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Upgraded hardware—What about the software? Brain updates for return to play following ACL reconstruction

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The 'release for full activity' or the determination of 'return to sport' (RTS) is an important landmark for any athlete following anterior cruciate ligament reconstruction (ACLR). The 'clearance' to RTS following ACLR is not the golden ticket back to safe and successful preinjury level activity. Unfortunately, the 'cleared' status is accompanied by an up to 40-fold elevated risk of second ACL injury (relative to peers without a history of ACL injury) despite accepted 'time' postsurgery.¹

Why Rely on 'Time' as a Clearance Criterion?

The reliance on *time* since surgery is too common, with the majority of investigations using time postoperative as a key criterion for RTS. Even more concerning, one-third of the investigations indicated that time from surgery was the *only* determinant for RTS decision-making.² The insistence of a time-based and accelerated RTS may be heightened with pressures from coaches, parents and/or teammates to meet specific sport timelines. However, reliance on time as distinct from function to drive sport reintegration contributes to the gap between the athletes' perceived versus actual sports readiness.

Enough of Graft Type, Tunnel Placement and Anchor Strategies

Historically, little attention has been focused on late-phase rehabilitation and RTS strategies, but why? *The current literature is heavily weighted in surgical outcomes related to graft type, tunnel placement and anchor strategies* A very important randomised trial of 330

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patients that compared two types of ACL reconstruction found that younger age (a surrogate for return to sport) explained more of the risk of re-rupture than did the surgical approach. This was the case for re-ruptures, re-injuries and revision outcomes.³ As recent evidence indicates, successful RTS hinges less on surgical intervention (as exceptional advancements have been achieved in this arena) and more on criteria-based rehabilitation progressions.⁴ We note that the surgeon in the large RCT was an experienced expert —among the very best in North America. Clearly poor surgery will compromise outcomes; when surgery is performed by experts, what else can an athlete do to mitigate the risk of re-rupture?

Which Rehabilitation Factors are Key?

As noted in the paper from Kyritsis *et al.*,⁴ athletes who do not meet the functional discharge criteria before returning to sport are at four times greater risk of sustaining an ACL graft rupture compared to those who met all six RTS criteria. However, only 33% of high-level athletes achieved the functional criteria before returning to play, indicating the need to improve compliance with RTS training.⁵

The neuromuscular deficits associated with the original injury are magnified by the bilateral asymmetry in knee loading after injury and reconstruction; these deficits persist months after RTS. Release to full activity and RTS are too often influenced by temporal guidelines relative to time from surgery and subjective opinion, despite the strong evidence for the use of functional performance to guide decision-making.² Compounding the issue further of high re-injury rates when athletes RTS, only over slightly half of the returning athletes return to the same competitive level.⁶

ACL is Much More than Hardware, So Give the Software a Chance to Operate too

We now know that ACL provides more than simple mechanical stability, and the injury and recovery process has systemic neuromuscular effects. Therefore, only reconstructing the mechanical structures of the knee and then sending the athlete back to sport ‘when it’s time’ produce unsuccessful outcomes. Rehabilitative interventions are needed to restore dynamic knee stability after ACL reconstruction. However, looking beyond the knee for optimal development of dynamic knee stability may be warranted. As rehabilitation strategies have evolved, we have seen the field grow to accept the role of proximal muscles such as the hip rotators and trunk frontal plane stabilisers as key target for rehabilitation. Emerging evidence indicates that ACL injury induces a mild neurological insult to the central nervous system (CNS), causing neuroplastic changes due to the lost mechanoreceptors, pain and developed motor compensations.⁷⁸ Neuroplastic disruption likely begins immediately after ACL injury (and perhaps even before as the non-contact mechanism is a motor coordination error) and progresses until altered motor strategies become the norm. Restoring baseline function becomes a fight against maladaptive neuroplasticity developed in the wake of the altered CNS input and subsequent motor output compensations.⁹ What does the future hold as it relates to advancing ACL RTS management? The answer could rely on evolved neuroscience technologies that can now add the brain as a key rehabilitation target.

Explaining the Brain's Role after ACL Injury

The neural computations that generate displayed strength or injury risk movement profile are typically left out of the return to play therapy, limiting our ability to improve the patient's chance to successfully pass the RTS criteria. Rehabilitators need to better challenge the brain during training to transfer gains from the clinic to activity.⁹ Maintaining neuromuscular control in challenging sporting environments compounds the neurocognitive complexities and computations the CNS must undergo. Future ACL rehabilitation may integrate visual-spatial-cognitive-motor training to support neuromuscular optimisation. Recent technology, for example, that incorporates realtime detailed, external focus and implicit feedback, has the capability to induce adaptive neuroplasticity and improve coordination strategies.¹⁰ Considering *brain* dynamics in musculoskeletal rehabilitation is an untapped arena. We think that it might be *time* to move beyond temporal determinants of ACL rehabilitation, and we look forward to the exciting future of neuroscience applications in sports medicine to optimise outcomes.

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