

# Weightbearing Protocols After Posterolateral Corner Reconstruction

## A Systematic Review

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**Background:** Multiligamentous knee injuries with a posterolateral corner injury represent a devastating insult to the knee.

**Purpose:** To evaluate multiligamentous knee reconstruction rehabilitation programs and recommend a rehabilitation program based on a review of published outcomes studies.

**Study Design:** Systematic review; Level of evidence, 4.

**Methods:** A MEDLINE (PubMed), OVID, and Embase database search was conducted using the terms “posterolateral corner” and “rehabilitation.” All articles obtained were examined to confirm their rehabilitation programs for multiligamentous knee injuries. These injuries included a posterolateral corner injury plus an isolated anterior or posterior cruciate ligament injury or a combined cruciate injury.

**Results:** Ten publications representing 245 patients with multiligamentous knee reconstruction were analyzed. Rehabilitation protocols were divided by weightbearing (WB) status: in 2 studies, patients were non-WB until postoperative 4 weeks (delayed WB;  $n = 61$ ); 5 studies permitted progressive WB until postoperative 6 weeks (progressive WB;  $n = 123$ ); and 3 studies allowed WB immediately after surgery (immediate WB;  $n = 61$ ). No significant difference in outcome scores among the 3 WB groups was found. Arthrofibrosis requiring manipulation under anesthesia was the most common complication (11%) in the delayed WB group, followed by the immediate WB group (3%) and the progressive WB group (0%;  $P < .01$ ). Overall complication rates were highest in the delayed WB group (44%), followed by the immediate and progressive WB groups (25% and 3%, respectively;  $P < .00001$ ). The delayed WB group was permitted to return to sport at a mean of 10.5 months from the index procedure; the progressive WB group, at 6.0 months; and the immediate WB group, at 9.0 months ( $P < .05$ ).

**Conclusion:** This review revealed no significant difference in outcome scores when comparing immediate, progressive, and delayed WB protocols. Time to permitted return to sport was not significantly different among the groups, but there existed a trend toward earlier return in the progressive WB group. Patients in the delayed and immediate WB groups experienced a higher overall complication rate. Progressive WB postoperative protocols may decrease the risk of complications without compromising outcomes; however, more research is needed to identify the optimal postoperative rehabilitation protocol, given the significant data heterogeneity currently available in the literature.

**Keywords:** guidelines; nonoperative rehabilitation; PLC; postoperative rehabilitation

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Multiligamentous injuries to the knee represent devastating injuries that can be challenging to treat. Posterolateral corner (PLC) injuries have historically been overlooked and frequently occur concurrently with cruciate ligament injuries.<sup>12,15</sup> The PLC has been referred to as the “dark corner” of the knee; however, recent literature has helped guide diagnosis and treatment of this important knee ligament

complex.<sup>19</sup> Surgical reconstruction is often indicated to treat multiligamentous knee injuries, which makes early recognition critical to restoring knee function and stability as well as optimizing functional patient outcomes.

Once surgery has been completed, recovery shifts toward implementation of a physical therapy regimen and adherence to a rehabilitation program. Although it can safely be assumed that multiligamentous reconstruction often relates to an extended recovery and slower progression through rehabilitation, the exact time frames for postoperative recovery are not well documented. Variability exists

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in the literature pertaining to weightbearing (WB) progression, immobilization and/or bracing, and expected return to sport.

Injury to the PLC with concurrent damage to the anterior or posterior cruciate ligament can occur via several mechanisms, which include a posterolaterally focused impact to the proximal tibia with subsequent hyperextension and inward movement at the knee, noncontact hyperextension combined with external rotation twisting injury, a direct blow to a flexed knee, or high-energy trauma.<sup>1,5,6,7,13,17,22</sup> PLC injuries rarely occur in solitude, and other cruciate damage usually coexists, especially a posterior cruciate ligament injury.<sup>2</sup> Postoperative rehabilitation of multiligamentous knee reconstruction must balance optimizing knee range of motion and preservation of quadriceps muscle strength with protecting surgical grafts from creep as they incorporate into the knee. Consensus on postoperative rehabilitation would improve consistency for future research on this injury and assist rehabilitation specialists by ensuring optimum healing while rehabilitation commences and progresses. The purpose of this article was to classify postoperative rehabilitation protocols based on review of current peer-reviewed multiligamentous knee reconstruction rehabilitation programs, specifically WB status, to identify if an association exists between postoperative rehabilitation programs and patient outcomes and complications, and, if possible, to recommend an optimal rehabilitation program for multiligamentous knee reconstruction.

## METHODS

### Search Strategy and Study Selection

The study followed the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) guidelines.<sup>16</sup> Because this study was a systematic review of published studies, institutional review board approval was not required. A systematic search of the literature was conducted utilizing MEDLINE (PubMed), OVID, and Embase databases and the following keywords: “posterolateral corner,” “postoperative posterolateral corner,” and “rehabilitation.” All articles published through November 2019 were included for analysis. Three investigators (B.L.M., T.P., K.K.) performed a separate study selection of identified articles to exclude repetitions and select those related to the study question. The primary author (B.L.M.) resolved any discrepancies in article selection among

investigators. Reference lists of all selected articles were also examined for any relevant articles.

### Eligibility Criteria

Clinical studies that included the following criteria were considered eligible: studies published in the English language and in vivo clinical studies reporting on rehabilitation protocols for posterolateral reconstruction with isolated anterior or posterior cruciate ligament or combined cruciate injury. All studies with levels of evidence of 1 to 4 were included. Articles were excluded if they did not specify reconstructed ligaments; reported the surgical procedure as a PLC injury ligamentous repair; or reported PLC reconstruction with concomitant meniscal repair, chondral repair, or chondral restorative techniques. Case reports, biomechanical studies, animal studies, review articles, surgical technique articles, and studies not reporting postoperative rehabilitation protocols or outcomes were also excluded.

### Data Extraction and Quality Appraisal

Postoperative protocols in each article were reviewed and divided into 3 categories: delayed WB, until postoperative 4 weeks; progressive WB, which allowed partial to full WB by postoperative 6 weeks; and immediate WB, which permitted full WB immediately after surgery. For each rehabilitation group, Lysholm, Tegner, and International Knee Documentation Committee (IKDC) scores were recorded as well as time to permitted return to sport and total complications. Reviewers assessed methodological quality using the Cochrane Collaboration tool, with a designated tiebreaker (B.L.M.) in case of any disagreement.

### Statistical Analysis

Outcome data, such as Lysholm, Tegner, and IKDC scores and time to return to sport, were presented as continuous data (means) and compared among all 3 groups. Lysholm and Tegner scores were recorded pre- and postoperatively in several studies, which allowed comparison of mean improvement in several groups. Arthrofibrosis requiring manipulation and total number of complications were analyzed as categorical data, reported as percentages, and evaluated using a chi-square test. A *P* value < .05 was considered significant. The statistical software used was R Version 4.0.3.

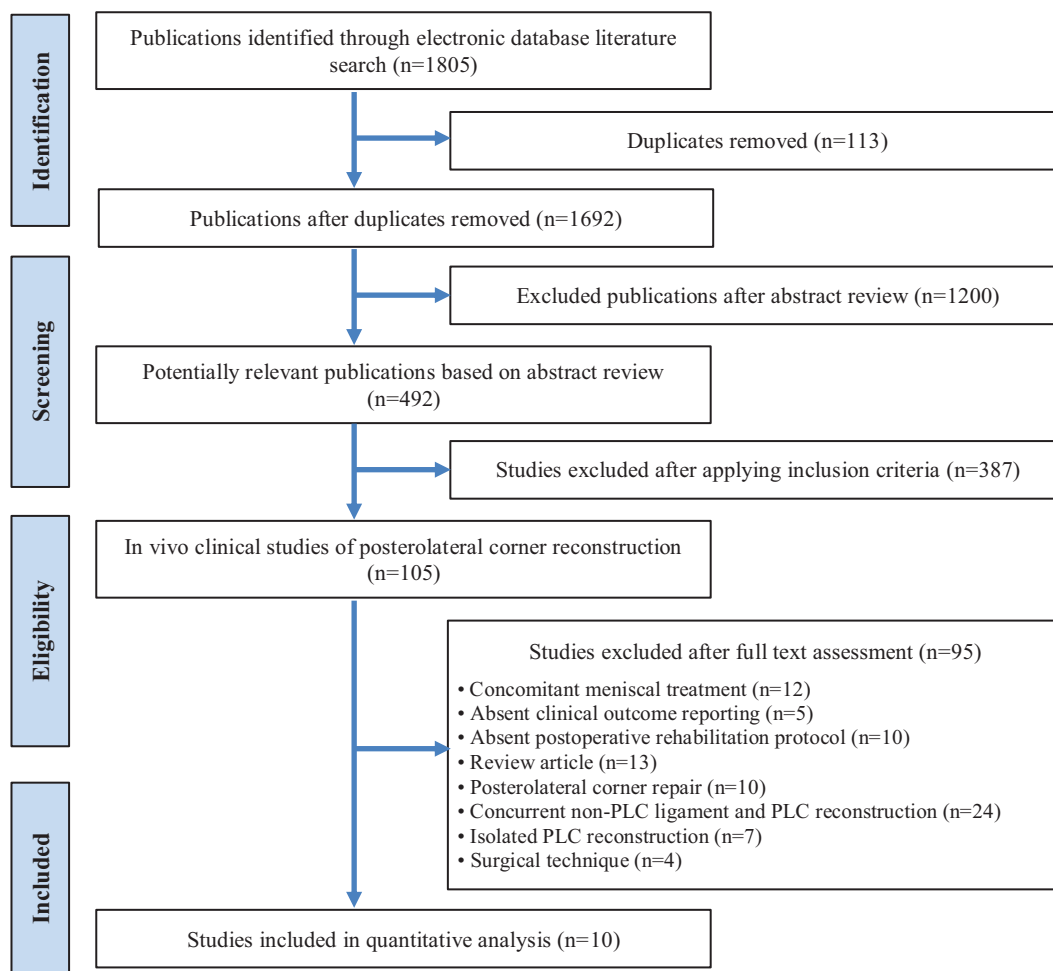
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**Figure 1.** Systematic review flowchart following the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) guidelines. PLC, posterolateral corner.

**TABLE 1**  
Study Demographics

Lead Author	Mean Age, y	Male:Female, No.
Fanelli <sup>3</sup>	15-40 (range)	31:10
Ibrahim <sup>8</sup>	26.4	20:0
Helito <sup>4</sup>	29.9	8:1
Jung <sup>9</sup>	33.5	34:5
Strobel <sup>20</sup>	30.7	13:4
van Gennip <sup>21</sup>	27	11:0
Lee <sup>14</sup>	35.6	82:10
Kim <sup>11</sup>	36.4	16:7
Zorzi <sup>24</sup>	29	13:6
Khanduja <sup>10</sup>	29.6	18:1

**RESULTS**

A search performed of the English-language literature in MEDLINE (PubMed), OVID, and Embase yielded 1805 results using the PRISMA guidelines. Of the search results, 492 articles were selected for further review based on abstract review, and 105 articles discussing PLC reconstruction were

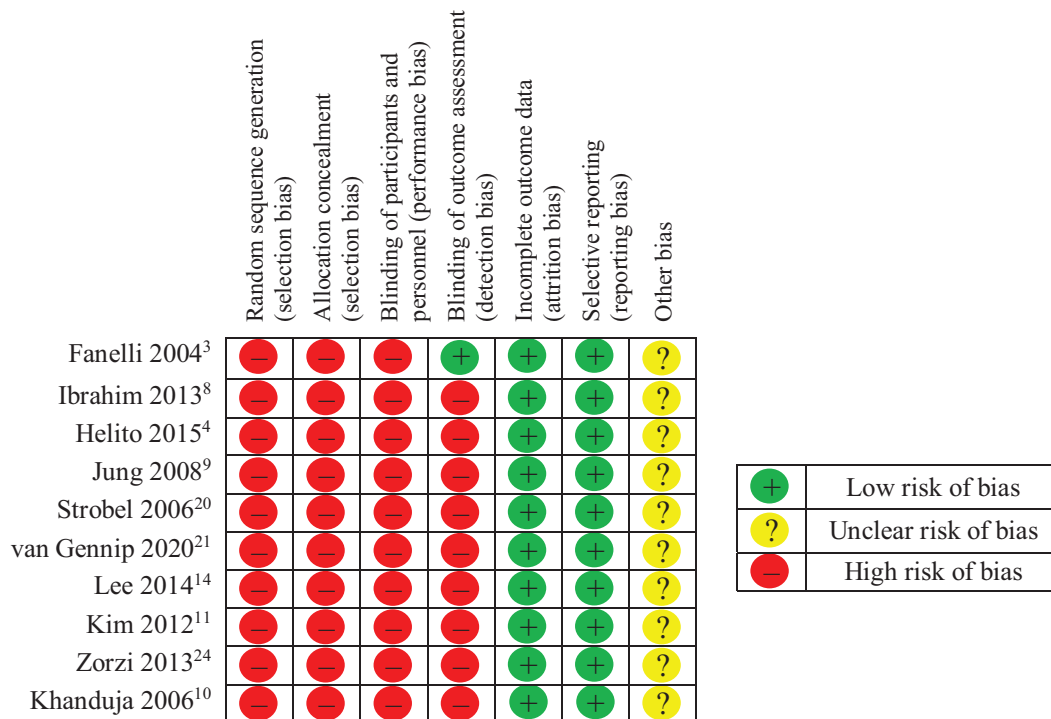
identified. After application of our exclusion criteria, 10 articles representing 245 patients were identified for analysis (Figure 1, Table 1).

Results of the methodological quality assessment are shown in Figure 2.

As noted, rehabilitation protocols were separated by WB status: delayed WB until postoperative 4 weeks, progressive postoperative WB, and immediate postoperative WB. Of the 245 patients, 61 patients were in the non-WB group; 123, in the progressive WB group; and 61, in the immediate WB group.

Two articles met the criteria for the delayed WB group.<sup>3,8</sup> Fanelli and Edison<sup>3</sup> indicated that patients were in full extension for 3 weeks and non-WB on their operative extremity; after 3 weeks, progressive WB was allowed. Ibrahim et al<sup>8</sup> limited WB until postoperative 3 to 4 weeks, with gradual WB initiated at that time. Mean postoperative follow-up for this group was 34 months.

In the progressive WB group, 5 articles met analysis criteria.<sup>4,9,14,20,21</sup> Helito et al<sup>4</sup> allowed patients to partially weightbear immediately after surgery. Jung et al<sup>9</sup> instructed patients to partially weightbear for 6 weeks,



**Figure 2.** Quantitative bias according to the Cochrane Collaboration tool for each study reviewed.

followed by progression to full WB as pain permitted. Strobel et al<sup>20</sup> implemented partial WB for 6 weeks with the knee kept in extension. Lee et al<sup>14</sup> allowed partial WB in crutches for the first 4 weeks after surgery. van Gennip et al<sup>21</sup> restricted flexion and extension of the knee to 20° to 70° during the first 2 postoperative months. WB was limited to 5 to 10 kg for 8 weeks, at which time patients began transitioning under the guidance of a physical therapist to full WB by 16 weeks.<sup>21</sup> Mean postoperative follow-up for this group was 38 months.

Three articles were included in the immediate WB group: Kim et al,<sup>11</sup> Zorzi et al,<sup>24</sup> and Khanduja et al.<sup>10</sup> Kim et al allowed WB as tolerated immediately after surgery; however, the knee was immobilized during this time. Zorzi et al instructed their patients to be full WB with the knee in extension for 2 weeks after surgery; knee range of motion was permitted starting at week 2, and the brace was discontinued when patients achieved 90° of knee range of motion. Last, Khanduja et al allowed patients to be full WB after surgery with the knee locked in full extension. Mean postoperative follow-up for this group was 43 months.

To compare length of patient follow-up, 4 studies were analyzed (1 immediate WB,<sup>24</sup> 3 progressive WB<sup>9,14,20</sup>). There were 19 patients with immediate WB, with a mean (SD) follow-up of 38 (12.3) months. There were 103 patients with progressive WB, with a mean follow-up of 42.16 (14.10) months. No significant difference between the groups was found ( $P = .1881$ ; 95% CI,  $-10.3728$  to  $2.0446$ ).

All studies reported outcomes using Lysholm, Tegner, or IKDC measurements. For the Lysholm score analysis, 3 studies were eligible for analysis (1 immediate WB,<sup>11</sup> 2 progressive WB<sup>4,14</sup>). There were 23 patients with immediate WB, with a mean (SD) postoperative Lysholm score of 90.1 (7.00). There were 56 patients with progressive WB, with a mean postoperative Lysholm score of 89.54 (7.21). There was no significant difference between immediate and progressive WB ( $\Delta = 0.56$ ;  $P = .75$ ; 95% CI,  $-2.92$  to  $4.04$ ).

Five studies reported on pre- to postoperative improvement in Tegner scores, with a 2.21 increase in the delayed WB group,<sup>3</sup> 2.6 in the progressive WB group,<sup>14,21</sup> and 3.9 in the immediate WB group<sup>10,24</sup> ( $P = .58$ ) (Table 2).

Serious complications in all groups were relatively uncommon, but the most common complication was arthrofibrosis requiring manipulation. The rate of arthrofibrosis requiring manipulation under anesthesia was 11% in the delayed WB group as compared with 3% in the immediate WB group and 0% in the progressive WB group ( $P < .01$ ) (Table 3). The overall complication rate was the highest in the delayed WB group (44%). The most common complication in this group was removal of implants, which occurred in 30% of knees. The immediate WB group had the second-most complications (25%). Removal of implants occurred in 7 patients. The progressive WB group had the lowest percentage of complications (3%) ( $P < .01$ ).

Reported time of permitted patient return to sport varied greatly throughout the 12 studies reviewed. Of the 10 studies identified for review, 6 reported on return-to-sport criteria.<sup>3,8,10,14,20,24</sup> Overall mean time of permitted return to

TABLE 2  
Outcomes by Weightbearing Group<sup>a</sup>

Lead Author	Ligamentous Reconstruction	PLC Reconstruction Technique	Return to Sport	Measures	
				Preoperative	Postoperative
Delayed weightbearing					
Fanelli <sup>3</sup>	PLC + PCL	Biceps tenodesis capsular shift	9 mo	<ul style="list-style-type: none"> <li>• Lysholm mean: 65.48</li> <li>• Tegner mean: 2.71</li> </ul>	<ul style="list-style-type: none"> <li>• Lysholm mean: 91.6</li> <li>• Tegner mean: 4.92</li> </ul>
Ibrahim <sup>8</sup>	PLC + cruciates	Larson fibular-based figure of 8	12 mo	<ul style="list-style-type: none"> <li>• Tegner: 8-9 (n = 5), 6-7 (n = 11), 5-6 (n = 4)</li> </ul>	<ul style="list-style-type: none"> <li>• IKDC: normal (n = 9), abnormal (n = 9), severely abnormal (n = 2)</li> <li>• Tegner: 4-7 (n = 5), 5-7 (n = 11), 4-5 (n = 4)</li> <li>• Lysholm mean: 90</li> </ul>
Overall means: return to sport, 10.5 mo; Lysholm, 65.48 (pre) and 90.8 (post)					
Progressive weightbearing					
Helito <sup>4</sup>	PLC + ACL	2-tailed tibial and fibular based	NA	<ul style="list-style-type: none"> <li>• IKDC mean: 43.6; level C (n = 3), level D (n = 6)</li> <li>• Lysholm mean: 62.1</li> </ul>	<ul style="list-style-type: none"> <li>• IKDC mean: 84; level A (n = 6), level B (n = 3)</li> <li>• Lysholm mean: 90.8</li> </ul>
Jung <sup>9</sup>	PLC + PCL	<ul style="list-style-type: none"> <li>• 19 patients with tibial tunnel</li> <li>• 20 patients with fibular tunnel</li> </ul>	NA	<ul style="list-style-type: none"> <li>• IKDC: level C (n = 16), level D (n = 23)</li> </ul>	<ul style="list-style-type: none"> <li>• IKDC means: 84.6 and 82.1; level A (n = 10), level B (n = 22), level C (n = 6), level D (n = 1)</li> </ul>
Strobel <sup>20</sup>	PLC + cruciates	Fibular-based sling	6 mo	NA	<ul style="list-style-type: none"> <li>• IKDC mean: 71.8; level B (n = 4), level C (n = 10), level D (n = 2)</li> </ul>
van Gennip <sup>21</sup>	PLC + cruciates	Fibular-based sling	NA	<ul style="list-style-type: none"> <li>• Lysholm mean: 67</li> <li>• Tegner mean: 1</li> <li>• IKDC mean: 46</li> </ul>	<ul style="list-style-type: none"> <li>• Lysholm mean: 86</li> <li>• Tegner mean: 8</li> <li>• IKDC mean: 79</li> </ul>
Lee <sup>14</sup>	PLC + PCL	Fibular-based sling	6 mo	<ul style="list-style-type: none"> <li>• IKDC mean: 53.3</li> <li>• Lysholm mean: 56.7</li> <li>• Tegner mean: 2.5</li> </ul>	<ul style="list-style-type: none"> <li>• IKDC mean: 86.2</li> <li>• Lysholm mean: 89.3</li> <li>• Tegner mean: 5.1</li> </ul>
Overall means: return to sport, 6 mo; IKDC, 48.5 (pre) and 81.7 (post); Lysholm, 59.4 (pre) and 90.1 (post); Tegner, 2.5 (pre) and 5.1 (post)					
Immediate weightbearing					
Kim <sup>11</sup>	PLC + ACL	Tibial and fibular based	NA	<ul style="list-style-type: none"> <li>• IKDC: level B (n = 2), level C (n = 10), level D (n = 11)</li> <li>• Lysholm mean: 64.4</li> </ul>	<ul style="list-style-type: none"> <li>• IKDC: level A (n = 6), level B (n = 14), level C (n = 2), level D (n = 1)</li> <li>• Lysholm mean: 90.1</li> </ul>
Zorzi <sup>24</sup>	PLC + PCL	Fibular based	9 mo	<ul style="list-style-type: none"> <li>• Tegner mean: 2</li> </ul>	<ul style="list-style-type: none"> <li>• IKDC mean: 86</li> <li>• Tegner mean: 6</li> </ul>
Khanduja <sup>10</sup>	PLC + PCL	Fibular based	9 mo	<ul style="list-style-type: none"> <li>• Lysholm mean: 41.2</li> <li>• Tegner mean: 2.6</li> <li>• IKDC level D (n = 19)</li> </ul>	<ul style="list-style-type: none"> <li>• Lysholm mean: 76.5</li> <li>• Tegner mean: 6.4</li> <li>• IKDC: level A (n = 6), level B (n = 11), level C (n = 2)</li> </ul>
Overall means: return to sport, 9 mo; Lysholm, 52.8 (pre) and 83.3 (post); Tegner, 2.3 (pre) and 6.2 (post)					

<sup>a</sup>ACL, anterior cruciate ligament; IKDC, International Knee Documentation Committee; NA, not applicable; PCL, posterior cruciate ligament; PLC, posterolateral corner; post, postoperative; pre, preoperative.

sport was 8.5 months. The delayed WB group included 61 patients who were permitted return to sport at 10.5 months on average from their index procedure. The progressive WB group had 64 patients who were permitted return to sport at 6.0 months on average, and the immediate WB group had 38 patients with a mean permitted return to sport of 9.0 months ( $P > .05$ ) (Table 2).

Data confounders include injury mechanisms (high vs low energy), timing of surgery from the injury, number of reconstructed ligaments, and variation of PLC reconstruction techniques. An analysis of confounders was unable to be performed, owing to variability in reported outcome measures as well as a lack of individualized patient data (Table 4).

TABLE 3  
Postoperative Complications<sup>a</sup>

Study	Ligamentous Reconstruction	Complications	Arthrofibrosis With Manipulation, No.
Delayed weightbearing			
Fanelli <sup>3</sup>	PLC + PCL	Removal of implants in 18 knees; arthroscopic lysis of adhesions in 3 knees; superficial suture abscess in 1 knee	3
Ibrahim <sup>8</sup>	PLC + cruciates	4 patients with arthrofibrosis; 1 patient who had loss of flexion of 10°	4
Overall: 61 patients with complications, 27 total complications (48%), 14 manipulations (17%)			
Progressive weightbearing			
Helito <sup>4</sup>	PLC + ACL	1 patient had a delayed wound infection and required debridement at postoperative 6 mo; no other complications	0
Jung <sup>9</sup>	PLC + PCL	2 intraoperative peroneal nerve injuries: traction injury and reamer injury; 1 incomplete fibular neck fracture	0
Van Gennip <sup>21</sup>	PLC + cruciates	Not reported	NA
Strobel <sup>20</sup>	PLC + cruciates	No major complications in the perioperative and postoperative period; 1 case of ACL failure	0
Lee <sup>14</sup>	PLC + PCL	2 cases of failed PLC reconstruction by the single fibular sling in this study	0
Overall: 123 patients with complications, 7 total complications (3%), 0 manipulations (0%)			
Immediate weightbearing			
Kim <sup>11</sup>	PLC + ACL	1 knee had a flexion deficit of >5°, 2 knees had extension deficit >5°; a correction loss of posterolateral rotational instability of >10° was found in 1 knee; no overall complications besides range of motion deficits	0
Zorzi <sup>24</sup>	PLC + PCL	No reported postoperative complications	0
Khanduja <sup>10</sup>	PLC + PCL	Implant removal in 7 patients; 2 patients developed a superficial infection of the posterolateral corner; 2 patients had manipulation under anesthesia	2
Overall: 61 patients with complications, 15 total complications (25%), 2 manipulations (3%)			

<sup>a</sup>ACL, anterior cruciate ligament; NA, not applicable; PCL, posterior cruciate ligament; PLC, posterolateral corner.

TABLE 4  
Study Confounders<sup>a</sup>

Lead Author	WB Status	Follow-up, mo	Time to Surgery	Injury Mechanism	No. of Ligaments Reconstructed	Bracing Use
Fanelli <sup>3</sup>	Delayed	Minimum, 24 (range, 24-120)	No mean reported (range, 4-20 mo)	NR	2	Yes, 3 wk
Ibrahim <sup>8</sup>	Delayed	Mean, 44 (range, 24-52)	Range, 15-21 d	NR	3	Yes, 5 d
Helito <sup>4</sup>	Progressive	Mean ± SD, 27.3 ± 3.3	NR	2 MVA, 7 sports related	2	No
Jung <sup>9</sup>	Progressive	Mean, 35.3	10.4 mo	14 MVC, 3 fall from height, 11 sports related, 10 pedestrian, 1 work related	2	Yes, splint (wk 0-3) and brace (wk 3-6)
Strobel <sup>20</sup>	Progressive	Mean ± SD, 41.3 ± 12.8	Mean ± SD, 70.2 ± 96.7 mo	9 MVA, 6 sports related, 2 work or recreation	3	Yes, 6 wk
van Gennip <sup>21</sup>	Progressive	Mean, 24 (range, 24-34.8)	NR	NR	3	Yes, 4 mo
Lee <sup>14</sup>	Progressive	Mean ± SD, 48.2 ± 16.2	Mean ± SD, 9.4 ± 3.5 mo	NR	2	Yes, 12 wk
Kim <sup>11</sup>	Immediate	Mean, 24	Mean, 7.8 mo (range, 1-30 mo)	4 MVA, 16 sports related, 3 falls	2	Yes, 4 wk
Zorzi <sup>24</sup>	Immediate	Mean ± SD, 38 ± 12.3	Mean ± SD, 11 ± 9.3 mo	12 MVA, 7 sports related	2	Yes, 8 wk
Khanduja <sup>10</sup>	Immediate	Mean, 66.8 (range, 24-110)	Mean, 27.3 mo (range, 3-105)	4 MVA, 15 sports related	2	Yes, 6 wk

<sup>a</sup>MVA, motor vehicle accident; MVC, motor vehicle crash; NR, not reported; WB, weightbearing.

## DISCUSSION

Each reviewed article utilized non-WB, progressive WB, or immediate WB in the early phase of rehabilitation. Delayed WB was associated with an increased risk of arthrofibrosis and sustaining other postoperative complications when compared with the immediate and progressive WB protocols; however, this conclusion should be interpreted with caution because of the heterogeneity of the cohorts available for analysis. Patients in the delayed WB group experienced an overall 44% complication rate. Patients in the immediate WB group demonstrated the next most frequent amount of postoperative complications (25%), while those in the progressive WB group reported the fewest complications (4%;  $P < .01$ ). For outcomes, no significant difference was identified among the delayed, progressive, and immediate WB groups; however, this result is limited in its applicability, given the variation of reported outcomes among studies. Analysis of time to return to sport suggested that the progressive WB group demonstrated the earliest permitted return (6 months).

Permitted knee range of motion varied among the WB protocols. In our practice, we begin unloaded passive range of motion efforts immediately after surgery, with the goal of 90° of knee flexion by postoperative 2 weeks. Upon reaching the milestone of 90° of knee flexion, we permitted increasing range of motion as tolerated and progressed gradually to full knee range of motion by 6 weeks. During this initial 6-week period, physical therapists avoided stretching the knee into hyperextension and educated patients to avoid postural knee hyperextension.

No article provided details of specific exercises used during postoperative rehabilitation. In our opinion, proper exercise prescription and timing are imperative in restoring lower extremity function and optimal long-term patient outcomes. More research is needed to determine optimal exercise regimens and rehabilitation time frames for recovery after multiligamentous knee reconstruction. In our experience, initial emphasis should be in restoring quadriceps function as soon as possible. When the patient has achieved adequate quadriceps function and has progressed to full WB, exercises should progress to closed chain exercise, which usually occurs around postoperative 6 to 8 weeks. Progression should be made to single-leg closed chain exercise to enhance the neuromuscular reeducation of the operative limb at approximately the 8- to 10-week postoperative time point. We advocate for the use of blood flow restriction therapy within the first 12 weeks of rehabilitation to aid in muscle mass improvement without graft compromise.<sup>23</sup> Attention should be given to any kinetic chain dysfunction or surrounding muscle weaknesses to prevent unnecessary stress on the healing tissue and decrease future injury risk. Serra Cruz et al<sup>18</sup> recommended avoidance of isolated open chain hamstring-resisted exercises for 4 months after surgery, which is consistent with our exercise protocol. Sport-specific training, advanced plyometric exercises, and multiplane exercises are reserved for the final phase of rehabilitation, which occurs between 16 and 24 weeks postoperatively. Return to sport is based on patient readiness and is

determined through functional testing using limb symmetry index, clinical evaluation of knee stability, and patient-reported knee function. Estimated return to sport is usually at a minimum of 6 months but can be longer, more likely 9 to 12 months.

Limitations of this systematic review include the small sample size of articles available for analysis, the heterogeneity of reported outcome measures, and the data reported in aggregate. No study reported data with the specificity required to analyze how confounders affected individual patient outcomes. The lack of specific patient data also limited our ability to pool patients from different studies to perform a meta-analysis. Given the less frequent occurrence of multiligamentous knee injury as compared with the occurrence of isolated knee ligament injury, we purposefully kept our literature search terms and our inclusion criteria broad to capture as many studies as possible for review, which increased the potential for heterogeneity among our included studies. Our oldest study dates from 2004, and the most recent study is from 2020, which affects our results as well because surgical reconstruction techniques and postoperative rehabilitation protocols have evolved over the 16 years between the earliest and latest years of publication. Despite these limitations, however, we believe that our review provides evidence that progressive WB postoperative protocols have similar outcomes to the delayed and immediate WB protocols but may have fewer complications.

On the basis of these findings and our own experience, we currently limit WB to either progressive or touchdown WB for 6 weeks. During this protective phase, physical therapy should concentrate on restoration of passive mobility of tibio- and patellofemoral joint motion, reduce postoperative pain and swelling, and minimize quadriceps atrophy. However, more research needs to be conducted on the rehabilitation of multiligamentous knee injuries to determine the appropriate postoperative rehabilitation protocol. We believe that ligamentous reconstruction requires sufficient healing time before WB stress is permitted to protect against graft elongation or failure. The ideal time frame that allows for early WB while providing graft protection remains unidentified.

## CONCLUSION

Review of peer-reviewed multiligamentous knee injury rehabilitation protocols revealed that there was not a significant difference in outcome scores among the immediate, progressive, and delayed WB protocols. Time to permitted return to sport was not significantly different among the groups but trended toward significance, with the progressive WB cohort having the earliest permitted to return to sport of all 3 groups. For complications, delayed and immediate WB had higher overall complication rates. This study indicates that progressive WB postoperative protocols may possibly decrease the risk of complications without compromising outcomes when compared with delayed or immediate WB protocols; however, more research is needed to determine optimal rehabilitation.



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