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Meniscus Injury Postoperative Standard Rehabilitation and Emerging Therapies

Yunxiao Ma

RCF Experimental School, Beijing, China
M13552681207@outlook.com

Abstract. Meniscus injury is a common clinical injury to the knee joint, often as a result of sporting trauma or degenerative changes. Although the main treatment modality is arthroscopic surgery, postoperative complications are frequent including quadriceps atrophy, joint stiffness and persistent pain, and with time the high risk of post-traumatic osteoarthritis is also seen, which seriously decreases patient's physical function and quality of life. Standardized postoperative rehabilitation is necessary to link the surgical intervention, support the optimal meniscal healing and regain knee joint function. This article systematically reviews conventional postoperative rehabilitation strategies for meniscus injuries, based on the latest research from the foreign literature published in the past five years, focusing on two main rehabilitation methods—exercise therapy and auxiliary physical and pharmacological treatment, and summarizing the new and emerging therapy—biological repair and intelligent rehabilitation technology. Clinical value and benefit of each therapeutic approach is analyzed quantitatively. There is considerable heterogeneity across current clinical rehabilitation protocols and emerging therapies lack evidence-based support, are not well-standardized, and are costly to implement. Future research should be directed towards the development of individualized, standardized comprehensive rehabilitation programs that aim to maximize meniscal healing safety and maximize functional recovery, minimize risk for long-term joint degeneration, and give scientific guidance for meniscectomy post-rehabilitation.

Keywords: Meniscus injury, postoperative standard rehabilitation, emerging therapies

1. Introduction

The meniscus is a very important fibrocartilaginous component of the knee joint that provides load transmission, shock absorption, joint stability and lubrication of the joint, all of which are fundamental biomechanical roles necessary for normal knee motion. Meniscus injury is a very common injury for both traumatic and degenerative knee problems globally. Epidemiological data show that around 61/100, 000 people each year develop the disease, and the overall prevalence is 12%–14%, thus it is one of the most prevalent knee disorders clinically. This type of injury is seen in different demographics, with young adults developing an acute tear from sporting injuries and the elderly developing a degenerative tear. If left untreated or if the timing or type of surgery and

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rehabilitation is incorrect, the meniscus injury can result in swelling and pain of the knee, quadriceps wasting, loss of motion, further meniscal tears, and, ultimately, post-traumatic arthritis, which can dramatically affect mobility and quality of life. At present, arthroscopic surgery, which is less invasive than standard surgery, is the standard remedy for meniscus injury. However, surgery only deals with the repair, while the rehabilitation after surgery is equally important and must be standardized to influence the quality of healing and function of the joint in the long term. As the concepts in sports medicine have developed the post-meniscectomy rehabilitation has shifted from the conservative long-term immobilization paradigm to precise, individualized, and functional rehabilitation [1]. This article have highlighted recent advances in international research over the past 5 years to systematically review the conventional and new rehabilitation techniques for meniscus injury, analyse the challenges and discuss the theoretical aspects on enhancing the postoperative rehabilitation outcomes.

2. Conventional rehabilitation therapies

2.1. Exercise-based rehabilitation

The exercise therapy is the key to post-meniscectomy rehabilitation, focusing to reduce muscle atrophy, restore joint range of motion, reestablish proprioception and scientifically manage mechanical loading on the meniscus. Phased rehabilitation model is commonly used clinically. Early postoperative interventions are mainly isometric quadriceps contractions, straight-leg raise and closed chain low load exercises, with a focus on protecting the repaired tissue, which means avoiding high grade knee flexion and rotational exercises. Restrictions on weight bearing differ widely, depending on the type of injury, as those with a torn root may need a longer period of non-weight bearing. For early-stage patients who are unable to tolerate high-intensity resistance training, BFR is an effective low-load training technique to delay quadriceps atrophy and is a valuable supplement to conventional exercise therapy. A randomized controlled trial of 112 patients with arthroscopic meniscus repair was conducted, with a 12-week phased strength and proprioceptive training intervention. At the end of the intervention, training group VAS pain score was 2.1±0.8, while the control group was 4.3±1.1, with a significant decrease in pain score in the training group. The IKDC knee function score was 86.7±5.4, which was improved over the control group score of 72.2±6.1. There was a significant increase in knee flexion and extension range, and in gait parameters like stride length and walking speed. The number of patients with joint stiffness and quadriceps atrophy trended downwards by 31.4% which is a good sign of improvement in patients' functional capacity of daily living. The benefits of standardised exercise rehabilitation have been proven in clinical research [2]. The study stressed that the duration of the postsurgery period shouldn't be the only indicator of the progress of rehabilitation; postrecovery should be judged instead by the subsidence of joint swelling and a return of muscle strength of the affected side to more than 80% of the unaffected side. One of the major risk factors for postoperative re-injury is premature return to high-intensity activities. While some exercise programs have been shown to effectively improve knee function as a result of a process of phasing, existing programs across centers are very different and there are no agreed clinical standards.

2.2. Physical and pharmacological adjunctive therapies

During the postoperative period, physical therapy and pharmacologic interventions are important adjuncts in the acute phase immediately following meniscus surgery to control postoperative

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inflammation, minimize joint swelling and pain, and encourage a favorable environment for active rehabilitation. Interventions such as cryotherapy, pulsed ultrasound, neuromuscular electrical stimulation and joint mobilisation techniques for improving local microcirculation, preventing inhibitory atrophy of the quadriceps and releasing joint adhesions are all commonly used. Eighty-two patients after arthroscopic meniscus surgery were enrolled in a randomized controlled trial to evaluate whether high-energy laser plus proprioceptive training for 10 weeks could improve a standard rehabilitation program. Results showed that there was a significant difference between the VAS pain score in the intervention group (4.23±0.63) and the control group (5.97±0.59), and the intervention group exhibited greater performance in the active knee flexion angle, gait speed and stride length. AKS knee function scores and SF-12 quality-of-life scores were significantly better, and the rate of postoperative complications was much lower at 4.88% compared to the control group at 21.95%. The patients' satisfaction with rehabilitation also rose significantly, effectively providing protection against postoperative joint adhesion and chronic pain. This approach has clearly been established as a clinical role in sports medicine [3]. Pharmacological therapy is primarily short-term use of oral or topical nonsteroidal anti-inflammatory drugs (NSAIDs) that quickly bring acute pain and inflammation under control. However the use for an extended period can impede healing of soft tissue and meniscal regeneration, therefore long-time administration is not recommended. Some patients may have a high level of fear of motion and physical and pharmacological interventions may be ineffective in controlling the neuromuscular dysfunction, thus a psychological intervention is needed to improve adherence to the rehabilitation protocol. Physical and drug therapies have shown effectiveness in the short-term in managing pain, restoring joint mobility and walking function, but have limitations in promoting the repair of fibrocartilaginous meniscal tissue.

3. Emerging advanced therapies

3.1. Biological regenerative approaches

Biological regenerative therapies have become a big research priority in recent years, considering the poor healing potential of the avascular zones of the meniscus and the difficulty of conventional rehabilitation in promoting a healing response. The major techniques involve platelet-rich plasma (PRP) injection, mesenchymal stem cell therapy and its use as intra- and postoperative adjuncts. PRP contains high levels of growth factors and releases them to promote fibrochondrocyte proliferation and optimization of the microenvironment for repair, thereby promoting meniscal healing at the tissue level. This overcomes a problem with traditional rehabilitation that helps restore function, but not cartilage defects. Randomized controlled trial of 96 patients undergoing meniscal surgery suturing PRP to the experimental group during surgery, and a standardized 12-month post-operative follow-up. The results indicated that the total healing rate of the meniscus of the experimental group was 81.25%, while that of the control group was 62.50%, clearly showing that it was significantly higher than the control group. The experimental group scored 88.4±6.7 on the IKDC score at 12 months following surgery, which is significantly better compared to the control group, which scored 79.6±7.2. Moreover, VAS pain scores were found to be continuously decreasing and radiographic progression of cartilage degeneration in the knees was significantly slowed, indicating better long-term knee protection. Based on relevant evidence-based studies, it has been demonstrated that [4]. But the effectiveness of this therapy is still not a fact as other studies suggest that the effectiveness of PRP can depend on the method used to prepare it, the time of treatment and also the type of injury, with some instances not seeing any major benefit clinically [5]. In animal experiments, stem cell therapy has shown very promising potential for cartilage repair,

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differentiating effectively into fibrochondrocytes and repairing cartilage. But there are still not enough high quality clinical RTCs and the dosage/delivery systems and target groups are not yet standardized. Further long-term follow-up data are needed before it can be used routinely in clinical practice.

3.2. Intelligent new rehabilitation technologies

As digital health care advances intelligent rehabilitation technology including remote rehabilitation apps, virtual reality (VR) training systems, electromyography biofeedback and wearable sensors are increasingly being incorporated into post meniscectomy rehabilitation, overcoming many problems with traditional home rehabilitation, namely lack of uniformity, patient compliance and lack of professional input. Multicenter clinical studies have demonstrated the clinical value of intelligent rehabilitation [6]. Electromyography biofeedback technology can help real-time monitoring of muscle activation status, improve training precision, correct the delayed vastus medialis activation and knee extension lag [7]. VR immersive training can real-time correct abnormal knee biomechanics and improve proprioceptive recovery. Progressive weight bearing training is possible by using lower limb exoskeleton robots, although the technological costs and lack of availability have so far restricted their use to a few specialized centres and research facilities. Meanwhile, remote digital rehabilitation can effectively facilitate the athletes' recovery to sport by offering their functional recovery program in a personalized manner [8]. These smart rehabilitation devices break the previous constraints of time and space, improve the accuracy and standardization of rehabilitation training. However, there are issues with accessibility to the devices and uniformity of technology.

4. Challenges / limitations

The existing post-meniscectomy rehabilitation protocols continue to have many drawbacks. First, there is no standardization of rehabilitation protocols and no standardized high-level evidence-based guidelines for the optimal rehabilitation strategies, based on injury type, surgical technique or age of the patient [9]. The treatment for injuries in the avascular zone is especially controversial. Second, the evidence for biological repair therapies is inconsistent: the clinical outcomes of PRP and stem cell treatments vary, standards of intervention vary, and the costs of treatment are still high, so these therapies are not widely adopted. Long term data corroborating their effectiveness in the prevention of osteoarthritis are also lacking. Thirdly, there are some practical obstacles in the implementation of intelligent rehabilitation. Smart terminals are used at digital devices and are problematic for older patients and those who aren't digitally literate. The majority of consumer devices are not medically certified and have poor data accuracy. Lastly, patient compliance is poor, with fear of motion and pain avoidance causing low completion rates of home exercises, and thus compromising rehabilitation. Furthermore, a quantitative consensus of when an athlete or general patient should return to sport is lacking, and so it is hard to accurately prevent re-injury [10]. While there is evidence for weight-bearing rehabilitation, there is still a need for safe weight bearing thresholds for various injury types that need to be further refined and validated [11].

5. Conclusion

In summary, the conventional rehabilitation strategy which focuses on the use of phased, individualised exercise therapy in addition to physical and pharmacological management of the condition is still the cornerstone of clinical postoperative rehabilitation for meniscus injuries.

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Effective for improving short-term knee pain, joint ROM and FMS and decreasing postoperative complications. The limitations of traditional rehabilitation in the fields of tissue repair and the standardization of home-based recovery can be overcome by biological regenerative therapies (such as PRP and stem cell treatment) and by intelligent rehabilitation technologies based on digital remote monitoring, virtual reality and biofeedback, which offer new paths to improve the long-term results of rehabilitation and delay the onset of cartilage degeneration. However, there are challenges emerging therapies have to overcome, with the need for standardization and evidence-based data, and the need to implement them on a widespread scale, and so these therapies cannot replace conventional rehabilitation. Larger-scale, multicentered, randomized controlled trials should be performed in the future to establish standardized procedures for new therapies. A comprehensive rehabilitation model, that includes both traditional and innovative approaches, should be implemented, tailored to the individual needs of the patient, the injury profile and functional needs. This will provide optimal recovery of knee function and promote safe meniscal healing as well as reduce the risk of secondary osteoarthritis.

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