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Abstract
In the UK, approximately 35 cases of ACL injury per 100,000 people occur annually[1]. 40% of all sports related knee injury involves ligament damage, 59% of which involves the ACL[2]. ACL originates from the anterior tibial plateau and runs superiorly, posteriorly to the lateral femoral condyle. It consists of an anteromedial and posterolateral bundle. ACL resists anterior translation, medial and lateral rotation of the tibia. ACL injuries arise from sudden rotation, putting the knee in an unnatural position. It can cause injuries to surrounding tissues such as menisci, increasing the chance of future OA development[3]. Decisions on graft selection and whether it should be a single or a double graft remain unsolved. Methods of improving and reducing rehabilitation time are debated constantly. The evolution of ACL management is outlined below, followed by discussions about reconstruction methods, alternative therapies and reflections on clinical experience from patients recovering from ACL injuries.

Key Words
ACL Injury; Management; Reconstruction; Single Bundle; Double Bundle

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Background

ACL injury management has revolutionised since the first reported treatment in 1837 by Robert Adams[4]. Throughout the late 19th century, clinicians had gained knowledge about symptoms associated with ACL injury. Up until 1900, clinicians managed the injury conservatively and were reluctant to perform an open surgery.

In 1900, the first repair was performed by Mayo Robson who sutured both cruciate ligaments in a 41 -year-old miner. His knee was reported as 'perfectly strong' after cast immobilisation postoperatively[5]. Suturing was widely criticised, especially by Ernest Groves who believed suturing failed to restore function and the only reliable management was to use natural cicatrical tissue[6]. In 1916, he performed the first ACL reconstruction by securing the fascia lata onto the tibia via a bone tunnel. Galeazzi then discovered using a semitendinosus tendon as an autograft for a new ACL[7] in 1924 which initiated numerous experiments over the next few decades to find alternative autologus tissue graft such as patella and quadriceps tendon. Synthetic graft was wrongly believed to be more durable and equipped to withstand stress during the 1980s, and was soon disregarded. Arthroscopic technique was discovered by Jackson and Dandy which reduced invasiveness and infection. The current gold standard recruits either a patella or hamstring tendon graft.

Methods

MEDLINE, PubMed and Google Scholar were used to locate resources. Single Bundle vs Double Bundle literatures were searched using terms: ACL reconstruction.exp (1683 results), bundle.m_titl (7433). Both terms were combined to form 215 results, and filtered to 11 relevant articles. Hydrotherapy and cryotherapy studies were derived from descriptive search terms: alternative ACL management, knee kinetics, motion, muscle performance. Literatures were selected based on hierarchy of evidence reliability, samples size, bias, sufficient blinding, relevance to ACL rehabilitation, validity, presentation of results and creditability.

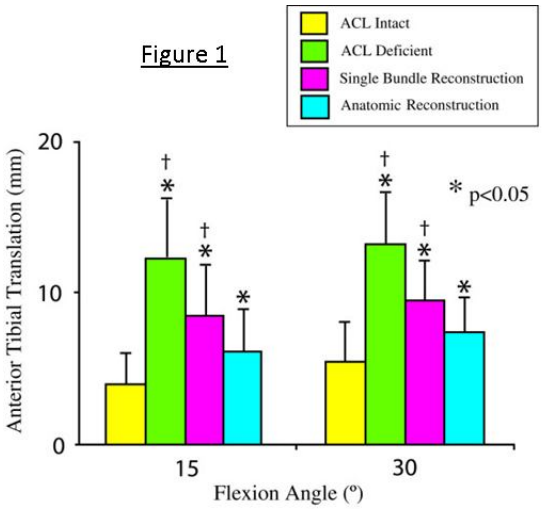
Literature gave efficacy of ACL management based on knee kinetics, but rarely accounted for patients' emotions towards different management plans, therefore limiting the holism required to understand rehabilitation from a patient's stance. To build upon literatures reviewed, an innovative approach was taken and ACL hydrotherapy clinical experience was arranged to provide extra dimensions in understanding rehabilitation regime as feedback on efficacy in pain and symptoms management, personal satisfaction and limitations in daily activities

were given.

Single or Double Bundle?

Conventional ACL reconstruction restores the anteromedial bundle, whilst limiting the restoration of the posterolateral bundle. The double bundle (DB) tension pattern of ACL was discovered as early as 1832 by the Weber brothers, but was not acknowledged until 1982, when Mott[8] created two tunnels in the femur and tibia to pull through the semitendinosus tendon for a DB reconstruction, but without any follow-up nor outcome measures to compare DB to a single bundle (SB). Mott had recognised that, if he replicated both bundles, it would restore the knee closer to its original anatomical state.

Figure 1



Results

In a retrospective non-randomised case-control study[9] from 1992-1996, 56 patients treated with SB and 79 with DB ACL reconstruction were compared following a minimum of 24 months. 34% of SB group were still Lachman test positive, compared to 13% in DB group. KT-1000, a device to assess the amount of anterior knee translation between 20 to 30 degrees of knee flexion, was used as a measure of ACL function and showed an anterior laxity of 2.7 ± 2.3 mm (95% CI) in SB compared with 1.9 ± 1.9 mm (95% CI) in DB. A normal ACL should show anterior laxity of less than 3mm.

A more recent prospective randomised 5-year study by Suomalainen[10] allocated 90 patients equally into three groups for SB reconstruction with either bio-absorbable screw or metallic screw or DB with bio-absorbable screw. Clinical examination, KT-1000, Lysholm knee score and radiographic imaging were used to analysis the outcome. Postoperatively, seven patients with SBB (bio-absorbable), three with SBM (metallic) and one with DB had graft failures ($P < .043$). In a 5-year follow-up, 30% of DB developed osteoarthritis and 51% in SB group. Figure 1 [11] is derived from examining knee kinematics in 10 cadaveric knees by external loading conditions and demonstrates DB reduces anterior translation more than SB.

Discussion

Muneta et al. defined two intervention groups with a clear purpose to measure the efficacy of both techniques. Patients were drawn exclusively from the hospital due to their condition (ACL rupture) with no intention of recruiting a randomised group from the population which induced selection bias. Controlling selection criteria such as damage to their ACL, same surgeon and rehabilitation protocol would be difficult unless it was a RCT. Suomalianen et al. found DB lowers the chance of graft failure and radiographers concluded less osteoarthritis would develop from DB graft. However, it showed no significant statistical difference between SB and DB in Lysholm and laxity score (derieved from KT-1000), contrasting to Muneta et al.. Bias was minimised by triple blinding, confounders were eliminated as one surgeon performed all surgeries with the same rehabilitation protocol. 14 patients were unable to be followed up five years postoperative.

Similar outcome measures were used in both literatures, but did not result in parallel findings on knee mechanics post ACL reconstruction. There are many factors for the differences in outcomes and further research with bigger sample size and longer follow-up can show if differences between both literatures were significant. Both studies indicated DB resembles a more natural ACL than SB as DB allows a wider contact area between graft and bone. Evidence for DB superiority over SB is insufficient, therefore, rotatory stability, long term outlooks and comparisons with other reconstruction techniques such as bone-patella tendon-bone graft should be implemented to establish the clinical utility of DB reconstruction.

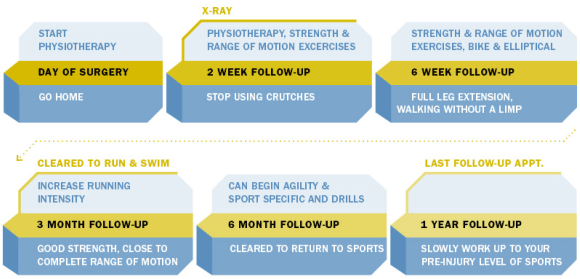
Rehabilitation Programme

Objectives of rehabilitation include swelling control, recovery of range of motion and improving stability. Nowadays, post-operative rehabilitation begins as soon as the patient wakes up from anaesthesia to reduce stiffness by passive motion. Neuromuscular electrical stimulation is used to reduce muscle atrophy and to begin the process of quadriceps strengthening. Rehabilitation is just as important as the surgery itself. If a patient does not follow the protocol then reconstruction should be rejected because the quality of outcome is dependent on physiotherapy.

A typical timeline of rehabilitation is shown[12].

Can alternative therapies improve rehabilitation?

In addition to the normal rehabilitation protocol, alternative methods such as cryotherapy, hydrotherapy and shockwave therapy are popular.



Results

Cryotherapy is a low cost method to alleviate pain and swelling in early rehabilitation due to the physiological effects of low temperature on tissues damage. In a RCT[13] with 25 post-surgery patients, 10 patients were selected for the intervention group and a control group of nine patients, with six patients failing to meet the selection criteria. Normal rehabilitation protocol set by the hospital was followed by both groups. Intervention group received an ice pack to place on the affected knee for 20 minutes after each physiotherapy session (2x daily). Pain intensity was measured by Visual Analog Scale, knee flexion and extension by goniometry. There were significant differences in outcomes when comparing intervention against control. Pain satisfaction improved by 47%, flexion increased by 9.1° and extension by 4.3° when using cryotherapy compared to the control.

Discussion

Characteristics of participants were similar: all male, same type of graft. ROM was examined by one clinician and sufficient blinding took place to ensure reliability. Pain is an unpleasant sensory state and tolerance will vary between individuals. VAS is a subjective scale, but provides vital information on the effects of cryotherapy. It can only represent an individual's perception of pain at a certain time, therefore diminishing reliability. Nevertheless, VAS provides good indication of patient satisfaction in treatment. Patients experienced a bigger range of movement, less inflammation and pain following cryotherapy treatment, highlighting the benefits of a simple ice pack in restoring function and accelerating recovery.

Results

Hydrotherapy involves doing exercises such as squats, lunges and step-ups in a warm water pool. In a RCT[14], 10 patients were treated with pool rehabilitation and 10 patients with land rehabilitation for eight weeks post-surgery. Different outcome parameters were measured at the end of rehabilitation. Both groups showed a significant decrease in mid-patella girth with an increase in quadriceps muscle girth in land rehabilitation patients. Pool rehabilitation gave a mean Lysholm score of 92.2 (SD=4.31) and land rehabilitation with 82.4 (SD=12.36) (P=0.03).

Discussion

The increase in muscle girth may not represent a true muscle girth as joint effusion will affect the size of muscle at the point of measurement. It is more likely that land rehabilitation elicited more stress on the knee, thus leading to more joint effusion and a false increase in muscle girth. A big difference in Lysholm score indicated patients were more comfortable with doing daily living activities, pain management and had an increased physical tolerance by reducing joint effusion and avoiding overstress of the graft through warm water exercises. A relatively high SD in Lysholm score reported by land exercise patients may represent high variability and signifies confounding variables other than rehabilitation method choices are contributing to their knee function.

Conclusion

At the moment, there is not a distinctive answer for the best intervention because not all injuries are identical. Studies show DB ACL has certain advantages over SB reconstruction by returning the knee to a more natural anatomy and kinematics. Future research should focus on comparing knee performance such as daily functional activities between both interventions to provide a holistic answer. Evidence from rehabilitation studies show alternative methods can improve recovery in terms of reducing time and regaining function. Consequently, it will be beneficial to patients if alternative therapies can be combined with conventional physiotherapy in the future.

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