

Current Status of Rehabilitation Training After Meniscus Repair Surgery

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Abstract:

Rehabilitation is an important component of recovery after meniscus repair surgery. Over the past few years, a growing number of studies have examined different rehabilitation approaches and their clinical outcomes. This review summarizes recent findings and discusses their implications for postoperative management. Available evidence suggests that rehabilitation should be incorporated throughout the recovery period. Commonly used interventions include range-of-motion (ROM) exercises, weight-bearing (WB) progression, brace use, and guidance on return-to-sport activities. In current practice, rehabilitation programs are generally classified as either unrestricted or restricted, with protocol selection often influenced by factors such as tear type, location, and size. However, considerable variation still exists among rehabilitation protocols, and a widely accepted standard has yet to be established. Further research is needed to better integrate surgical and rehabilitation strategies and to support the development of rehabilitation programs that can be adapted to individual patient needs.

Keywords:

Meniscus Injury, Meniscus Repair Surgery, Rehabilitation Training

1. Introduction

The meniscus is composed of two fibrocartilaginous structures situated between the femoral and tibial condyles. It plays a key role in shock absorption, load transmission, and knee joint stability during movement. Because of its biomechanical function, the meniscus is also vulnerable to injury, particularly during activities involving repetitive loading, twisting, or high-intensity knee motion. In China, meniscal injury is a common orthopedic condition, with an estimated 5 million affected individuals. The number of cases has continued to rise in recent years, partly due to increasing participation in sports, fitness activities, and outdoor recreation.

Over the past few decades, the management of meniscal injuries has changed considerably. Earlier treatment strategies often relied on partial or total meniscectomy, whereas current approaches place greater emphasis on preserving meniscal tissue through repair and reconstruction whenever possible. The rationale behind this shift is the growing recognition of the meniscus in maintaining normal joint mechanics and long-term knee health. As a result, meniscus repair has become an increasingly important topic in orthopedic research and clinical practice [1].

Although surgical techniques for meniscus repair have improved substantially, postoperative rehabilitation remains an area of ongoing debate. Questions regarding the appropriate timing and progression of range-of-motion exercises, weight-bearing protocols, and brace use have not been fully resolved, and recommendations still vary across studies [2]. This review summarizes current evidence on rehabilitation following meniscus repair and discusses recent developments in this field, with the aim of providing a reference for future research and clinical practice.

2. Definition and Effects of Rehabilitation Training

Rehabilitation training refers to a series of interventions designed to restore joint mobility, improve muscle strength, recover weight-bearing function, and enhance movement coordination. Following meniscus repair, it is generally regarded as an important part of postoperative management. As meniscus-preserving procedures have become more widely used, increasing attention has been paid to the role of rehabilitation during recovery. In practice, rehabilitation occupies a large proportion of postoperative treatment and is closely related to functional outcomes.

Previous studies have reported beneficial effects of rehabilitation training after meniscus injury. Evidence suggests that patients who participate in structured rehabilitation programs tend to experience less knee pain, lower symptom severity, and better functional performance, regardless of differences in age, sex, or disease duration [3]. Although recovery outcomes vary among individuals, rehabilitation is widely considered helpful for symptom relief, functional restoration, and return to daily or sporting activities. For this reason, it remains a routine component of treatment after meniscus repair.

3. Strategies and Methods of Rehabilitation Training

3.1. Rehabilitation Strategies

Postoperative rehabilitation protocols after meniscus repair are commonly grouped into two broad approaches: unrestricted rehabilitation and restricted rehabilitation. Unrestricted protocols generally encourage earlier joint movement and a faster return to daily activities, whereas restricted protocols place greater emphasis on protecting the repaired tissue during the initial recovery period.

One study compared clinical outcomes between these two rehabilitation approaches [4]. In the unrestricted group (n=21), patients did not use a postoperative brace, began joint movement immediately after surgery, and progressed to full weight-bearing from the third postoperative week. In the restricted group (n=25), a brace was worn during the first six weeks after surgery. Knee motion was limited to 0–30° during weeks 0–2, 0–60° during weeks 3–4, and 0–90° during weeks 5–6. Unrestricted joint movement was permitted only after six weeks. Weight-bearing was not allowed during the first four weeks, was increased to 50% during weeks 5–6, and progressed to full weight-bearing after week six. Clinical outcomes were assessed using the KOOS and Tegner scales at 3 months, 1 year, and 3 years after surgery.

Improvements in KOOS scores were observed in both groups. Mean scores in the unrestricted group were 78, 84, and 86 at 3 months, 1 year, and 3 years, respectively, compared with 74, 80, and 81 in the restricted group. Differences between groups were statistically significant ($p < 0.05$). Similar trends were seen in Tegner scores. The unrestricted group achieved scores of 4.5, 4.3, and 5.2, whereas corresponding

values in the restricted group were 4.3, 4.2, and 4.7, with significant differences reported at all follow-up points ($p < 0.05$).

The findings suggest that satisfactory outcomes can be achieved with either rehabilitation approach. At the same time, the available evidence is still insufficient to determine whether one strategy is consistently superior to the other. In current clinical practice, many rehabilitation protocols continue to place some restrictions on postoperative range of motion and weight-bearing. As a result, relatively cautious rehabilitation remains common, particularly during the early stages of recovery.

3.2. Methods of Rehabilitation Training

Common rehabilitation interventions after meniscus repair include range-of-motion (ROM) exercises, weight-bearing (WB) progression, brace management, and related functional training. Although rehabilitation protocols differ across institutions and patient populations, ROM and WB training generally form the basis of postoperative rehabilitation. These programs are often divided into three stages according to the patient's recovery status and tissue healing process [5].

The early stage mainly involves muscle activation, pain control, and the promotion of local circulation. Isometric quadriceps contractions are commonly recommended during this period. Patients are instructed to tighten the quadriceps muscles for 10 seconds and then relax for 10 seconds, with 10 repetitions per set and 3–5 sets per day. After several days, isotonic quadriceps exercises and straight-leg raises may be introduced. A typical straight-leg raise is performed in the supine position, lifting the leg approximately 15–20 cm from the bed and holding the position for 3–5 seconds. Fifteen repetitions per set and two sets per day are commonly prescribed, usually following isometric exercises with a short rest interval.

During the middle stage, rehabilitation gradually shifts toward restoring joint mobility, increasing weight-bearing tolerance, and improving basic knee stability. Exercise selection is often adjusted according to the progress of tissue healing. Patients with slower recovery may continue to focus on knee flexion exercises, whereas those with better functional recovery can begin standing and walking activities under supervision. Common exercises at this stage include wall slides with the knee maintained at approximately 30° of flexion for 30–60 seconds, isometric hamstring contractions performed by pressing the heel against the bed, and low-resistance stationary cycling. Weight-bearing is also progressed from partial loading with crutch assistance to full weight-bearing walking. Additional activities may include step-up and step-down exercises as well as single-leg standing practice, initially with external support and later without support.

The late stage is directed more toward muscle strengthening, balance recovery, and return to normal daily activities. Rehabilitation exercises may include deeper wall slides, lunge squats, bilateral heel raises, leg press exercises, and leg curls using light to moderate resistance. Balance training can be progressed to single-leg standing on unstable surfaces such as balance pads or soft mats. Lateral stepping, forward and backward stepping, and other movement drills are often introduced to improve coordination and basic agility.

Despite the widespread use of these rehabilitation methods, considerable variation remains in clinical practice. Patients with similar injuries may receive different recommendations regarding the timing of ROM exercises and weight-bearing progression. In many cases, rehabilitation decisions are influenced not only by

published evidence but also by the treating physician's clinical experience. An analysis of FREIDA data found that among 59 rehabilitation cases involving radial meniscal tears, the mean time to full weight-bearing was 7.5 weeks, while the mean time to full ROM was 7.3 weeks [6]. These findings suggest that rehabilitation timelines are still largely individualized.

Further work is needed to clarify how rehabilitation protocols should be adjusted for different injury patterns and repair techniques. More consistent recommendations regarding the initiation of weight-bearing, the timing of early activity, and expected recovery milestones may help reduce variability in postoperative management and support clinical decision-making.

4. Factors Influencing the Selection of Rehabilitation Training Methods and Strategies

4.1. Meniscus Injury Type

Assessment of meniscal injury is usually based on arthroscopic findings and MRI examination. Arthroscopy allows direct visualization of the meniscus and generally distinguishes normal tissue, degenerative changes, and tears. MRI evaluation commonly follows the Stoller grading system, in which Grade III lesions are considered meniscal tears and are characterized by abnormal high-signal intensity extending to the articular surface.

Treatment decisions are often influenced by these findings. Patients with degenerative changes alone are frequently managed with conservative treatment or minimally invasive procedures. When a tear is present, surgical planning and postoperative rehabilitation are usually tailored to the specific tear pattern. Common tear types include horizontal tears, longitudinal tears, radial tears, root tears, and Ramp lesions.

The type of tear is one of the factors considered when determining postoperative rehabilitation. Different tear patterns show different biomechanical characteristics and healing potential, which may affect the timing of activity progression and weight-bearing. Horizontal tears are commonly associated with degeneration. Although repair can be performed in selected cases, meniscectomy remains a common treatment option. Long-term MRI follow-up has shown that anatomical healing is not achieved in as many as 41% of repaired horizontal tears, suggesting that patient selection remains an important issue in this group [7].

More cautious rehabilitation protocols are often used for unstable tear patterns that compromise circumferential load transmission, such as radial tears and root tears. By contrast, longitudinal tears and Ramp lesions generally preserve greater biomechanical stability, and earlier progression to full weight-bearing is often permitted [8]. Similar trends have been reported in sports medicine practice. A review of treatment protocols found that rehabilitation decisions were frequently influenced by the integrity of meniscal hoop stress, with more conservative programs commonly applied when circumferential tension had been disrupted [9].

A systematic review examining rehabilitation strategies after meniscus repair reached similar conclusions [10]. For longitudinal tears and Ramp lesions, in which the hoop stress mechanism remains largely intact, unrestricted rehabilitation was generally recommended. Weight-bearing of up to 20 kg was allowed during the first

four postoperative weeks, while ROM was restricted to 90°, followed by gradual progression according to patient tolerance. For radial tears and root tears, where circumferential fibers are interrupted, a more restricted approach was suggested, including non-weight-bearing during the first six weeks and ROM limited to 90°. Even so, considerable variation remains in how these recommendations are applied in clinical practice.

4.2. Meniscus Injury Location and Length

The meniscus is characterized by marked regional differences in vascular supply, and these differences are closely related to healing potential. The peripheral red zone contains a relatively rich capillary network and receives an adequate blood supply. As a result, tears in this region generally show better healing capacity and higher repair success rates. The central white zone, in contrast, lacks direct vascularization and depends largely on diffusion from synovial fluid for nutrition. For this reason, injuries involving the white zone have traditionally been regarded as more difficult to heal and more likely to fail after repair.

Recent studies have suggested that the white zone may not be entirely biologically inactive. Evidence of multipotent mesenchymal stem cells and limited microvascular formation has been reported, indicating some capacity for repair. Nevertheless, healing potential in the white zone remains substantially lower than that observed in the red zone [11]. These biological differences are often reflected in rehabilitation planning. Patients with tears located in well-vascularized regions may tolerate earlier progression of activity, whereas injuries involving poorly vascularized areas are more commonly managed with cautious rehabilitation protocols.

Tear length is another factor that may influence recovery. Longer tears are generally associated with greater tissue damage and lower healing potential, while shorter tears tend to have more favorable healing outcomes. As a result, rehabilitation programs for larger tears are often more conservative than those used for shorter lesions.

4.3. Patient-Specific Factors

Meniscal injuries frequently occur together with anterior cruciate ligament (ACL) injuries. When meniscus repair is performed at the same time as ACL reconstruction, the biological environment created by ACL reconstruction may influence subsequent meniscal healing and rehabilitation.

One study reported that, among patients undergoing both procedures, lateral meniscal extrusion width decreased by an average of 0.4 mm after surgery. Although sagittal extrusion increased, coronal extrusion was significantly reduced compared with preoperative measurements [12]. In addition, a review of published studies found an overall meniscal healing success rate of 92% in patients undergoing concurrent ACL reconstruction, compared with 63% in those who underwent meniscus repair alone [13]. The formation of intra-articular blood clots and fibrin clots during ACL reconstruction has been proposed as one possible explanation, as these structures may provide both biological stimulation and a scaffold for tissue repair. The extent to which concomitant ACL injury affects rehabilitation progression, however, remains incompletely understood.

Patient characteristics may also affect rehabilitation outcomes. Previous studies have shown that adolescents with higher body weight and BMI experience higher rates of repair failure and are less likely to return to sports or recover their pre-injury

activity levels [14]. These findings suggest that postoperative rehabilitation should not be determined solely by surgical factors. Individual characteristics, including body composition and associated injuries, may also need to be considered when rehabilitation plans are developed.

5. Conclusion and Outlook

Rehabilitation remains an important part of recovery after meniscus repair. Current postoperative programs generally follow either an unrestricted or a restricted approach, with differences mainly involving ROM progression, weight-bearing, brace use, and the timing of return to sports. The literature reviewed in this article suggests that rehabilitation decisions are rarely based on a single factor. Tear type, injury location, tear size, and individual patient characteristics may all influence the choice of rehabilitation protocol.

At present, considerable variation still exists in postoperative rehabilitation practice. Recommendations regarding weight-bearing progression, ROM recovery, and return-to-sport timing are not always consistent across studies, and some aspects of rehabilitation continue to rely heavily on clinical judgment. This is particularly evident in patients with different tear patterns, where rehabilitation timelines may differ substantially even after similar repair procedures.

Several issues remain unclear and deserve further attention. More evidence is needed regarding the appropriate timing of weight-bearing, restoration of full ROM, and return to athletic activity after different types of meniscal repair. Clearer criteria for selecting between unrestricted and restricted rehabilitation may also help reduce variation in clinical practice. In addition, the interaction between surgical techniques and postoperative rehabilitation has not been fully defined and remains an area of ongoing interest.

As meniscus-preserving procedures continue to evolve, rehabilitation protocols will likely undergo further refinement. Larger clinical studies and longer follow-up data may help clarify some of the current uncertainties and support the development of more consistent rehabilitation recommendations. At the same time, individual differences among patients are unlikely to be fully addressed by a single rehabilitation pathway, making personalized rehabilitation an important consideration in future practice.

Conflicts of Interest

The author declares that there is no conflict of interest regarding the publication of this article.

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