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Case Studies

Adductor tendon avulsion repair with associated rectus abdominus, gracilis and adductor brevis injury: A rehabilitation case study in an elite rugby union player

Fearghal Kerin[1,2], Garreth Farrell[2]

[1] School of Public Health, Physiotherapy and Sports Science, University College Dublin, Dublin, Ireland, [2] Leinster Rugby, Dublin, Ireland

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Adductor muscle strains and chronic adductor related groin pain have been described frequently in the published literature. There is less discussion however regarding adductor longus tendon avulsion injuries, making rehabilitation more difficult. This case report details the repair and rehabilitation of a 25-year-old elite professional rugby player following an adductor longus tendon avulsion during a competitive fixture. Video review confirmed forceful abduction in a position of hip flexion. Subsequent imaging confirmed a complete adductor longus tendon avulsion, with concurrent injuries to the adductor brevis and rectus abdominis attachment. This case report presents the surgical intervention 9 days following injury and subsequent rehabilitation. Rehabilitation was based on current research in tendon loading, and included strength training, isometrics, heavy slow resistance, neuromuscular control training and field-based conditioning. Outcome based measures of pain, strength, range of motion and function were defined, and used to guide progress. The player progressed to unrestricted training 58 days following injury and returned to play at 69 days. This case report adds to the existing publications in this area by integrating current concepts in progressive criteria-based rehabilitation. It demonstrates that accelerated rehabilitation and safe return to play following surgical repair in an elite athlete can be achieved using a criteria-based approach.

INTRODUCTION

The most common injuries to the adductors are chronic adductor related groin pain (CAGP), and strains of the adductor muscles occurring at the musculotendinous junction.[1,2] Such injuries are seen across all sports, although, common in field-based sports that involve sprinting, kicking and change of direction.[3–5] The third highest incidence of muscle injury in rugby union matches are adductor strains, most typically during twisting and turning actions.[3]

The adductor muscle group includes the adductor longus (AL), adductor brevis, (AB) adductor magnus, pectineus, gracilis and obturator externus. The adductor longus has a fibrocartilaginous enthesis, with a completely tendinous insertion. It has been reported that 3mm from the insertion at the pubic bone, the AL is more than 90% tendon tissue.[6] The AB originates inferior and posterior to the AL upon the pubic bone. Although injuries to the adductor muscles are common, injuries involving the proximal tendon are less prevalent.[1] AL tendon tears at the proximal origin, or avulsions, are infrequently described in the published literature with small case series,[7–13] case reports[14–19] and a single systematic review[20] guiding management. Grading of injuries from Grade 0 (no acute muscle injury) to Grade 3 (high grade muscle tear) remains the most frequently used at the adductor muscle group.[1] Mueller-Wohlfahrt, et al.[21] have extended this scale to include a Grade 4 classification to include complete avulsions in their *Munich Classification*.

Both conservative and surgical approaches to management have been advocated in the existing literature. It has been suggested however that osseous avulsions,[16] injuries involving the rectus abdominis attachment[9,19] or those with significant retraction (>2cm) require surgical intervention.[8,11,16] Although, conservative management has been shown to be successful at 12 months follow up[12,14,17,22,23] and may result in quicker return to play (mean 6-13 weeks) than surgery (5-21 weeks).[12] Serner, et al.[12] reported a mean conservative rehabilitation period of 69 days (IQR 62-84) for confirmed avulsions, with excellent results on follow up.[12] This group also described low rates of re-injury (7%) and ongoing pain (7%).[12] In most cases, insight into the specific rehabilitation approach, key considerations and criteria for progression are not available, which makes direct replication of these difficult. However, Short, et al.[19] provides explicit detail surrounding the rehabilitation of a professional basketball player in their case study while Serner, et al.[24] has recently published a detailed criteria-based rehabilitation pathway for adductor injuries which included the rehabilitation of 17 grade 3 injuries. The following paper aims to address the rehabilitation of a professional rugby union player who, having underwent surgical repair of a traumatic acute adductor avulsion, completed an algorithm-based rehabilitation protocol, and returned to match play 9 weeks later.

CASE DESCRIPTION

A 25-year-old male professional rugby union player with a height of 1.86m and body mass of 102kg, playing as 'wing-forward' sustained a right adductor injury in the 23rd minute of an international rugby union game. His previous injury history included an ipsilateral anterior cruciate ligament reconstruction one year previously, ipsilateral syndesmosis repair 3 years previously and arthroscopic microfracture to his left (contralateral) hip 6 years previously. He had concurrent CAGP. The injury occurred as the athlete was tackled. An opponent landed directly on the medial aspect of the athlete's right thigh while the hip was in flexion having tackled the athlete at a ruck. This likely caused a high force, eccentric abduction moment at the lengthened adductor muscles. The player was in immediate pain and later described feeling a sharp, tearing sensation in the upper groin. He attempted to continue to play until the next stoppage, but was subsequent removed from the field following assessment by the team's medics. On initial physical examination, he was able to walk with a shortened stride. He was tender on palpation of the proximal adductor complex and at the rectus abdominis aponeurosis. Pain was elicited with hip abduction and hip flexion. Adductor contraction was deemed weak but not graded. The examiners were suspicious of a high-grade lesion of the adductor complex and imaging was organised for the following day.

DIAGNOSTIC IMAGING

Magnetic resonance imaging confirmed the clinical diagnosis of an acute avulsion of the right adductor longus from its attachment at the pubic bone, in fitting with a *Munich classification* grade 4 injury (Figure 1). There were further tears to the AB and gracilis (these were described as *Grade 2 Munich Classification* on MRI), with disruption of the rectus abdominis attachment at the superior pubic symphysis. The image found moderate degenerative changes to the pubic symphysis, more marked on the right, and demonstrated the previous surgical changes to the left hip.

SURGICAL MANAGEMENT

The medical team took time to research the injury and reflect upon the outcomes within the published literature with consideration of both conservative and surgical outcomes in elite athletes. Opinions and advice were sought from surgeons, doctors and physiotherapists who had experience in the management of these injuries. A summary of the potential risks and benefits of both conservative and surgical management were provided to player. He subsequently decided to pursue surgical repair and the operation was carried out 9 days post-injury by an orthopaedic surgeon, whose specialty was hip and groin surgery. The goal of surgery was to reconstruct the right AL and AB following their extensive avulsion from their proximal insertion. The athlete was set up in supine and prepared and draped with the right leg free. Under general anaesthetic, a 7cm incision was made distal to the groin crease which centred on the adductor longus tendon. The area was explored, and it was deemed that the inguinal ligament and rectus abdominis insertions were intact. The AM and gracilis were mostly intact. Distinct retraction of the adductor sleeve was noted, and the AL and AB were reattached to their pubic attachment using 7 anchors. Following closure of the fascial layers and cutaneous incision, the athlete recovered from the procedure in the hospital over two days. While in the observation ward, he was given a Game Ready® (GRPro® 2.1 system) compression and cryotherapy device to provide analgesia and attenuate inflammation and advised to use as frequently as he could tolerate, for up to 20 minutes at a time.[25,26] Range of motion (ROM) in the sagittal plane was stimulated with a Continuous Passive Motion device. On discharge, he was advised to weight bear as tolerated using crutches, and to avoid abduction (stretching of the repair) and resisted adduction for the first two weeks following surgery.

INTERVENTION AND OUTCOMES

Three phases of rehabilitation were identified, 1) post-operative protective phase, 2) introductory loading 3) advanced loading (including an introduction running and turning) and 4) return to play reconditioning (including sprinting, agility and rugby simulation). Distinct goals were identified for each phase (Table 1). Rehabilitation progression was determined by pain, ROM, strength and power. However, although all parties committed to a criteria based approach, the surgeon contraindicated stretching and adductor loading for two weeks following surgery, and maximal sprinting for six weeks. This was intended to avoid adversely stressing the repair. Criteria for phase progression are detailed in Table 1.

PHASE 1

On discharge from hospital, the athlete was restricted to weightbearing as tolerated with two crutches. His pain level was high for the first 5 days, which impacted his sleep and mood. This was primarily at the site of the anchors which had been inserted to his pubic tubercle. He had daily input from a nutritionist, with the goal of maintaining his body weight (and fat free mass). This was achieved through a high protein, high calorie diet. It was believed this would allow him to regain strength and achieve his previous performance levels quickly (Figure 2). He was comfortable carrying out strength training in the gym. Exercises at lower loads (higher repetitions) were used to stimulate hypertrophy. Lighter exercises were hypothesised to reduce the risk of the athlete straining and placing the repair at risk. Up-

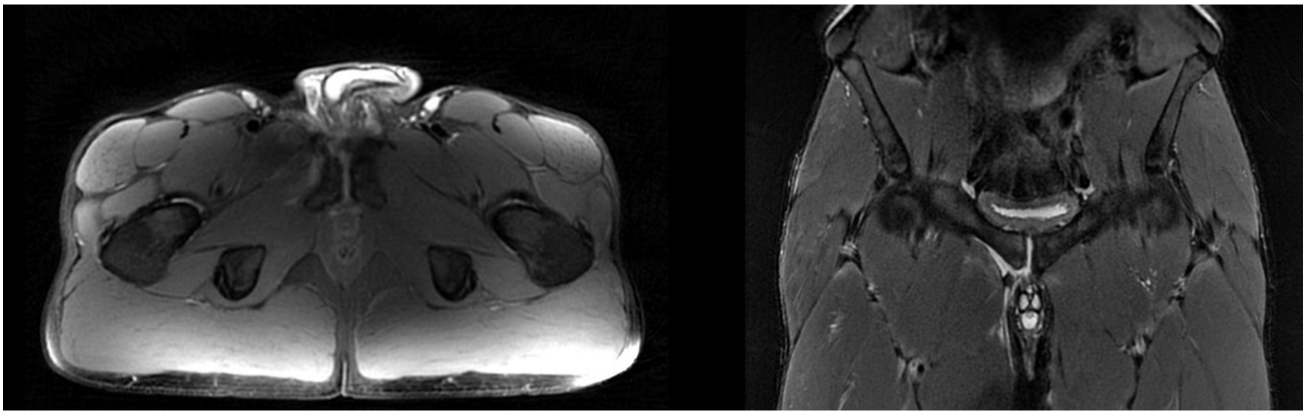

Figure 1. The athlete's injury viewed on MRI (axial and coronal views) 48 hours post-injury.

per body exercises such as bench press, bench pull, cable pull down and shoulder press were comfortable at lower loads so were included in the first week. To minimise active adductor loading during lower body exercises, only compound exercises activating the posterior leg muscles were used (stiff leg deadlift, restricted range rack pull and standing calf raise). Isolated exercises for the quadriceps and hamstring, such as seated knee extension and Swiss Ball hamstring curls. The athlete was able to commence some isometric neuromuscular control exercises, including pallof press, isometric sit up and banded abduction.

PHASE 2

The athlete commenced Phase 2 fourteen days post-op. This phase was categorised by the introduction of adductor specific loading, and progression in weightbearing (full weightbearing and single leg exercises), conditioning (stationary bike and rower), manual therapy (stretching and massage) and more extensive compound lifting in the gym (front squat and barbell step ups). Full depth squat has been shown to stimulate hypertrophy of the adductors, by exploiting its function as a hip extensor, this was therefore cautiously reintroduced as a strengthening exercise.[27] ROM was monitored in supine and using a Sports Specific Range Of Motion test (SSROM).[28] The athlete carried out a structured rehabilitation session 5 days per week in addition to four strength sessions; two lower body and two upper body. Progressions of the neuromuscular control and hip strengthening exercises described in Phase 1 were included in this phase. These specifically targeted abdominal control, hip flexor strength, lateral hip control/strength and hip extension,[29] and aimed to develop the strength and range of motion required to achieve the progression criteria (Table 1).

The introduction of specific loading of the adductor muscles was a central component of this phase. The development of isometric and concentric strength were tested using a sphygamonometer and hand held dynamometer (HHD) respectively with 80% of baseline/symmetry required for progression. Isometric ball squeezes at various angles of hip flexion (0, 45 and 90 degrees) were introduced at the maximal tolerable intensity and the athlete was encouraged to progress output as possible.[30] 30 second holds were used initially, before being progressed to 45 seconds. These exercises were carried out daily. Isotonic load was used to restore muscle bulk and to strengthen the athlete through tolerable ranges of motion.[31] Initially this was commenced at higher volume (15 repetitions per set), while heavier load was increased over time (eventually 6 repetitions per set), while using a metronome to ensure the concentric and eccentric components of the exercise were each controlled for 3 seconds.[32] These were carried out 3-days per week, spaced across the week to allow for recovery. The exercises used included heavy banded abduction-adduction, slide board adduction and short-lever Copenhagen adduction exercise. Frog pumps with external load using a barbell were also used to replicate the position of injury. Pain was allowed during exercise up to a score of 3 on a subjective numerical pain rating scale of 0-10, where 0 is no pain and 10 is the worst pain perceived to be possible.[31,33,34] If pain was 0 or 1 out of 10, It was deemed appropriate to progress the exercise using the model described in Figure 3. For example, encouraging more forceful isometric squeezes or progressing the range during isotonic exercises. Once the athlete had achieved each of the criteria for progression, they progressed to phase 3.

PHASE 3

The athlete entered this phase 36 days post-surgery and at this point was allowed to re-commence running. The athlete completed four field-based rehabilitation sessions during this period with the goal of increasing running volume (total distance), controlled turning and running speed up to a speed of 70% (Table 2). This was monitored using a wearable GPS tracker (STATSports Apex, Ireland). Gym based rehabilitation was progressed from Phase 2 (Figure 3). Loads and ROM during the isotonic exercises were steadily increased. This was to allow to athlete to establish regain his baseline isometric strength (sphygamonometer), concentric adduction and abduction symmetry using the ForceFrame device (VALD Performance, Australia) (a 3 second maximal contraction test was assessed) and eccentric strength test (HHD). A thorough list of the criteria for pro-

Table 1. Description of the aims and outcome measures for progression within each phase of rehabilitation (ROM: range of motion).

Criteria for completion of phase	
Phase 1 : Post-op protective phase	
Aim	Outcome measure
Protect repair	Avoid infection or irritation of wound site
Maintain body composition	Maintain body mass at same level as pre-injury (102kg)
Maintain lower limb strength	Deadlift, hip thrust and single joint exercises three times per week (10-15 repetitions at RPE: 6)
Develop lumbopelvic control	Exposure to concentric and isometric abdominal and hip strength work 5 times per week
Phase 2: Introductory loading	
Aim	Outcome measure
Adductor capacity	Adductor squeeze test pain free and at 80% of previous level (250mmHg)
Concentric adduction strength	Hand-held dynamometry testing at 80% symmetry with uninvolved leg
Isometric adduction strength	Able to perform and sustain side lying adductor raise for 5 seconds
FABERs test	FABERs test at 90% symmetry without any apprehension
Bent Knee Fall Out test	Pain-free BKFO test at 90% symmetry
Hip abduction strength	Unbreakable to manual muscle abduction testing in side lying at mid- and inner range
Sagittal plane hip strength	Unbreakable hip flexion and hip extension manual muscle testing at inner range
Hip Internal and External Rotation ROM	Pain free ROM at baseline levels in all planes
Phase 3: Advanced loading	
Aim	Outcome measure
Adductor capacity	Adductor squeeze test pain free and at previous level (310mmHg)
Concentric adduction strength	Symmetrical hand-held dynamometry testing
Isometric adduction and abduction strength	Symmetrical strength and 1:1 abductor to adductor ratio using ForceFrame device
Flexion Abduction External Rotation (FABER) test	Symmetrical, pain free FABERs test without any apprehension
Bent Knee Fall Out (BKFO) test	Symmetrical, pain free BKFO test
Hip ROM	Pain free ROM at baseline levels in all planes
Rate of force development	Technical competence in linear skipping and lateral force projection drills
Phase 4: Return to play reconditioning	
Aim	Outcome measure
Training week replication	Match external load demands of a training week (see Table 2)
Aerobic conditioning	Achieve baseline performance on 1.2km Bronco time trial
Maximal speed exposure	Sprint at 95% of personal max velocity on two occasions
Agility exposure	Complete 2 sessions of 'game specific agility' with technical competence
Game specific tasks	Confident, competent completion of game tasks - rucking, tackling and curve running
Training re-introduction	Match positional training load standards in training for 2 consecutive week

gression to Phase 4 are outlined in Table 1, which included baseline or symmetrical ROM.

This stage was characterised by the introduction of energy-absorption and -production load tolerance of the tendon, and developing rate of force development.[35] Vertical and horizontal plyometric training of both slow- and fast-stretch shortening cycles were introduced as part of the athlete's strength training. The volume and intensity of these jumps and landings were increased throughout the period with the aim of returning the athletes countermovement jump (height in cm), single leg CMJ (cm), drop jump (reactive strength index – jump height to contact time ratio and single leg drop jump) to his pre-injury level. This were assessed using a standard jump mat. These exercises were carried out at twice per week and at no-less than 72-hour intervals to allow tendon adaptation between sessions.[36] Exercises such as those described by King, et al.[29] to develop tendon stiffness and technical qualities relating to linear running and multidirectional mechanics were intro-

Table 2. Running load during rehabilitation as derived using a wearable a Global Position Sense (GPS) tracker.

Total Distance (m)	HSR Distance (m)	VHSR Distance (m)	Sprint Efforts (>85%)	%Vmax	Collision Load	Accelerations	Decelerations	HSR Efforts
2887	0	0	0	50%	0	3	0	0
2208	685	0	0	63%	0	10	24	24
2765	625	0	0	66%	0	56	35	35
1895	490	30	0	75%	0	47	35	35
4474	523	99	1	89%	0	59	35	13
3009	510	0	0	70%	0	58	44	20
4192	560	124	2	91%	0	59	28	19
4772	314	30	0	78%	74	55	33	19
4050	378	101	2	97%	55	41	29	18
1519	50	1	0	70%	54	22	4	4
1367	365	0	0	69%	0	16	13	13
4399	323	23	0	78%	57	66	22	22
3474	197	13	0	74%	56	42	13	13

HSR = High Speed Running – distance covered above 55% of individual maximum velocity. VHSR = Very High Speed Running - distance covered above 70% of individual maximum velocity) . %Vmax = percentage of the previously recorded maximum speed for this individual player). Collision load = count of collisions detected by a change in axis orientation and impact force of 8g per minute. Accelerations = count of accelerations above 3m/s/s. Decelerations = count of decelerations above 3m/s/s.

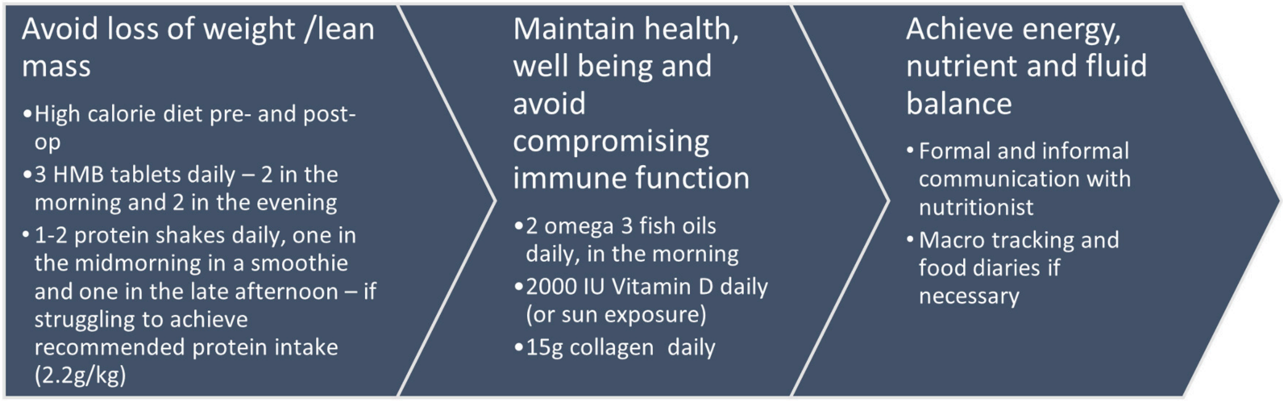

Figure 2. Summary of nutritional advice provided to the athlete following their injury.

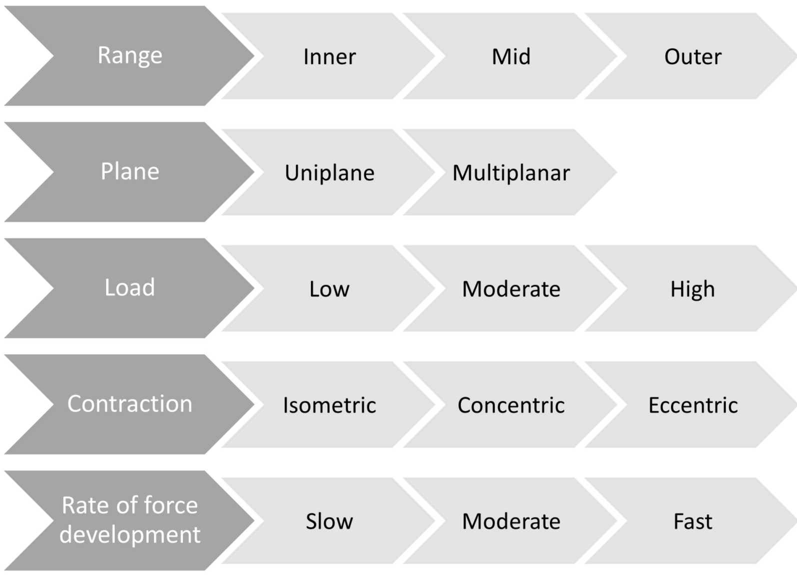

Figure 3. A progressive loading pathway allows for appropriate progression of variables in rehabilitation and protects against surges in loading

duced and recorded on video so feedback could be given to the player.

PHASE 4

Once the athlete had achieved full ROM, was clinically clear of pain,[1] demonstrated symmetrical or baseline levels of strength, and was tolerating running with appropriate technical competence, the athlete moved into the final stage of rehabilitation ahead of a return to team training. This this was considered a crucial timepoint in rehabilitation where the risk of a setback was highest, particularly as reduced sport-specific conditioning has been identified as a risk factor for groin injury in sport.[37] Field based sessions were progressed by increasing distance covered per sessions, volume and intensity of acceleration and deceleration, running velocity (Table 2). This was to ultimately expose the athlete to external training load demands comparable to those previously achieved in training. Drills involving accelerating and decelerating while carrying out rugby specific tasks or curve running were used to challenge the athlete beyond linear running. Conditioning drills including extended periods of conditioning to mimic rugby union phases were used, and the athlete was required to complete a 'Bronco' test – a standardised 1.2km time trial in a time equivalent to his end of pre-season baseline. Contact and tackling training were included within this phase (Figure 4), particularly given the contact-based mechanism. Sprint training was included in the reconditioning cycle. Once the athlete had achieved a speed greater than 90% of his previous maximum sprinting speed on two distinct oc-

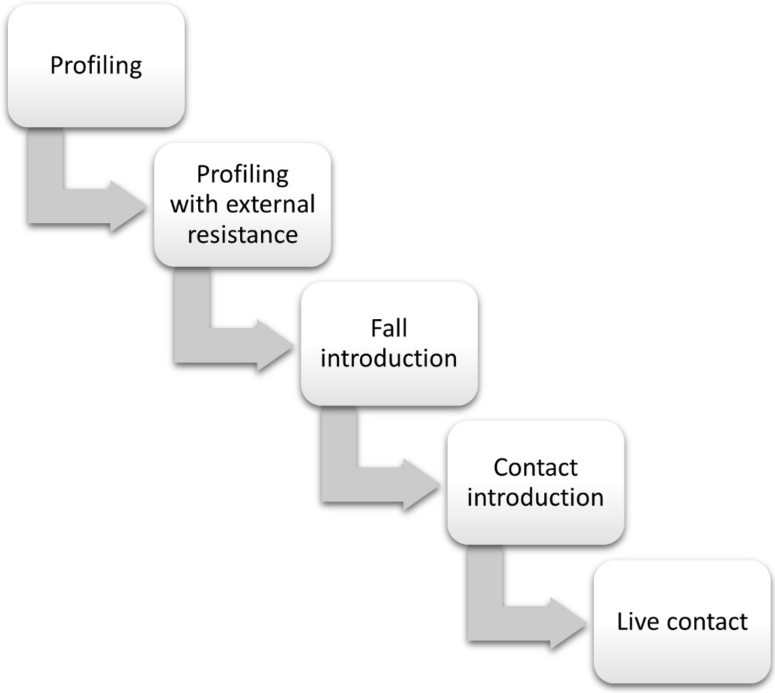

Figure 4. An intensifying model for 'contact' progression.

Initially beginning with adopting positions associated with the tackle and ruck, before introducing progressive external load as competency is demonstrated and clinical markers allow, is suggested as an appropriate continuum for reintroduction of these tasks.

casions, in addition to the other specified running metrics, the athlete was cleared to return to full training.

Having completed unrestricted team-based training for six consecutive occasions without compromising symptoms or KPIs, the player was deemed available for selection by the team's coaches and played his first game 69 days post initial injury.

FOLLOW UP

Measures of strength using the sphymanomometer[38] and ForceFrame,[39] ROM (of the hip in supine, prone and SSROM position), and pain (daily wellness questionnaire) were monitored for the remainder of the season and subsequent months to ensure no change in function or symptoms. The athlete continued to use isometric squeeze exercises as a warmup exercise before every field training session, and adductor training was programmed twice per week as maintenance. At twelve months follow up, the athlete reported having noted occasional CAGP, consistent with his pre-operative presentation, but had not missed training or match play as a result on any occasion and continued to compete at the same level as previously.

DISCUSSION

There is no consensus within the literature as to definitive indicators for surgical rather than conservative management of adductor avulsions. One of the largest case series to date by Schlegel, et al.[22] tracked adductor avulsion recovery in professional National Football League (NFL) players. The mean time for recovery amongst the surgical group (mean 12.0 weeks, range 10-16) was double that for the conservative rehabilitation cohort (mean 6.1 weeks, range 3-12 weeks). Serner, et al.[12] describe excellent outcomes following conservative management at 12 months, although 3 of the 16 cases had a subsequent adductor injury or groin pain within the follow up period. As a result, it is not yet absolutely clear whether surgical or conservative approaches should be advocated preferentially in professional sports people, and whether it is necessary to delay return to play for 12-weeks and beyond if progressive, criteria-based rehabilitation approaches are instigated. In our case, the athlete was able to return to play 9-weeks post injury (7.5 weeks post-op) and play consecutive games on his return to the team. He had not missed a game due to injury at 12-months follow up.

Algorithmic, criteria-based models of rehabilitation have been advocated for several other types of injury.[33,34,40,41] Pre-determined benchmarks are set out to determine the speed at which rehabilitation is progressed. This strategy is an evolution from time-based rehabilitation approaches where return to play clearance was based on chronology rather than specific competence. Criteria-based models allow clinicians to have confidence that an athlete is appropriately prepared for the next stage of progression and minimise the risk of setbacks, potentially accelerating the return to play process. Consideration of the physiology of healing however should still impact upon progression. For instance, an initial protective phase to allow for wound and repair healing appears to be prudent. Also, because tendon load increases exponentially during sprinting,[42] and collagen remodelling in tendon is slower than in muscle,[43] it may be wise to delay sprinting to protect the repair as collagen remodelling begins. Beyond this, it is unclear how exactly free tendon strain rehabilitation should practically differ from muscle strains and what impact this should have on the rate of progression and what deficits are target by clinicians. Serner, et al.[33] advocate a homogenous approach to injury locations where achieving progression criteria is clearly important. Further lessons can perhaps be taken from the tendinopathy research on loading strategies for degenerative tendons.[31] It is also clear from the research in CAGP that deficits in strength and ROM exist. Because considerable demands of the adductor musculature are made during running tasks, with an increase in tensile load at higher speeds as cadence increases, it is necessary to regain appropriate strength and ROM before progressing the stages of rehabilitation. Serner, et al.[33] require pain-free palpation of the adductors, pain free maximal adduction in outer range, tolerance of through range adduction with elastic resistance, and the Copenhagen adduction exercise for progression. Though this work was published after completion of this case, similar metrics had been included as key clinical performance indicators of adductor functional recovery.

The adductor squeeze test using a sphygmomanometer is another established measure of adductor capacity, which has validity in identifying athletes with CAGP and those at risk of acute injury in the forthcoming season.[38,44–46] A similar outcome measure has been described which also considers an athlete's pain while carrying out the isometric adduction in the squeeze.[47] Thus, pain and force output were tracked throughout this athlete's recovery.

It is long established that adductor loading is beneficial in those with CAGP[30] and for tendon degeneration at other sites in the lower limb.[32] Hölmich, et al.[30] utilised high volume isometric squeezes in varying positions of hip flexion as central components of an adductor reconditioning protocol. Such exercises are advocated as they allow a safe, self-limiting entry point for athletes to begin loading, while isometric loading has been shown to have a beneficial effect in the management of tendon pain.[48] This type of exercise may reduce pain and inhibition,[48] which was deemed necessary in this case following surgery and a period of unloading. It has been proposed at the hamstring that eccentric inhibition may exist initially in the presence of pain.[49] It is hypothesised that isometric contractions at the beginning of a rehabilitation may prepare the athlete for progression to alternative contraction types.[49,50]

Serner, et al.[24] progressive model for adductor injury rehabilitation included 17 grade 3 injuries (although the location of these injuries within the musculotendinous unit were not stated). This approach for acute muscle injuries, like that suggested by Hölmich, et al.[30] for CAGP, utilises high activation adductor exercises to promote healing of the tissue, promote function and reduce pain. Both these studies have demonstrated excellent outcomes from specific adductor training. In addition, other training approaches are important in tendon rehabilitation. Eccentric and isotonic exercises using heavy slow resistance[32] are important approaches that can improve outcomes in athletes with tendon pain. These approaches allow for progressive load tolerance to be build, and to elicit strength and hypertrophy adaptations. Specific eccentric deficits have previously been observed in athletes with CAGP, suggesting there is a role for developing this competency.[51] Exercises such as the Copenhagen adduction exercise[52,53] or exercises using elastic bands[54] have been suggested. These were both central tenets of the loading strategy for the athlete in this case report. The introduction of eccentric exercise in rehabilitation however can result in muscle soreness initially and risk irritating the athlete. As a result a progressive pathway of loading is suggested, similar to that described by Blanchard and Glasgow[55] (Figure 3). As rehabilitation exercises are progressed, for instance the introduction of eccentric training, the load and range that the athlete are accustomed to should be reduced initially. This can then be progressed as the athlete becomes accustomed to the progression. This allows for new concepts to be introduced while controlling for the most challenging variables in rehabilitation.

While adductor strengthening can be deemed vital in rehabilitation, an alternative approach is suggested by King, et al.[29] These authors rehabilitation model centres on the training of intersegmental control, linear and agility mechanics instead of local adductor strengthening in subjects with CAGP. They proposed that the adductor is a victim of overuse due to suboptimal biomechanics. While omitting adductor loading may be appropriate in athletes with CAGP, that would not be appropriate following adductor avulsion however, where both adductor strengthening and biomechanical retraining are recommended. Having suffered significant insult to the adductor complex, rebuilding adductor strength, capacity and elasticity is necessary.[56] Further, as the player in this case had concurrent right sided CAGP, previous surgeries to the knee and ankle on that side and a contralateral hip microfracture surgery and had spent two weeks mobilising with crutches, there were likely to be biomechanical impairment present. In addition, training linear and multidirectional competencies provide a useful bridge within rehabilitation to prepare the athlete for field-based training.

Field based methods of testing have become popular at other sites of muscular injury as they can provide contemporaneous measures of progress, particularly when baseline measures have been taken.[57] A precise and valid measure of isometric adductor strength has been reported upon,[39] and this was used in this case. Thus, the recovery of adductor and isometric force output at specific angles of hip flexion could be tracked on a weekly basis and matched with progression through the phases. Optimal adductor to abductor ratios have been discussed at length in previous research[58,59] and while there is not consensus as to what an optimal relationship is, in this case the athlete had previously demonstrated 1:1 strength ratio during pre-season screening so a target was to achieve this ratio again whilst regaining and improving force output.

Running rehabilitation began once the athlete had demonstrated appropriate ROM, strength and no residual pain (Table 1). Higher volume running at low speed was deemed the appropriate starting point as this would not excessively strain the healing tendon as there was minimal stiffness or flexibility demands. Volume and subsequently speed of running were progressed until the athlete had ran at a speed equivalent to 70% of his previous maximal speed. Change of direction tasks, acceleration and deceleration were introduced at this point and subsequently sprint training in scenarios replicating those of rugby training and matches. It is important that athletes accumulate running load before returning to full training. A simulated training week was planned which allowed the athlete to mimic the total distance, high speed running and sprint metres of a typical week during controlled, supervised running. This progression of these metrics of running training load are represented in Table 2. This approach protected him from spikes in acute to chronic work load ratio,[60] preparing him for the demands of team-based training,[61] and mitigating against subsequent injury.[62] As the injury occurred during contact,[63] re-training competence for this facet of the sport was an important aspect of the process (Figures 4, 5). A progressive pathway was implemented beginning with reintroducing the athlete to functional ranges of motion and subsequently the addition of external loads (Figure 3). This acted as a rehabilitation tool in addition to technical re-training for returning to rugby union match play.

In conclusion, while we have identified that there are several considerations in adductor rehabilitation, recognition of the key components of each allows for a progressive rehabilitation approach, based on clear criteria. Such an approach gives direction to progressions and may assist in accelerating return to play. There is no consensus as to optimal management of acute, traumatic adductor avulsions in sports, or the required period of recovery following injury before returning to play.

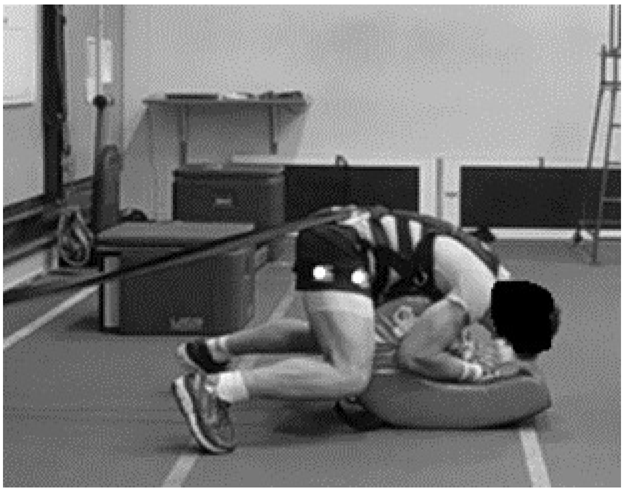

Figure 5. Rehabilitating sports specific tasks and recreating the mechanism of injury are an important adjunct to accelerated return to play.

INFORMED CONSENT

Informed consent was sought and received from the athlete for the publication of this case. The athlete and primary investigator both retained copies of this signed Consent Form.

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