Bracing After Anterior Cruciate Ligament Reconstruction: Systematic Review and Meta-Analysis

Ön Çapraz Bağ Onarımı Sonrası Ortez Kullanımı: Sistematik Derleme ve Meta-Analiz

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ABSTRACT There is a considerable amount of literature on knee bracing after anterior cruciate ligament reconstruction. However, current studies suggest that bracing protocols after anterior cruciate ligament reconstruction remain a controversial topic. The objective of this review and meta-analysis was to analyse the efficacy of knee bracing on clinical outcomes include knee laxity, muscle strength, knee functional status, range of movement, pain, complications following anterior cruciate ligament reconstruction. The electronic databases AMED, CINAHL Plus, the Cochrane Central Register of Controlled Trials, EMBASE, MEDLINE (via OVID) and Physiotherapy Evidence Database (PEDro) were searched from their inception to May 2012. All English-language systematic reviews, randomised controlled trials and quasi-randomised controlled trials were included. Two reviewers performed study selection and data extraction independently and assessed the methodological quality of the included studies based on the PEDro scoring system. Eleven papers met the criteria. The methodological quality assessments revealed several limitations, including not blinding patients or clinicians, or not concealing subject allocation. Meta-analysis was performed on knee laxity and muscle strength measurements and found a small positive effect of bracing on knee laxity only. This systematic review and meta analysis has found little added benefit from the use of bracing after cruciate ligament reconstruction. The published evidence was generally of low and insufficient quality. Further good quality research is needed in terms of the clinical efficacy and appropriate prescription recommendations.

Key Words: Anterior cruciate ligament reconstruction; brace; bracing

ÖZET Ön çapraz bağ onarımı sonrası diz için ortez kullanımıyla ilgili olarak literatürde çok sayıda çalışma vardır. Ön çapraz bağ onarımı sonrası ortez kullanımı ile ilgili protokoller hala tartışmalı bir konudur. Bu sistematik derleme ve metaanalizin amacı, ön çapraz bağ onarımını takiben yapılan diz ortezlemenin diz laksitesi, kas kuvveti, dizin fonksiyonel seviyesi, eklem hareket açıklığı, ağrı ve komplikasyonları içeren klinik sonuçlar üzerine etkinliğini analiz etmekti. AMED, CINAHL Plus, Cochrane, EMBASE, MEDLINE (OVID bağlantılı) ve PEDro elektronik veri tabanları başlangıcından Mayıs 2012'ye kadar tarandı. Çalışmaya İngilizce sistematik derlemeler, randomize kontrollü çalışmalar ve yarı-randomize kontrollü çalışmalar dahil edildi. İki bağımsız derleyici tarafından çalışmaların metodolojik kalitesi Pedro puanlama sistemi temel alınarak seçildi. On bir çalışma kriterleri karşıladı. Metodolojik kalite değerlendirmelerinde; hastayı ya da klinisyeni yapılan çalışmaya kör etmeme, olgu dağılımında randomizasyon olmaması gibi çeşitli limitasyonlar tespit edildi. Meta-analiz, diz laksitesi ve kas kuvveti ölçümleri için uygulandı ve cerrahi sonrası dizi ortezlemenin sadece diz laksitesi üzerine küçük bir pozitif bir etkisi olduğu bulundu. Bu sistematik derleme ve meta-analiz, ön çapraz bağ onarımı sonrası ortez kullanımının çok az bir yarar sağladığını tespit etmiştir. Literatürde bu konuyla ilgili yayınlar genellikle yetersiz ve düşük kalitededir. Ön çapraz bağ onarım cerrahisi sonrası ortezin etkinliğini ve önerilmesini destekleyen daha iyi kalitede araştırmalara ihtiyaç vardır.

Anahtar Kelimeler: Ön çapraz bağ onarımı; ortez; ortez kullanımı

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Anterior cruciate ligament (ACL) reconstruction (ACL-R) is a common procedure which can allow patients to return to their active lifestyle. The surgical techniques, postoperative management and accelerated physiotherapy programmes for patients following ACL-R have changed considerably over the last two decades.[1] Knee braces have been prescribed frequently over this period and used to assist individuals with ACL-deficiency or to protect the ACL graft after ACL-R.[2,3] They typically incorporate the use of double-hinged uprights with range-of-motion stops and straps and fitted cuffs. They are intended to restore normal knee motion and kinematics by reducing anterior translation of the tibia in relation to the femur.

The results of survey studies suggest that bracing protocols after ACL-R remain a controversial topic.[4-6] In a study, on attitudes of members of the American Academy of Orthopaedic Surgeons regarding ACL injuries, sixty percent of respondents indicated that they recommended a brace for the first six weeks after ACL-R.[7] Despite much research having been conducted on bracing, the need for prescription knee braces after ACL-R is still questionable.

Clinicians often believe that braces improve the outcome of ACL-R by decreasing pain and graft strain and increasing muscle strength, functional outcomes and range of movement.[8] The decision to use knee braces after ACL-R still depends greatly on the surgical outcomes in terms of stability and the patient's physiological factors. There have been a variety of studies that have attempted to provide evidence of the effects of a brace post ACL-R in terms of anterior translation, ligament strain loads, sensorimotor function, range of knee motion, and subjective knee stability.[9-15]

Smith and Davies reported the last systematic review on bracing following ACL-R which searched for studies up to 2006.[16] They could find no evidence of significant long term differences in knee laxity, dynamometry, swelling, range of movement, muscle bulk, complications, patient satisfaction, function or pain between patients who wore post ACL-R knee braces and those who did not. Based on their review, physiotherapists and orthopaedic surgeons still have questions remaining on the routine prescription of knee braces after ACL-R. Since the review by Smith and Davies, we believe that it is important to critically assess any new evidence in the last 6 years for efficacy of bracing after ACL-R. A more recent systematic review did not include published studies from the past 5 years.[2]

Therefore, the goal of this systematic review was to assemble and review the available clinical trials which have evaluated the effectiveness on clinical outcomes of bracing following ACL-R and to attempt meta-analysis if the data were appropriate.

INCLUSION CRITERIA

The review included full text English language publications of randomised clinical trials which used bracing as part of ACL-R rehabilitation. Clinical trials including patella-tendon and hamstring graft ACL-R with adult male or female subjects. Patients with acute and/or chronic ACL rupture were included.

EXCLUSION CRITERIA

Case reports, editorials, comments, letters, guidelines, protocols, abstracts, studies not comparing a brace group against a non-brace group, studies comparing two different braces, animal and cadaver studies were excluded. Additionally, studies which assessed bracing after ACL rupture, but not surgical repair were excluded.

SEARCH STRATEGIES

The electronic databases AMED (1985 to May 2012), Cinahl Plus (1937 to May 2012), Cochrane database, EMBASE (from 1974 to May 2012), Ovid Medline (from 1948 to May 2012), Physiotherapy Evidence Database (PEDro) were searched up to May 2012 for articles appropriate to this study. For the database search strategy was:

#1 MeSH term: anterior cruciate ligament OR ACL,

#2 MeSH term: brace, OR, braces, OR, knee brace OR, bracing

#3 (#1 AND #2)

The titles and abstracts of all identified studies were assessed to determine whether they were suitable for the research question. Both reviewers (GIK and MJC) reviewed the full text of these articles independently to determine which adhered to the selection inclusion criteria.

The data extracted from each article are presented in tabular form (Table 1). The methodological quality of each study was assessed using the 11-item PEDro scoring system which is reliable and valid for the assessment of randomised controlled trials.[17] Each article was screened independently using this tool and was scored out of 10 points by the reviewers who were blinded to each others score. Any disagreements in scores were resolved through discussion until a consensus was met. Studies were included if they were a randamise controlling trials (RCTs) of at least good quality and scored ≥6/10 on PEDro.

From all databases, 598 papers were retrieved. Titles or abstracts not related to the research question were disregarded. The CONSORT diagram illustrates the process (Figure 1). Manuscripts from 239 articles were screened, and 178 failed to meet the required criteria, 61 potentially appropriate articles were read for eligibility. Of the 61 articles, 48 were excluded as not adhering to the inclusion or exclusion criteria leaving 13 studies, one of which was a systematic review. A further paper by Harilainen & Sandelin had 5-year follow-up data.[18] All methodological details in the study were unchanged from the original publication in 1997. Therefore the final total of studies included was 11.

Seven out of eleven studies were RCTs, two out of eleven studies were prospective controlled trials, one out of eleven studies was a clinical trial, one out of eleven studies was a cross-over study (Table 1). The studies in this review were analysed by main outcomes including knee laxity, muscle strength, functional outcomes, range of movement, and pain.

The PEDro scores for each of the studies are summarised in Table 2, which shows that the methodological quality of this topic was generally poor. The highest methodological score was 8 and the lowest was 2.[19-21] Although the majority of studies were randomised, none of them employed concealed allocation, allowing the potential for selection bias to be introduced into the subject's group allocation.

In total, 616 knees were investigated in the eleven studies included in this review; there were 346 male and 170 female participants. Nine studies presented data on mean age which was 27.06 years.[19-27] The shortest interval from injury to surgery was less than 1 month and the longest interval was 360 months.[23,26,28]

A bone-patellar tendon-bone ACL surgical reconstruction was performed in 9 studies with 2 studies using a semitendinosus-gracilis graft.[19,27] Meniscal repair was also performed in five studies.[20,23,26,28,29] It was unclear if such additional surgery was performed in the other five studies.[21,22,24,25,27] Additional meniscal repair was an exclusion criteria in one study.[19] All studies employed Shelbourne's accelerated rehabilitation protocol with varying modalities for both groups except in two studies.[19,27]

The most commonly used brace was the Donjoy brace.[21-24,26,29] Kartus et al., used a Genu Syncro Quick-lock S 2300; Hiemstra et al. used a Breg unhinged tripanel knee immobilizer; Davis et al. and Feller et al. devised their own functional brace.[19,25,27,28] Nazem et al. did not mention the type of brace they used in their study.[20]

The duration of brace wearing varied between studies and the details are in Table 1. One study did not report the duration of brace wearing.[20] Three studies assessed the immediate effects of the brace.[21,19,21,27]

KNEE LAXITY

Eight studies assessed anteroposterior knee laxity using a variety of instrumented laxity tests.[21-26,28,29] Five studies used a KT-1000 arthrometer (MEDmetric, San Diego, California, USA).[22-25,28] One study used a KT-2000 arthrometer (KT-2000, MEDmetric, San Diego, USA).[21] One study used the

TABLE 1: A summary of the papers included in this review, investigating the efficacy of knee braces following reconstruction of the anterior cruciate ligament.

No	Study	Design	Patients/ Surgery	Group Differences	Randomization	Duration in splint	Intervention	Outcome Measurements	Results	Follow-up Period
1	Harilainen and Sandelin/1997	RCT	60 patients/ BTB Arthroscopic ACL reconstruction	Brace for 12 weeks vs no brace	Birth year	3 months	Gp 1 (n=30) Donjoy brace with PWB first 3 weeks then FWB. Brace 0-90° for 3 weeks, then 0-120° for further 3 weeks then free ROM to remove brace at 12 weeks. Gp 2 (n=30) without brace. PWB for 2 weeks with 0-90° ROM, then FWB with free ROM.	Lysholm Score, Tegner Activity Level, Arthrometer Knee Laxity, Dynamometer for Isokinetic Strength	No significant difference between groups for any outcome	1,2 years
2	Brandsson et al./ 2001	RCT	50 patients/ BTB autograft reconstruction	Brace 6 weeks vs no brace	Not reported	3 weeks	Gp 1 (n=25) knee brace. Worn day and night and during rehabilitation. ROM allowed by brace unspecified. Gp 2 (n=25) without brace. All subjects FWB postoperatively.	Lysholm Score, Tegner Activity Level, Arthrometer Knee Laxity, Dynamometer Isokinetic Extension and Flexion, One-leg Hop Test, IKDC Evaluation System, ROM goniometer, early complications, VAS pain	No significant difference between groups for any outcome except VAS scores at 2 weeks, where Gp 2 recorded less pain than Gp 1	2 weeks, 6, 24 months
3	Feller et al./ 1997	RCT	40 patients/ BTB Arthroscopic ACL reconstruction	Hinged passive extension brace vs no brace	Not reported	6 weeks	Gp 1 (n=20) without brace. Gp 2 (n=20) wore dynamic extension brace that allowed active ROM but returned to full extension when patient was not flexing knee. Worn throughout except for exercising and physiotherapy sessions. All subjects could weight-bear as tolerated.	ROM goniometer, Arthrometer Knee Laxity, Dynamometer for isometric assessment of quadriceps and hamstrings	No significant difference between groups for any outcome.	4 months
4	Kartus et al. / 1997	Prospective controlled trial	78 patients/ Patella tendon autograft reconstruction	Brace 4 weeks (range, 3-6 weeks) vs no brace	Consecutive not random	3-6 weeks	Gp 1 (n=39) with full extension knee brace but free ROM for exercising. Gp 2 (n=39) without brace. All subjects could weight-bear as tolerated immediately postoperatively.	Arthrometer Knee Laxity, Lysholm Functional Score, Tegner Activity Level, IKDC score, One-leg Hop Test	No significant difference between groups for any outcome?	22-28 months

Continued→

TABLE 1: A summary of the papers included in this review, investigating the efficacy of knee braces following reconstruction of the anterior cruciate ligament *(Continued)*.

No	Study	Design	Patients/ Surgery	Group Differences	Randomization	Duration in splint	Intervention	Outcome Measurements	Results	Follow-up Period
5	Möller et al./ 2001	RCT	62 patients/ Patella tendon autograft reconstruction	Brace 6 weeks vs no brace	Not reported	6 weeks	Gp 1 (n=30) without brace postoperatively. Gp 2 (n=32) with brace postoperatively locked in full extension. Brace only released when exercising. Worn for 2 weeks day and night, and then a further 4 weeks during day. All subjects could weight-bear as tolerated immediately postoperatively.	Arthrometer Knee Laxity, Isokinetic assessment dynamometer, functional assessment with one-leg hop test, ROM goniometer, circumference around knee joint, Tegner activity level, Lysholm score, VAS pain.	No statistically significant difference between groups for any outcome, with the exception of the Tegner score at 6 months significantly better for Gp 1, but no difference at 2 years	6 months, 2 years
6	Muellner et al./ 1998	RCT	40 patients/ Arthroscopic patella tendon reconstruction	Hinged brace at 0° and increased progressively vs neoprene sleeve for 6 weeks	Not reported	6 weeks	Gp 1 (n=20) neoprene bandage applied just under patella for 6 weeks. Gp 2 (n=20) full extension Donjoy brace for first postoperative day, then ROM progressively increased, but unclear how much ROM increased over what time period. All subjects could weight- bear as tolerated immediately postoperatively.	Tegner activity score, ROM goniometer, dynamometer isokinetic assessment of quadriceps and hamstrings, artrometer, one-leg hop test, OAK score	No difference between groups for all outcomes except Gp 1 regained full ROM earlier than Gp 2. Gp 1 significantly better ROM at 12 weeks. At 24 weeks, one-leg hop test better in Gp 1 than Gp 2, but difference not present at 1 year.	6,12,24, 52 weeks
7	Risberg et al./ 1999	RCT	60 patients/ Bone-patellar-bone ACL reconstruction	Rehabilitative brace 2 weeks; functional 10 weeks vs no brace	Block	3 months	Rehabilitation begun by two weeks. Gp 1 (n=30) brace at 0-90° for 6 weeks then full ROM for first 3 months. Gp 2 (n=30) without brace. All patients were PWB at 4 weeks and FWB at 6 weeks postoperatively.	Arthrometer for knee laxity, Cincinnati Knee score, ROM goniometer, Computed tomography of cross-sectional area of hamstrings, quadriceps and whole thigh, patient satisfaction, dynamometer for isokinetic strength, Tegner activity score, functional knee tests, single leg hop test, stairs, triple jump	No significant difference between groups for any outcome, except significant improvement in Cincinnati Knee Score in Gp 1 compared with Gp 2 at 3 months	6 weeks, 3,6,12, 24 months

Continued→

TABLE 1: A summary of the papers included in this review, investigating the efficacy of knee braces following reconstruction of the anterior cruciate ligament *((Continued)*.

No	Study	Design	Patients/ Surgery	Group Differences	Randomization	Duration in splint	Intervention	Outcome Measurements	Results	Follow-up Period
8	Hiemstra and Heard/2009	RCT	82 patients/ Semitendinosus-gracilis graft	Soft, Unhinged tripanel knee immobilizer with Velcro straps vs no brace	Computer generated randomization, stratified with variable block sizes	14 days	Patients meeting intraoperative criteria were randomized (immobilizer or no immobilizer) after wound closure	VAS, Analgesic use in the first 14 days after surgery, complications and range of motion (app.3 weeks postoperatively)	No differences in pain or any of the secondary outcomes were detected between immobilized and nonimmobilized patients at any point during the first 14 days fter ACL-R.	2,14 days
9	Lu et al./ 2006	Prospective controlled trial	30 patients/ 15=ACLD; 15=ACL-R with BTB patellar graft	First with Donjoy Gold Point brace vs without brace	Not reported	On experiment day	ACLD and ACLR patients (at 10.3 months postoperatively) were fitted with/without brace walked at a self-selected pace for kinematic and kinetic data	Three dimensional joint moments, angular impulses	Functional knee bracing support bilateral kynetic symmetry during gait in each group.	No follow-up
10	Nazem et al./ 2006	Clinical trial	100 Patients/ ACL-R with Bone-Patellar Tendon-Bone Graft	Brace vs no brace	Not reported	Not reported	50 patients used braces after ACLR?	ROM, Complications, Quadriceps atrophy	No statistically significant difference between groups for all outcomes.	1,3,6, 12 months
11	Davis et al./ 2011	Crossover study	14 patients/ BTB (n=5) and Hamstring grafts (n=9)	With brace, sleeve or control	Not reported	Not reported	During each of three sessions (With brace, sleeve or control) patients performed a standardized aerobic exercise protocol on a treadmill. (Baseline, pre-exercise with brace, post exercise with brace, postexercise without brace)	Normalized torque during maximal voluntary isometric contraction (TMVIC), Quadriceps central activation ratio (CAR)	Decrease in (TMVIC) after brace application was not accompanied by differences between bracing conditions.	Not reported

BTB: Bone tendon bone; PWB: Pre-fabricated walking brace; FWB: Fort walton beach; VAS: Visual analog scala; IKDC: International knee documentation committee; ACLD: ACLD deficient

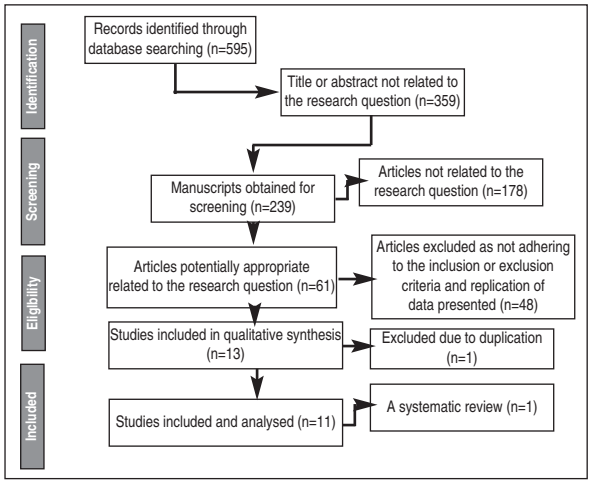

FIGURE 1: The CONSORT diagram illustrates the process.

instrumented laxity test (Knee Laxity Tester, Stryker Kalamazoo, Mich., USA) performed at 20° flexion.[29]

One study used a CA 4000 Instrumented Laxity tester (OSI Inc., Hayward, California, USA).[26] Eight studies reported that there was no statistically significant difference between brace and non-brace groups for knee laxity at any follow-up assessment.

Only two trials using the KT-1000 (total sample size 62) had sufficient and comparable data at 2 years follow up to allow meta-analysis (Figure 2A).[26,29] Although the overall treatment effect suggests a significant positive effect (p=0.04) with a standard mean difference of -0.37 mm (95% CI; -0.73, -0.01). Harilainen et al's trial was NSS and the overall positive effect of a brace on improved knee laxity is created by Moller et al.[29]

MUSCLE STRENGTH

Five studies assessed knee extension/flexion torque by a variety of isokinetic dynamometers.[22-24,26,29]

TABLE 2: The Physiotherapy Evidence Database Score for papers in this review, investigating the efficacy of knee braces following ACL-R.

Paper	Eligibility Criteria	Random Allocation	Concealed Allocation	Baseline Comparability	Blind Subject	Blind Clinician
Brandsson et al.2001	1	1	0	1	0	0
Feller et al.1997	1	1	0	0	0	0
Harilainen et al.1997	1	0	0	1	0	0
Kartus et al.1997	1	0	0	0	0	0
Möller et al.2001	1	1	0	1	0	1
Muellner et al.1998	1	1	0	1	0	0
Risberg et al.1999	1	1	0	1	0	0
Davis et al.2011	1	1	0	1	0	0
Nazem et al.2006	1	1	0	0	0	0
Lu et al.2006	1	0	0	0	0	0
Hiemstra et al.2009	1	1	1	1	0	0
	Blind assessor	**Adequate Follow-up**	**Intention to treat**	**Between group analysis**	**Point estimates and variability**	**Total score**
Brandsson et al.2001	1	1	0	1	1	7
Feller et al.1997	0	1	0	1	1	5
Harilainen et al.1997	0	1	0	1	1	5
Kartus et al.1997	1	0	0	1	1	4
Möller et al.2001	0	1	0	1	1	7
Muellner et al.1998	0	1	1	1	1	7
Risberg et al.1999	1	1	0	1	1	7
Davis et al.2011	0	0	0	1	1	5
Nazem et al.2006	0	0	0	0	0	2
Lu et al.2006	0	0	0	0	1	2
Hiemstra et al. 2009	0	1	1	1	1	8

1: one point; 0: no points. Each satisfied item (except blind subject) contributed 1 point to the total score.

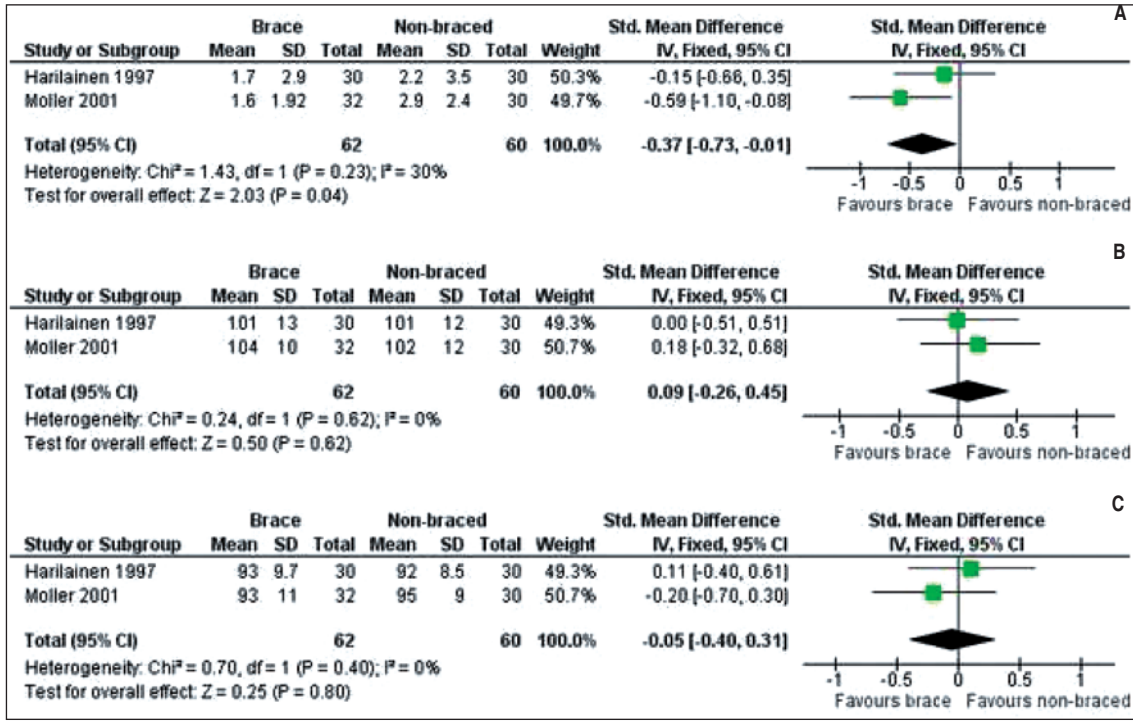

FIGURE 2: A) Effect of brace on knee laxity (mm). **B)** Effect of brace on isokinetic knee flexion strength ratio (%). **C)** Effect of brace on isokinetic knee extension strength ratio (%).

Isometric torque was assessed by Davis et al. and Feller et al.[25,27] Seven studies reported that there was no statistically significant difference between the brace and non-brace groups in their dynamometry results.

Only two trials (total sample size 62) had sufficient and comparable data at 2-year follow-up on muscle strength to allow meta-analysis (Figure 2B; 2C).[26,29] The overall treatment effect was not statistically significant (p=0.62) with a standard mean difference of 0.09% (95% CI; -0.26, 0.45) for isokinetic knee flexion muscle strength measured at 180°/s (Figure 2B). For knee extensor strength at 180°/s the overall effect was not statistically significant (p=0.80) with a standard mean difference of -0.05% (95 percent CI; -0.40 , 0.31) (Figure 2C).

KNEE FUNCTIONAL STATUS ASSESSMENTS

The studies presented a variety of self reported functional outcome scores. Four studies did not report functional outcomes.[19-21,27] The details are in Table 1.

RANGE OF MOVEMENT

Knee flexion and extension range of movements were assessed manually using a goniometer in six articles.[20,22-25,29] Five of these studies reported no significant difference in range of movement between the brace group and the non-brace group for early and later postoperative assessments.[20,22,23,25,29] Muellner et al., reported that during the first twelve postoperative weeks, range of motion was significantly better in the non-brace group than the brace group, and that the non-brace group regained full range of movement earlier than the brace group.[24] However, this difference was not statistically significant at 24 weeks and 1 year.

PAIN

Five studies assessed pain and discomfort directly using visual analogue scales (VAS).[19,20,22,23,29] Four studies reported no significant difference in the levels of pain between the brace and non-brace groups.[19,20,23,29] On the other hand, Brandsson et al.

reported significantly higher levels of pain in the non-brace group (mean VAS score 2.3 range 0-9) compared with the brace group (mean VAS 1.0, range 0-7) during the first two weeks postoperatively.[22] However, this difference was not significant after two postoperative weeks. In Hiemstra et al. study, no differences in VAS pain scores were detected between the immobilized and nonimmobilized patients at any point during the first two days after reconstruction.[19]

COMPLICATIONS

Postoperative complications were recorded in five studies with no significant difference between the brace and non-brace groups.[19,20,22,28,29] Complications included lateral numbness of the knee which decreased gradually, cellulitis/periostitis, meniscal injury, collateral ligament injury, extension deficit, flexion deficit, removal of tibial screw, rupture of reconstructed ACL and loose body.[19,20,22,28,29]

QUANTITATIVE DATA ANALYSIS

For the meta-analysis, "knee laxity" and "isokinetic flexion/extension muscle strength" were defined as outcomes to assess any differences between the braced and non-braced group. Means and 95% confidence intervals (CIs) were calculated using standard meta-analysis software (RevMan 5.0, Version 5.1.7; Copenhagen: The Nordic Cochrane Centre, The Cochrane Collaboration, 2011). A meta-analysis of continuous outcomes was calculated with a random effect model using the inverse of the estimated sampling variances as weights. The Chi^2 test and Higgins I^2 test were used to assess heterogeneity. The forest plots are also created that includes the individual study effects and the overall effects (Figure 2 A,B,C).

DISCUSSION

This systematic review and meta-analysis aimed to assemble the available clinical trials and analyse the effectiveness of bracing following ACL-R on clinical outcomes. Since the last systematic review by Smith and Davies there have been 5 new publications. Only one study was of high quality (8/10 PEDro scale) which also presented statistical differences of mean and standard deviations between groups and/or within groups.[19]

The meta-analysis was performed only on "knee laxity and isokinetic muscle strength" because they are the only variables with sufficiently detailed data and similar assessment. In addition, "knee laxity" and "muscle strength" are not only the most commonly assessed main outcomes but also said to be the best markers of management after ACL-R; therefore, the effect of bracing after ACL-R assessed by these variables has wide acceptance and relevance.[30,31] Meta-analysis was not possible for outcomes such as pain, range of movement, knee functional status assessments and complications because the included studies did not have sufficiently detailed data such as the difference between group means and group standard deviations. Additionally, the time points and in one case the method of assessment were too varied to pool data.

For knee laxity, the effect of bracing after ACL-R had a small positive effect on knee laxity at 2-year follow-up which although statistically significant, was clinically insignificant.

Muscle strength as measured isokinetically had low heterogeneity between the two studies (I^2= 0%).[26,29] The consistency between studies indicated that a lack of treatment effect with bracing after ACL-R can not be attributed to chance. Therefore, the practice of bracing after ACL-R to improve isokinetic knee flexion/extension muscle strength is not supported by the evidence we have reviewed. However, it should be noted that although they scored 5 overall on PEDro, it did not score on either random allocation or blinding which indicates a level of bias in their study.[26]

In general, the studies we reviewed suggest there are no significant differences in outcomes between patients who wore knee braces and those who did not.[14,19-23,25,28] Four studies reported significantly increased range of movement, less swelling, improved Cincinnati Knee Score and decreased during a maximal voluntary isometric contraction.[23,24,27,29] However, these significant differences

did not continue during the follow-up period. Results from the studies comparing brace and non-brace groups in terms of duration were similar.

The weakness of our review in part result from the inherent methodological weaknesses demonstrated by the low PEDro scores. These included not randomising the group allocation, not concealing group allocation and not blinding assessors.[19-29] Although we did not formally score sample size, we found only one study calculated the power to detect a statistically significant difference.[23] Therefore many studies were potentially underpowered. Blinding the clinician and/or assessor was only described by 4 studies.[22,23,28,29] Blinding of subjects was not attempted in any study. Selection bias by the randomisation method potentially existed in all but the one study.[19] Several studies had potential selection bias due to either insufficient randomisation methods or a lack of description of the randomisation techniques. The PEDro score showed deficits in the methodological quality of the studies that should be taken into account in future studies. Therefore, further higher quality RCTs are still required in order to clarify the effects of bracing after ACL-R.

This systematic review and meta-analysis demonstrated that bracing after ACL-R had a positive treatment effect only on knee laxity which may be considered clinically insignificant. Although there is a considerable amount of literature on bracing after ACL-R, this systematic review has noted methodological weaknesses in each study making interpretation and application of the findings a challenge. On the basis of the studies included and critically appraised in this review, we determined that there is no strong evidence of added benefit for postoperative bracing following ACL-R. There is a need for studies which are methodologically sound in order to improve the rationale behind the use of bracing after ACL-R.

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