—	—	0.9 (3.5)	1.1 (3.7)
Cincinnati score (maximum score 100)	59.62 (24.0)	62.2 (17.5)	—	—	69.1[b] (12.4)	62.7 (14.6)
Extension-deficit (degrees)	2.2 (7.7)	1.1 (3.0)	5.4 (4.8)	4.8 (4.4)	3.4 (4.1)	3.2 (4.4)
Flexion (degrees)	130.4 (20.6)	128.8 (23.2)	112.1 (18.0)	112.8 (15.1)	125.5 (17.6)	127.0 (9.7)

[a] B, braced; NB, nonbraced.
[b] Significant difference between the braced and the nonbraced group ($P < 0.05$).

usefulness of the brace. The patients in group NB were asked if they used bracing or other supports postoperatively.

Follow-up Evaluation

Knee joint laxity (anterior displacement of the tibia relative to the femur) was recorded with the KT-1000 arthrometer (MEDmetric, San Diego, California) at 89 N, 134 N, and the manual maximum force.[51] The tests were performed with the patient in a supine position with a standard bar beneath the thighs, representing 20° to 30° of knee flexion. A 7-cm wide VELCRO strap (VELCRO USA, Inc., Manchester, New Hampshire) was wrapped around the patient's thigh to ensure that the patella faced anteriorly, to minimize external rotation of the hip, and to maintain both legs in a resting position. The difference in displacements between the injured and uninjured knee was recorded for all three load magnitudes preoperatively and at each postoperative follow-up, except for at 6 weeks.

Knee function was evaluated with the Cincinnati knee score[36] preoperatively and at each follow-up time, except for the 6-week follow-up. The questionnaire included the following main variables: pain, swelling, giving way, general activity level, walking, stair climbing, and running, jumping, and twisting activities. The maximum score was 100 points. A goniometer was used to record range of motion preoperatively and at each postoperative follow-up.

Computed tomography (Hi-Speed, General Electric, Milwaukee, Wisconsin) was used to evaluate the cross-sectional area of the thigh before surgery and at 3 and 6 months after surgery. Two different CT scans were recorded for each leg: halfway between the greater trochanter and knee joint line (scan 1), and halfway between this point and the knee joint line (scan 2). The preoperative CT scan locations were registered, and the same positions were measured at the 3- and 6-month follow-up times. Three different areas were measured: the quadriceps muscle, the hamstring muscle, and the whole thigh. The cross-sectional area of the injured leg was expressed as a percentage of that of the uninjured leg.

Muscle strength was measured with the Cybex 6000 isokinetic test machine (Cybex, Division of Lumex, Inc., Ronkonkoma, New York) at 6 months and 1 and 2 years after surgery. Before testing, the patients performed aerobic ergometer cycling for 8 minutes. The test protocol consisted of 5 repetitions at an angular velocity of 60 deg/s, followed by a 1-minute rest period, and then 30 repetitions at 240 deg/s. Cybex data were analyzed to determine the extension total work at 60 deg/s, the extension total work at 240 deg/s, the flexion total work at 60 deg/s, and the flexion total work at 240 deg/s. Three functional knee tests (the stairs hopple, the triple jump, and the single-legged hop test) were used to evaluate lower limb function at 6 months and 1 and 2 years after surgery.[4,19,25,35,42]

The Tegner activity score was used to record the activity level of the patients before injury, preoperatively, and postoperatively after 2 years.[48] A visual analog scale was used at each follow-up time to record pain at rest, pain during activity, and patient satisfaction.[40]

Arthroscopic examination at the time of ACL reconstruction was used to establish baseline data with regard to meniscus injuries (medial meniscus injury, lateral meniscus injury, and type of meniscus surgery, if required) and to evaluate the status of the cartilage in the medial and lateral aspects of the tibiofemoral joint. Cartilage was categorized as being either degeneration-absent or degeneration-present in the following areas: 1) the medial tibial plateau, 2) the lateral tibial plateau, 3) the medial femoral condyle, and 4) the lateral femoral condyle. The location of the cartilage degeneration was recorded, but not the severity of the cartilage lesions. At the 2-year follow-up, MRI was used to determine intraarticular injury of the meniscus and cartilage degeneration in the tibiofemoral joint. The MRI was performed with a Vectra 0.5 T scanner (General Electric). Total imaging time was approximately 25 minutes. The patient was positioned supine with the knee at 15° to 20° of flexion and in 0° to 15° of external rotation. A standard knee coil was placed under the affected knee. The MRI protocol included a sequence of sagittal T1-weighted images, a sagittal proton density image, a sequence of sagittal T2-weighted images, and a sequence of T1- and T2-weighted fast spin echo images in the coronal plane. An increase in cartilage degeneration was defined as a new area of degenerative changes other than that observed at the time of the arthroscopic examination. The MRI results were categorized in a manner similar to that described for the arthroscopic examination.

TABLE 1
Continued

6 months		1 year		2 years	
B	NB	B	NB	B	NB
1.3 (4.0)	0.7 (4.9)	2.0 (3.5)	1.2 (4.2)	2.1 (3.7)	2.5 (4.0)
78.5 (11.3)	72.4 (15.1)	82.4 (15.3)	78.4 (14.3)	85.7 (12.3)	87.4 (12.8)
1.7 (3.4)	2.0 (3.3)	0.7 (2.0)	1.2 (2.6)	0.2 (1.6)	0.1 (0.5)
132.4 (10.5)	133.3 (7.6)	135.2 (6.3)	135.6 (5.9)	135.9 (5.4)	136.3 (4.1)

Statistical Analysis

Analysis of variance for repeated measurements with the Tukey multiple-comparison test was used to calculate differences between each follow-up time and between each group. Analysis of covariance was used to adjust for any initial differences between the groups with respect to the following covariates: age, sex, activity level, and acute or chronic ACL injury.

The chi-square test was used to calculate significant differences between the number of patients in each category based on the arthroscopic examination, intraoperative findings, and the MRI data 2 years after surgery.

Statistical significance was set at $P < 0.05$. All statistical analyses were performed with the SAS (Statistical Analysis System) program (SAS Institute, Inc., Cary, North Carolina) and the NCSS (Number Cruncher Statistical System) program (NCSS, Kaysville, Utah).

RESULTS

Fifty-six patients (93%) returned for follow-up evaluation and completed the outcome measures. Preoperatively, there were no significant differences between the two groups with respect to sex, age, time from injury to operation, instability, activity level, range of motion, or any of the other variables recorded (Tables 1 and 2).

At the time of surgery, we observed that there was significant difference between the groups with regard to prevalence of meniscus injury ($P = 0.03$). In group B, 10 of the patients (33%) had meniscus injuries, and in group NB, 18 of the patients (60%) had meniscus injuries. One patient in each group underwent meniscus repair, and the remaining meniscus injuries were partial tears. There was no significant differences between the groups with respect to cartilage lesions about the tibiofemoral joint. Three of the patients in group B (10%) had cartilage degeneration in the tibiofemoral joint, and six of the patients in group NB (20%) had cartilage degeneration.

Compliance with Bracing

None of the patients in group NB used a brace or other support. All patients in group B used the brace postoperatively, but one patient was excluded because of an incomplete brace compliance questionnaire. In group B, 22 patients (76%) used the brace as recommended the first 3 months. Four patients (14%) used the brace continuously during the first 2 months and periodically the 3rd month, one patient (3%) used the brace during the first 2 months, and two patients (7%) wore the brace for 1 month and periodically throughout the 2nd month. These seven patients (24%) did not comply with the recommended 3 months of bracing because of problems with eczema and discomfort associated with using the brace. Eleven patients (38%) stopped using the brace after the recommended 3-month period, and of the remaining 18 patients (62%) who continued to use the brace during sports activities, 6 patients (33%) used it up to 6 months after surgery and 5 (28%) used it for a year or more after surgery.

Outcome Measures

There were no significant differences between the groups with regard to knee laxity at each follow-up time (Table 1). There was a significant improvement in knee function (Cincinnati knee score) for group B, compared with group NB at 3 months after surgery. There were, however, no differences at the other follow-up times (Table 1). Similarly, there were no differences in the range of motion measurements between the two groups at each follow-up time (Table 1).

The cross-sectional area of the whole thigh, recorded in scan 1, decreased significantly in patients in group B compared with those in group NB 3 months after surgery (Table 2). The cross-sectional area of the quadriceps and the area of the whole thigh increased significantly in patients in group B from 3 to 6 months after surgery, and by 6 months after surgery there were no differences in cross-sectional areas for each muscle group.

There were no significant differences between the braced and nonbraced groups with regard to the isokinetic strength measurements at each follow-up time (Table 3). The hamstring and the quadriceps muscle strength at 60 deg/s in both flexion and extension increased significantly from 6 months to 1 year after surgery for both groups. Analysis of each group separately revealed a significant increase in quadriceps muscle strength at 60 deg/s in extension from 1 to 2 years for group NB, but not for group B. Patients who used the brace between 1 and 2 years after surgery showed significantly lower quadriceps muscle strength at 60 deg/s in extension than those who used the brace for 3 to 8 months ($P = 0.03$).

The functional knee tests revealed no significant differences between the braced and the nonbraced groups at any of the follow-up times (Table 4). There was a significant improvement for all patients from 6 months to 1 year after surgery for the stairs hopple test ($P < 0.001$), the

TABLE 2
The Cross-Sectional Area of the Thigh Muscles (Mean [SD]) Registered by CT: The Injured Leg in Percent of the Contralateral Leg for the Two Groups Preoperatively and at Follow-up[a]

Muscle	Preoperatively		Postoperatively			
			3 months		6 months	
	B	NB	B	NB	B	NB
Quadriceps	91.8 (9.9)	90.9 (8.7)	76.3 (9.5)	76.7 (6.6)	80.9[b] (10.4)	79.3 (6.5)
Hamstring	100.0 (10.2)	98.6 (11.8)	98.6 (19.8)	98.9 (8.7)	100.9 (12.5)	99.3 (9.5)
The whole thigh	97.4 (5.2)	96.7 (4.4)	90.3 (5.3)	94.9[c] (5.3)	94.2[d] (4.5)	94.5 (4.0)

[a] B, braced; NB, nonbraced.
[b] Significant difference between 3 and 6 months after surgery for the braced group ($P = 0.03$).
[c] Significant difference between the braced and the nonbraced group ($P < 0.0001$).
[d] Significant difference between 3 and 6 months after surgery for the braced group ($P = 0.009$).

TABLE 3
Muscle Strength Measurements (Mean [SD]): The Injured Leg in Percent of the Contralateral Leg for the Two Groups at Follow-up[a]

Test	6 months		1 year		2 years	
	B	NB	B	NB	B	NB
Extension total work (60 deg/s)	69.0 (15.9)	65.5 (17.0)	84.2 (12.4)	80.5 (13.2)	89.4 (9.5)	92.7 (11.1)
Extension total work (240 deg/s)	79.3 (17.5)	72.2 (14.7)	82.7 (17.8)	80.4 (10.8)	88.9 (13.8)	87.0 (11.0)
Flexion total work (60 deg/s)	89.5 (14.7)	84.8 (23.2)	99.3 (9.9)	96.4 (13.7)	96.8 (12.0)	99.9 (16.3)
Flexion total work (240 deg/s)	92.3 (24.3)	93.2 (23.5)	100.5 (16.3)	93.0 (18.3)	97.4 (11.2)	95.2 (13.2)

[a] B, braced; NB, nonbraced.

TABLE 4
Results of the Functional Knee Tests (Mean [SD]): The Injured Leg in Percent of the Contralateral Leg for the Two Groups at Follow-up[a]

Test	6 months		1 year		2 years	
	B	NB	B	NB	B	NB
Stairs hopple	80.4 (18.1)	78.4 (14.7)	90.7 (16.5)	90.1 (16.4)	94.1 (12.7)	92.3 (11.3)
Triple jump	94.5 (6.2)	91.5 (8.6)	95.7 (4.1)	96.2 (5.4)	97.5 (4.4)	97.1 (5.1)
Single-legged hop	86.1 (10.8)	83.8 (10.5)	90.6 (8.8)	91.6 (5.4)	94.8 (9.4)	94.6 (7.2)

[a] B, braced; NB, nonbraced.

TABLE 5
Pain and Patient Satisfaction Recorded in Millimeters on a 100-mm Visual Analog Scale (Mean [SD]) for the Two Groups at all Follow-up Times[a]

Visual analog scales	6 weeks		3 months		6 months		1 year		2 years	
	B	NB	B	NB	B	NB	B	NB	B	NB
Pain at rest	3.9 (6.5)	7.6 (11.1)	3.6 (8.0)	10.6 (19.5)	8.8 (22.2)	16.5 (30.5)	3.7 (6.1)	6.7 (13.6)	4.5 (12.7)	3.8 (7.8)
Pain during activities	21.1 (18.5)	26.8 (24.9)	27.1 (27.8)	32.1 (27.8)	29.2 (29.9)	31.6 (32.1)	20.5 (23.6)	31.6 (28.3)	18.0 (22.8)	22.0 (27.7)
Patient satisfaction	77.6 (24.5)	82.4 (22.1)	79.1 (23.4)	74.5 (27.5)	72.9 (29.3)	68.6 (28.3)	77.5 (26.1)	70.1 (25.9)	79.4 (28.1)	78.8 (24.6)

[a] B, braced; NB, nonbraced.

triple jump test ($P = 0.02$), and the single-legged hop test ($P = 0.001$). At 6 months postoperatively, the stairs hopple test and the single-legged hop test disclosed a significantly improved outcome for those in group B who used the brace for 3 months compared with those who used the brace for a longer period ($P = 0.04$ and $P = 0.03$, respectively).

The Tegner activity level for all patients significantly decreased from a preinjury level of 7.6 to a preoperative level of 3.5 ($P < 0.001$). This value significantly increased from 3.5 to 5.3 at 2 years after surgery ($P < 0.001$). Furthermore, there were no significant differences between the braced and nonbraced groups with regard to pain or patient satisfaction at any of the follow-up times (Table 5).

Analysis of the MRI data revealed three new meniscus injuries in group B, and none in group NB. The MRI also revealed an increase in the number of degenerative changes in the cartilage of the tibiofemoral joint to 4 (14%) of the patients in group B and to 7 (23%) of the patients in group NB. There were no significant differences between the groups with respect to increased incidence of cartilage degeneration.

DISCUSSION

Bracing has been considered necessary to protect the ACL graft from excessive strain in the early postoperative period and to reduce the risk for subsequent knee injury. We found no evidence of increased knee joint laxity in patients who did not wear a brace postoperatively compared with those who did. The results are supported by previous in vivo biomechanical studies that report no significant strain-shielding effect of functional braces at moderate or high anterior shear loads.[6] Beynnon et al.[6] demonstrated that some braces produced a strain-shielding effect at low anterior shear loads, but those loading conditions were below those expected during activities of daily living and sports activities.[33,34] Previous knee arthrometry studies of patients who have used braces have shown that pathologic anterior displacement of the tibia relative to the femur decreases significantly with bracing.[11,31,41] However, these differences may not necessarily be functionally significant, since the knee joint laxity tests did not evaluate the joint under physiologic loading conditions.

Our rationale for using a rehabilitative brace for 2 weeks after surgery followed by a functional brace for 10 weeks was based on a review of the literature and on the current standard of clinical care at our institution. The literature supports use of either a rehabilitative brace, a functional brace, or a combination of both for 2 weeks to 4 to 5 months after surgery.[8,38,39,43–46] No previous studies have determined either the optimal start or stop times for bracing nor the optimal duration of bracing after ACL reconstruction. This is confounded by the fact that the graft-healing process in humans is unclear. Our previous case study of a human ACL graft after 8 months of healing showed that the ultimate failure load and linear stiffness properties of the graft were similar to those of the normal ACL.[7] This suggests that bracing may not be needed after 8 months of graft healing. Animal models of graft healing have indicated that the graft is weak and continues to remodel after 3 months,[5,12,16] suggesting that this period may be the most important one for bracing. Most studies of functional braces have shown some effect of bracing at low loading conditions,[9,11,18,49] supporting the use of functional bracing during the early postoperative period.

Bracing produced significantly more thigh atrophy at 3 months after surgery than did nonbracing. When the brace was removed, the thigh atrophy was reduced, and no differences were found 6 months after surgery. The patients who continued to use the brace after 3 months reported that the brace improved their function or decreased the giving-way feeling, or both, during strenuous sports activities. Our investigation demonstrated that those subjects who wore braces for an increased time period (1 to 2 years) had significantly decreased quadriceps muscle strength compared with those who wore the braces for a shorter period (3 months). These results are in accordance with those of Houston and Goemans,[27] who found that bracing decreases quadriceps muscle strength by 12% to 30%.

Harilainen et al.[26] performed a prospective randomized study on the effect of rehabilitative bracing after ACL reconstruction. They also reported no significant differences between bracing and nonbracing 1 and 2 years after surgery, but they did not evaluate the effect of bracing early in the postoperative period. Their bracing period chosen was 3 months; however, brace compliance was not evaluated and therefore the actual bracing interval is unclear. In our study, 26 of the patients (90%) used the brace the first 3 months after surgery; 3 patients (10%) used the brace for only 1 to 2 months. Four patients (14%) did not use the brace continuously during the 3rd month. The reason that 10% of the subjects did not comply with the bracing routines was reported to be problems with the brace and a feeling of discomfort. This has to be considered when recommending bracing after surgery. Some patients might benefit from trying different braces to find the most comfortable brace, one that does not produce skin problems or other discomfort. The diminished brace compliance over time illustrated the difficulty of continuous bracing for more than 3 months after ACL reconstruction.

The brace's impact on performance has been discussed in the literature. Some studies have demonstrated that bracing improves function in ACL-deficient knees,[18,41] while others have not reported a major benefit of the brace during functional testing.[31,47] Cook et al.[18] found an improved function in braced patients with quadriceps muscle strength of 80% or less. The subjects in our study who preferred to use the brace 1 to 2 years after surgery had similar quadriceps muscle strength values (less than 80%), whereas those who ended bracing earlier than 6 months after surgery had significantly higher muscle strength. In addition, those who stopped wearing the brace after 3 months showed a significantly improved functional outcome at 6 months after surgery (evaluated by the stairs hopple test and the single-legged hop test) compared with those who continued bracing for between 1 and 2 years. Regaining full quadriceps muscle strength after surgery has been shown to be a problem for some patients.[29]

Grading of cartilage degeneration with the present MRI technology is difficult. The most consistent finding is edema of the cartilage, which shows up as an increased signal in the image. What appear to be minor cartilage changes when observed arthroscopically may be fairly extensive osteochondral changes when visualized on MRI. Therefore, we did not use MRI to study how the cartilage lesions or meniscus injuries that were observed at the time of surgery changed over time. Instead we were interested in identifying injuries at 2 years and evaluating potential differences between the braced and the nonbraced groups. We found three new meniscus injuries in group B, and none in group NB. These three patients suffered new injuries postoperatively (at 2, 6, and 10 months, respectively, after surgery). Only two of these meniscus injuries were symptomatic at the time of MRI (those that had occurred at 6 and 10 months after surgery). Magnetic resonance imaging revealed no statistically significant difference between the groups regarding new degenerative changes of the tibiofemoral joint; however, almost twice the number of degenerative changes were found in group NB compared with group B (7 versus

4). The literature supports the fact that meniscus injuries correlate with degenerative changes.[20] The fact that there were significantly more meniscus injuries preoperatively in group NB may be one explanation for the degenerative changes seen after 2 years in group NB. Another explanation could be that the degenerative lesions seen on MRI were not visualized arthroscopically at the time of surgery.[23] Our study showed that there were almost three times more new degenerative lesions in patients who had sustained chronic ACL injuries before reconstruction than in patients who had had an acute ACL injury (eight versus three). This study therefore indicated that bracing may not be a crucial factor in the incidence of new intraarticular injuries.

CONCLUSIONS

We found no evidence that bracing (DonJoy Gold Point brace) had an effect on knee joint laxity, range of motion, muscle strength, functional knee tests, patient satisfaction, or pain, in comparison to no brace after ACL reconstruction. However, the Cincinnati knee score improved significantly in the brace group 3 months after surgery, even though bracing significantly increased thigh atrophy early postoperatively. Furthermore, prolonged bracing (1 to 2 years after surgery) produced a significant decrease in quadriceps muscle strength compared with bracing for a shorter period. We found no evidence that bracing reduced the risk of further injuries to the meniscus or cartilage in the tibiofemoral joint.

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