Return to sport after ACL reconstruction: how, when and why? A narrative review of current evidence

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Abstract

Allowing a patient to return to sport and unrestricted physical activity after ACL injury and reconstruction is one of the most challenging and difficult decisions an orthopaedic surgeon has to make. Indeed, many factors have to be taken into account before it can be considered safe for a patients to load a reconstructed knee.

The current literature contains plenty of studies aimed at evaluating return to sport, and the factors that may affect or predict this outcome, e.g. intrinsic factors like genetics, biology, type of lesion, anatomical features, motivation and psychology, and extrinsic factors such as graft type, surgical technique, rehabilitation protocols, and biological support. It is possible that awareness of these issues could help the clinician to optimise outcomes, and possibly avoid failures too, although as yet no universal criteria for resuming sport have been produced.

Key Words: anterior cruciate ligament, injury, knee, rehabilitation, sport.

Introduction

Practising a sport is among the most complex and demanding activities for the human body and in particular for the musculoskeletal system and joints. When an injury occurs, it stops the perfect machine

that is the human body, which must then be restored to almost perfect condition in order to allow resumption of sports activity. When the anterior cruciate ligament (ACL) is injured, ACL reconstruction is usually considered the gold standard of treatment, especially in active young patients. However, it is also necessary to consider various interconnected aspects (anatomy, biomechanics and psychology) relating to the patient-athlete, as these can contribute to determine the outcome of the ACL reconstruction, which can range from successful to disastrous.

Allowing a patient to return to sport and unrestricted physical activity after ACL injury and reconstruction is one of the most challenging and difficult decisions an orthopaedic surgeon has to make. Indeed, many factors have to be taken into account before it can be considered safe for a patient to load a reconstructed knee. Moreover, return to sport itself is a controversial outcome measure when evaluating the success or failure of an ACL reconstruction procedure.

The current literature contains plenty of studies aimed at evaluating return to sport, and the factors that may affect or predict this outcome. Nevertheless, the most recent and influential meta-analysis on this topic by Ardern et al. (1) depicted a controversial scenario, as only 82% of patients who underwent ACL reconstruction were able to resume sports activity. The percentages were even lower when considering those who returned to their pre-injury level of participation (63%) and those who returned to competitive sports (44%), even though approximately 90% of patients presented normal or nearly normal knee function.

Although many factors have been suggested to explain this inconsistency, stringent evidence is lacking. Czuppon et al. (2), in a well-conducted systematic review, summarised all the available literature on this topic, and found that there exists weak evidence sup-

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porting pain, quadriceps torque, effusion, ROM, instability, kinesiophobia, athletic confidence, and self-motivation as factors having an influence of the ability to return to sport. Conflicting evidence was found as regards the effect, on this outcome, of hamstring torque, the hop test and IKDC and Lysholm scores, thus confirming the lack of clear evidence in this field. The aim of this narrative review is therefore to present all the issues that should be taken into account before allowing an athlete to return to unrestricted activity and the factors that could affect the return to sport outcome. Finally, we present the most widely used criteria for return to sport, based on current literature trends.

Intrinsic factors

The decision to allow an athlete to return to sport should be based first of all on a series of intrinsic factors, that depend exclusively on the patient himself. Each patient is unique and therefore generalisation of rehabilitation protocols could lead to unsatisfactory outcomes. Awareness of the following aspects could help clinicians to optimise outcomes and possibly avoid failures as well.

Genetics/biological response

Every patient has his own specific genetic makeup and biology. This should not be neglected, as lack of incorporation of the graft and biological failure are well-recognised causes of poor outcomes after ACL reconstruction (3). Moreover, graft healing, measured by graft signal intensity on magnetic resonance imaging (MRI), has been shown to affect anteroposterior (AP) laxity and clinical or functional outcomes (4). Therefore, the clinician should be aware that graft maturation is a slow process that can even take longer than two years (5, 6), and must be sure that it is complete before allowing activities that could stress an incompletely remodelled graft.

Type of lesion

The lesion pattern and concomitant injuries can also influence return to sport and other outcomes. First of all, the menisci have been demonstrated to interact closely with the ACL contributing to increased stability *in vitro*. Medial meniscus deficiency is responsible for increased stress on the ACL during AP tibial translation (7), while lateral meniscal deficiency is respon-

sible for increased rotational laxity during the pivot-shift manoeuvre (8). Therefore, meniscal deficiencies should be considered, in order to identify patients with higher laxity and a potential risk of failure.

A similar rationale could be applied when dealing with combined laxities. In fact, even though residual valgus laxity after ACL reconstruction with concomitant conservatively treated grade II medial collateral ligament (MCL) lesions has been shown not to affect AP stability (9, 10), grade II MCL lesions were recently recognised as a risk factor for ACL failure with an odds ratio of 13 (11). Lesions of the lateral side of the knee should not be neglected either, as *in vitro* ACL reconstruction alone does not completely restore knee stability in cases of concomitant ACL and posterolateral corner (PLC) lesions (12). Moreover untreated PLC lesions have been demonstrated to increase the risk of ACL failure and to worsen outcomes (13).

A similar concept, with regard to the need to take into account individual characteristics and lesion patterns, that of "pre-operative laxity". It has in fact been demonstrated *in vivo* that ACL reconstruction is able to reduce AP laxity regardless of the pre-operative laxity value, while rotational laxity shows higher post-operative values in patients with higher pre-operative laxity (14).

Finally, concomitant lesions such as cartilage injuries, are a fundamental variable in the final return to sport decision, as even isolated cartilage procedures like ACI or microfractures usually need a longer recovery time compared with ACL reconstruction, i.e. about 8-12 months even in competitive athletes submitted to aggressive rehabilitation (15, 16). The controlled weight bearing and ROM limitation necessary to ensure initial cartilage protection are the most important factors that could slow down the recovery of physical activity.

Anatomical features

Anatomical features, too, can potentially affect outcomes. Indeed, morphological knee parameters such as tibial slope, notch width, and femoral condyle shape have been correlated with increased risk of ACL injury, ACL reconstruction failure or post-operative laxity (17). Furthermore, with regard to knee alignment, varus deformity has been demonstrated to increase tension on the ACL (18).

Compliance with the rehabilitation protocol

Obviously, in order to allow a safe return to sport and

maximise the patient's outcome an appropriate rehabilitation protocol is crucial. However, if the patient fails, for different reasons (e.g. logistic or psychological) to comply with it adequately, this could compromise his ability to return to unrestricted physical activity or delay the whole rehabilitation process.

Motivation

This is another crucial factor that could jeopardise a successful reconstruction and rehabilitation outcome. In fact, patients' motives for sports participation and motivational orientation have been found to correlate with post-operative pain, symptoms, type of sports activity and participation in low or high risk sports (19).

Psychological attitude

Apart from motivation, the patient's character and psychological attitude could also affect ACL reconstruction outcomes. Indeed, several psychological scales have been reported to predict the ability to return to sport; this is confirmed by evidence that the reason for abandoning sport may not be related to objective knee problems but rather to psychological issues such as fear of re-injury, family or personal problems, or other factors (20, 21). In this regard, a psychological intervention was recently demonstrated to improve clinical outcomes after ACL reconstruction, highlighting the importance of the patient's psychological state (22).

Extrinsic factors

There are other several important factors related mainly to technical issues and the choice of graft that may affect the final outcome and should therefore be taken into consideration, helping to guide the clinician through the return-to-sport decision process.

Type of graft

This is undoubtedly one of the most debated and controversial issues of the whole ACL reconstruction field. It is well known that there is no such thing as the ideal graft, as each graft has advantages and disadvantages. One of the crucial aspects to consider in relation to the graft is its maturation. It is in fact well known from histological studies that autografts like bone-patellar tendon-bone (BPTB) grafts and hamstring grafts show quite rapid healing compared with allografts (5, 6,

23). During the graft healing and maturation process the graft undergoes an initial phase of necrosis, followed by fibroblast proliferation and reorganisation. These initial phases could constitute a particularly delicate moment in the rehabilitation protocol, as the graft may be not ready to withstand the stress of certain athletic actions and movements. Also the integration between bone and bone (in the case of a BPTB graft) or bone and ligament (in case of a hamstring graft) can affect the initial stability of the reconstruction and therefore make it unsafe to perform aggressive physical exercises.

Despite these differences between allografts and autografts, the most recent meta-analyses, when irradiated allografts were excluded, did not find significant differences in term of clinical scores, stability and failures (24). Furthermore, another systematic review did not report noticeable differences in time to return to sport based on the type of graft, with most of the studies reporting values of 6-9 months (25). Finally, the few studies that have compared the return to sport rate between different grafts reported controversial and inconclusive results (26, 27).

Despite this lack of evidence, from a practical point of view, graft-specific rehabilitation could be warranted in order to avoid donor site morbidity or risk of early failure.

Surgical technique

This is another much debated variable that could influence the success of an ACL reconstruction. Single- or double-bundle techniques, or the use of additional lateral plasty, have been often compared in order to identify the technique showing the best performance; however, when sports activity is considered, the results are still controversial. Zaffagnini et al. (28) reported a higher rate of return to sport and faster recovery in patients treated with double-bundle compared to single-bundle reconstruction. Dejour et al. (27) showed that lateral plasty had no effect on the return to sport rate, while Zaffagnini et al. (26, 29) reported better results for lateral plasty compared with isolated single-bundle reconstruction.

Rehabilitation phases

Since the introduction of the "accelerated rehabilitation" concept by Shelbourne and Gray (30), being able to return to sports activity as fast as possible has become a vital goal, especially for high-level athletes.

Therefore patient-tailored rehabilitation protocols have been developed, structured in progressive phases – specific goals rather than temporal criteria must be met in order to progress from one phase to the next –, and involving on-field rehabilitation with sport-specific movements and actions (31). Application of these principles allowed professional athletes to return to sport as soon as three months after ACL reconstruction (32). However, caution should be used, as early return to sport has been demonstrated to be related to ACL failure, in cases of primary reconstruction with allograft tissue (33).

Biological support

Since maturation of the graft is a crucial process during the recovery after ACL reconstruction, several studies have examined the issue of how to improve graft healing. Radice et al. (34) reported that application of a platelet-rich plasma gel to the ACL graft significantly reduced the graft maturation time measured on the basis of MRI. On the other hand, Del Torto et al. (35) showed that the use of a similar platelet-rich fibrin matrix did not produce significant differences in the results of clinical and objective assessments. However, future studies should be performed in order to establish the product, dose and timing that might best promote graft healing and therefore potentially shorten the recovery time after ACL reconstruction.

Return-to-sport criteria

Given the numerous variables that can interact and play a minor or major role in the decision to allow a patient to return to sport, it appears quite obvious that the rehabilitation and eventual return to sport should be a progressive and patient-tailored process.

In an interesting systematic review (25), Barber-Westin and Noyes found that, in most of the 264 studies included, the sport resumption decision was based on subjective non-specific criteria such as “regained full functional stability”, “normal knee function on clinical examination”, “good/normal/satisfactory stability” or “close to full ROM and muscle strength”. When objective criteria were considered, time since surgery, muscle strength, ROM and effusion were the ones most frequently used. As regards the first of these criteria, the vast majority considered 6 months as a cut-off value for allowing sport resump-

tion, without major differences emerging between grafts. This trend was confirmed by a survey of 211 expert surgeons, members of the German Arthroscopic Association (AGA), most of whom allowed sport-specific rehabilitation after 4 months, return to training between 4 and 6 months, and return to competitive sports after 6-8 months (36). As regards muscle strength, the cut-off value of >90% isokinetic strength compared to the contralateral side was the criterion most used, followed by lower values of the same parameter (>85%, >80%) or different parameters, such as a quadriceps index >90% and weighted leg extension >90% (23). The same AGA survey confirmed the trend reported by Barber-Westin and Noyes, identifying ROM, the Lachman test and the pivot shift test as the most widely used objective criteria, and finding a surprisingly limited use of validated clinical scales (36). The rationale for the use of such scales is summarised by the study of Jang et al. (37), who noted significantly worse muscle strength and rotational stability in athletes who were not able to return to sports activity.

The trends and evidence here reported certainly highlight the need for precise objective measurement criteria, and future efforts should therefore be focused on the improvement or development of tools designed to measure and quantify patient performance. Recently there has been considerable interest in quantification of the pivot shift test, with the development of methods using, for example, accelerometers, image-based software, tablets and an iPad application to measure acceleration or tibial translation during the pivot shift manoeuvre (38, 39). Future studies will be focused on motion analysis of specific athletic movements and actions.

The last important variable, often neglected in clinical studies, is the type of sport practised by patients. In fact an analysis from the recent literature highlights a quite surprising lack of sport-specific outcomes of ACL reconstruction. Warner et al. (40), in their systematic review, cited only eight studies reporting the outcomes of ACL reconstruction in patient cohorts involved in a single, specific sport. The results revealed, albeit with a limited level of evidence, different rates and timing of return to sport for different types of sport (higher in activities like cycling and jogging compared with cutting and jumping activities). It is clear, therefore, that there is plenty of room for improvement in this field: evidence-based sport-spe-

cific rehabilitation protocols need to be developed and evaluated in order to achieve the best outcomes for each athletic population (41). In this regard, Zaffagnini et al. (42), using a sport-specific programme, showed promising results in the treatment and rehabilitation of professional soccer players, with return to training at 6 months in almost 80% of patients, compared to 40% and 37% in other similar cohorts (43), and return to official matches at a mean of 186 days after surgery.

Conclusions

The decision to allow a patient to return to sport is still a challenge for the clinician. The available evidence is inconsistent and the variables involved are multiple. Therefore, no standardised criteria should be applied to each patient indiscriminately. Instead, it would be preferable to apply patient-tailored rehabilitation protocols and return-to-sport criteria, based on individual characteristics. In conclusion, future efforts should be directed at improving the objective evaluation of patient performance, in order to measure the variables most likely to affect the patient's ability to perform unrestricted physical activity.

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