Accepted Manuscript

Title: Conservative management of a traumatic meniscal injury utilising osteopathy and exercise rehabilitation: a case report.

Authors: Jack Feehan, Chris Macfarlane, Brett Vaughan

PII: S0965-2299(17)30132-2
DOI: http://dx.doi.org/doi:10.1016/j.ctim.2017.05.007
Reference: YCTIM 1693

To appear in: *Complementary Therapies in Medicine*

Received date: 26-2-2017
Revised date: 31-5-2017
Accepted date: 31-5-2017

Please cite this article as: Feehan Jack, Macfarlane Chris, Vaughan Brett.Conservative management of a traumatic meniscal injury utilising osteopathy and exercise rehabilitation: a case report.*Complementary Therapies in Medicine* http://dx.doi.org/10.1016/j.ctim.2017.05.007

Conservative management of a traumatic meniscal injury utilising osteopathy and exercise rehabilitation: a case report.

Jack Feehan[1]

Chris Macfarlane[1]

Brett Vaughan[1,2,*]

[1] College of Health & Biomedicine, Victoria University, Melbourne, Australia

[2] Institute of Sport, Exercise and Active Living, Victoria University, Melbourne, Australia

***Corresponding Author**

Brett Vaughan

Lecturer, Osteopathy

College of Health and Biomedicine

Victoria University

PO Box 14428

Melbourne VIC 8001

Australia

P. 61 3 9919 1210

F. 61 3 9919 1030

E. brett.vaughan@vu.edu.au

Abstract

Meniscal injury is one of the most common knee soft tissue injuries, commonly affecting young athletes and an older, degenerative population. Treatment largely depends on the type and extent of the injury with arthroscopic repair or meniscectomy being mainstays. Although non-surgical approaches have been described, there is no published literature regarding a combination of indirect osteopathic techniques and rehabilitation in the management of these injuries. The current case report follows a 20-year-old male presenting with a 5-day history of acute knee pain, following trauma during an Australian Rules Football (AFL) match. An 8-week management plan of indirect osteopathic techniques and a tailored rehabilitation program was implemented. The Knee Injury and Osteoarthritis Outcome Score (KOOS) and the Lower Extremity Functional Scale questionnaires were utilised to measure outcomes. After the 8-week

treatment and rehabilitation program, the patient had exceeded the minimum detectable change score for all outcome measures. This case report suggests that osteopathic manipulative treatment and rehabilitation may be an alternative, non-surgical approach in the management of post-traumatic meniscal injuries.

Introduction

Meniscal injuries are a common occurrence in young athletes, particularly in contact sports such as football and rugby (1, 2). Due to the unique vascular anatomy of the meniscus, with only the outer third of the tissue having a ready blood supply (3), treatment outcomes of these injuries can vary, based on the individual tear pattern. The type of treatment used varies and is largely dependent on the extent and location of the injury. Typically treatment is arthroscopic repair or meniscectomy (4). Appropriate management of these injuries is vital, as meniscal injury can significantly increase the risk of osteoarthritis development in later life (5). Conservative management of meniscal injuries is the preferred method of treatment, particularly in the case of stable meniscal tears, as arthroscopic repair or meniscectomy also increases risk of OA development (6). Current guidelines recommend acute inflammation management (rest, ice, compression and elevation), anti-inflammatory medications and physiotherapy (7) in the early stages, prior to potential surgical intervention. There are examples of conservative manual therapy management of meniscal pathologies (8-11) however where studies have been undertaken they have usually been in degenerative rather than acute meniscal presentations (10, 11). The current case report explores the application of indirect osteopathy manual therapy techniques combined with exercise rehabilitation as an alternative strategy for the management of an acute knee meniscal pathology.

Patient Information

A 20-year-old male patient presented to a metropolitan-based student-led osteopathy clinic (Melbourne, Australia) complaining of left knee pain with associated joint effusion and bruising. The patient reported diffuse, constant aching pain over the entire knee, with regular

sharp exacerbations localized to the anteromedial aspect. Major functional limitations were identified by the patient, and a self-rated pain level of 7/10 on a visual analogue scale. The functional limitations identified by the patient largely centred on a near total inability to bear weight on the affected limb, which in turn impeded any ADL's such as walking, standing from a seated position or climbing stairs at university. The onset of the complaint was four days prior to presentation following a moderate trauma whilst playing Australian Rules football. The patient reported jumping and landing on a hyperextended knee, while simultaneously receiving a heavy contact to the left side of the body from another player. This caused the patient to twist heavily on the fully extended left knee. The patient reported a sensation of "tearing" and the knee immediately gave way. The patient was unable to weight bear and was carried off the field where the left knee was immediately placed in a compressive bandage, and ice applied to assist with control of swelling. The patient continued to apply ice hourly in the days prior to presentation to the clinic.

The medical and family medical history was unremarkable, and there were no red or yellow flags, no current/past major illnesses, and the patient was not currently taking any medications. There was no previous history of lower limb injury reported despite a long history of participation in contact sport. Psychosocial factors were of little concern as the patient reported being quite active, a good diet, non-smoker, and consumed alcohol occasionally. The patient had not sought any treatment for the current knee complaint.

Clinical Findings

The physical examination findings are summarised in Table 1 below. The examination of the patient was guided by the clinical history and informed by the literature with regard to examination of acute knee complaints (12-18).

Diagnostic Assessment

Based on the patient's history and physical examination, a working diagnosis of an acute left medial meniscus injury was made (9). This diagnosis was based on the mechanism of injury,

positive orthopaedic testing (Apley's, McMurray's and Thessaly's), pain on palpation of the medial joint line, and pain with passive knee flexion and extension at end-range (18). Differential diagnoses were pathologies affecting the knee cruciate and collateral ligaments. Ligament stress testing (Table 1) did not provide support for these differentials.

The patient was provided with information regarding treatment options, including no treatment, obtaining diagnostic imaging to confirm/refute the working diagnosis, and seeking an orthopaedic surgical opinion. As the patient was of limited financial means, it was agreed that an 8-week conservative management and rehabilitation program would be implemented, with progress being monitored over that time. Utilisation of conservative care prior to surgery is also supported in the literature (20). Should there have been no response to the management plan, the patient would be referred for diagnostic imaging and a surgical opinion.

To aid in monitoring the management plan, patient-reported outcome measures (PROMs) were used. The Knee Injury and Osteoarthritis Outcome Score (KOOS) (21, 22) and the Lower Extremity Functional Scale (23, 24) were utilised as both are valid measures of functional limitations in lower limb and knee injuries. Pre-treatment scores for the PROMs are presented in Table 2.

Timeline

The planned and executed treatment regimen was spread over 5 treatments in eight weeks (Figure 1).

Intervention

Each treatment session was divided into three components: 1) 15 minutes for re-examination and history taking; 2) a 15-minute session of osteopathic manual therapy (OMT) aimed at symptom reduction and assisting in tissue healing; and, 3) a 15-minute exercise rehabilitation session including teaching and monitoring the patients' at home exercise and care.

Osteopathic manual therapy (OMT)

The OMT component utilised indirect osteopathic techniques (26, 27) with their administration varying based on clinical findings such as patient response, palpatory cues and range of motion changes. Specific techniques included strain-counterstrain (28) to tender points surrounding the knee; balanced ligamentous tension techniques to the knee (29), patellofemoral and superior tibiofibular joints, as well as the ankle and hip; and indirect myofascial release techniques to surrounding structures (30).

Exercise rehabilitation

Cavanaugh & Killian (31) suggest a protocol-based program is less effective for the management of meniscal injuries than a tailored approach informed by current medical and biomechanical knowledge. As such the patients' rehabilitation plan was designed in stages and evaluated the response evaluated at each treatment session. Progression of the rehabilitation plan was guided by the patients' response to exercises. The patient's rehabilitation program was designed in four stages (32), from initial to return to sport.

Follow-up and Outcomes

After the eight-week treatment regimen, the patient-reported outcome measures were re-evaluated (Table 3). The patient showed improvement greater than the minimum detectable change score for all KOOS subscales and for the LEFS. Additionally, the patients' self-reported pain score had reduced by 6 on a 10-point VAS. Clinically, the patient showed almost complete functional resolution, being able to run, hop and jump without pain and disability, and had complete restoration of both active and passive ranges of motion, without pain, even with pressure applied at end-range.

The patient reported being moderately compliant with the exercise rehabilitation plan, performing exercises as per the schedule (Table 3) and as instructed most of the time. Treatment and rehabilitation was well tolerated, with no adverse events reported, and no post-treatment pain at any time.

Discussion

The case report presents the conservative, non-surgical management of an acute knee meniscus pathology. A combination of manual therapy, in the form of indirect osteopathy manual techniques (26) and exercise rehabilitation, allowed the patient to return to performing a range of functional movements that were impaired following injury. The improvement in these functional movements is supported by the change in the KOOS and LEFS scores above their respective MDC score (23, 25). Further, the number of treatment sessions for the patient was comparable to that of Hudson et al. (9) who utilised up to 6 treatment sessions in their case-series on the conservative management of meniscal pathologies.

Indirect osteopathy manual techniques (26) were chosen for the patient given the acute nature of the injury and substantial reduction in range of motion, particularly at the initial appointment. These techniques are applied in the direction of 'ease' – taking the tissue tension away from the restrictive barrier. As this is intended to reduce tension in the tissues it is viewed as less stressful on the injured structures. A literature review by Tozzi (27) noted that there had been

no reports of injuries with indirect techniques had been reported in the literature. Later reviews (33, 34) support that of Tozzi (27), although they suggest that mild reactions to manual therapy are quite common. These reactions include muscular soreness, headaches and body aches, however these appear to be related to direct, rather than indirect, manual therapy techniques (stretching, massage and manipulation). Indirect techniques were applied throughout the management plan described previously with no adverse effects or post-treatment soreness (27). It is posited that this may be due to the low-force nature of the indirect treatment techniques used, where the forces on the structures being treated, such as the knee, are potentially less than that with direct manual therapy techniques such as mobilisation or soft tissue massage.

The authors found little research to support the use of these indirect techniques in knee complaints specifically however there is emerging research (35, 36) on the mechanism by which these techniques work. The current case report suggests there was a safe role for these techniques in the management of an acute knee pathology that did not require an immediate surgical opinion. The role of these techniques includes pain reduction and improvement in joint range of motion (30). In addition for this case the patient did not require any analgesic or anti-inflammatory medications to assist with their management. This is significant, due to the risk associated with the use of pharmaceuticals (37, 38), and limitation of their use for improving patient outcomes.

There are a number of limitations in this case report. Firstly, diagnostic imaging may have helped to confirm or refute the working diagnosis although the clinical history and examination may have provided enough information to support the diagnosis (16, 18). Consideration was given also to the patient's financial status as to whether imaging would be ordered. In the current report the patient was of limited financial means, therefore diagnostic imaging was not obtained in the first instance. Secondly, range of motion (ROM) measurements using a goniometer would have allowed for more accurate documentation in change of ROM. That said, the management plan emphasised changes in functional activities using PROM therefore ROM would have provided little additional supporting information. Thirdly, it is difficult to

conclude whether one of the OMT or exercise rehabilitation had a more significant impact than the other.

The outcome reported in the current case report suggests that a combination of indirect OMT and exercise rehabilitation may be an approach to the management of an acute knee meniscal pathology. Case-series, case-control or cohort studies would be valuable in ascertaining whether this management strategy provides benefits to a wider range of patients, including those undertaking rehabilitation post meniscal surgery.

Patient Perspective

The patient was contacted several months after their treatment had concluded to provide their perspective about the treatment. The patient identified an initial "disbelief" that the gentle treatment techniques used would be effective, as they were unlike any that they had previously experienced with manual therapy care. After the initial few treatments however, the patient began to feel more positive toward the methods used as their symptoms improved, finding the use of indirect osteopathic techniques painless in their application. When asked for further information on what the patient felt were the positive aspects of the management plan and outcomes, the identified the regular contact with the practitioner, the tailored nature of the rehabilitation program, and particularly, the rapid improvements in symptomatology and functionality. On questioning the patient could not identify any major criticisms they had going through the treatment protocol. Overall the patient expressed a high level of satisfaction with his management and the outcomes of his treatment and rehabilitation.

Statement of competing interests

The authors identify no competing interests in relation to the manuscript.

Informed Consent

The patient agreed to the publication of the case study, and provided written informed consent.

References

1. Drosos G, Pozo J. The causes and mechanisms of meniscal injuries in the sporting and non-sporting environment in an unselected population. The Knee. 2004;11(2):143-9. doi:10.1016/S0968-0160(03)00105-4.

2. Masini BD, Dickens JF, Tucker CJ, Cameron KL, Svoboda SJ, Owens BD. Epidemiology of isolated meniscus tears in young athletes. Ortho J Sports Med. 2015;3(7 suppl2). doi:10.1177/2325967115S00107.

3. Arnoczky SP, Warren RF. Microvasculature of the human meniscus. Am J Sports Med. 1982;10(2):90-5. doi:10.1177/036354658201000205.

4. Mordecai SC, Al-Hadithy N, Ware HE, Gupte CM. Treatment of meniscal tears: An evidence based approach. World J Orthop. 2014;5(3):233. doi:10.5312/wjo.v5.i3.233.

5. Anderson DD, Chubinskaya S, Guilak F, Martin JA, Oegema TR, Olson SA, et al. Post‐traumatic osteoarthritis: Improved understanding and opportunities for early intervention. J Orthop Res. 2011;29(6):802-9. doi:10.1002/jor.21359.

6. Englund M, Roos EM, Lohmander L. Impact of type of meniscal tear on radiographic and symptomatic knee osteoarthritis: A sixteen‐year followup of meniscectomy with matched controls. Arthritis Rheum. 2003;48(8):2178-87. doi:10.1002/art.11088.

7. De Carlo M, Armstrong B. Rehabilitation of the knee following sports injury. Clin Sports Med. 2010;29(1):81-106. doi:10.1016/j.csm.2009.09.004.

8. Polkinghorn BS. Conservative treatment of torn medial meniscus via mechanical force, manually assisted short lever chiropractic adjusting procedures. J Manipulative Physiol Ther. 1994;17(7):474-84.

9. Hudson R, Richmond A, Sanchez B, Stevenson V, Baker RT, May J, et al. An alternative approach to the treatment of meniscal pathologies: a case series analysis of the Mulligan concept "squeeze" technique. Int J Sports Phys Ther. 2016;11(4):564.

10. Katz JN, Brophy RH, Chaisson CE, De Chaves L, Cole BJ, Dahm DL, et al. Surgery versus physical therapy for a meniscal tear and osteoarthritis. N Engl J Med. 2013;368(18):1675-84. doi:10.1056/NEJMoa1301408.

11. Herrlin S, Hållander M, Wange P, Weidenhielm L, Werner S. Arthroscopic or conservative treatment of degenerative medial meniscal tears: a prospective randomised trial. Knee Surg Sports Traumatol Arthrosc. 2007;15(4):393-401. doi:10.1007/s00167-006-0243-2.

12. Beutler A, O'Connor F. Physical examination of the knee. In: Malanga GA, Mautner K, editors. Musculoskeletal physical examination: an evidence-based approach. 2nd ed. Philadelphia, USA: Elsevier Health Sciences; 2017.

13. Solomon DH, Simel DL, Bates DW, Katz JN, Schaffer JL. Does this patient have a torn meniscus or ligament of the knee?: value of the physical examination. J Am Med Assoc. 2001;286(13):1610-20. doi:10.1001/jama.286.13.1610.

14. Malanga GA, Andrus S, Nadler SF, McLean J. Physical examination of the knee: a review of the original test description and scientific validity of common orthopedic tests. Arch Phys Med Rehabil. 2003;84(4):592-603. doi:10.1053/apmr.2003.50026.

15. Hegedus EJ, Cook C, Hasselblad V, Goode A, Mccrory DC. Physical examination tests for assessing a torn meniscus in the knee: a systematic review with meta-analysis. J Orthop Sports Phys Ther. 2007;37(9):541-50. doi:10.2519/jospt.2007.2560.

16. Wagemakers HP, Heintjes EM, Boks SS, Berger MY, Verhaar JA, Koes BW, et al. Diagnostic value of history-taking and physical examination for assessing meniscal tears of the knee in general practice. Clin J Sport Med. 2008;18(1):24-30. doi:10.1097/JSM.0b013e31815887a7.

17. Chivers MD, Howitt SD. Anatomy and physical examination of the knee menisci: a narrative review of the orthopedic literature. Journal of the Canadian Chiropractic Association. 2009;53(4):319-33.

18. Lowery DJ, Farley TD, Wing DW, Sterett WI, Steadman JR. A clinical composite score accurately detects meniscal pathology. Arthroscopy: The Journal of Arthroscopic & Related Surgery. 2006;22(11):1174-9. doi:10.1016/j.arthro.2006.06.014.

19. McHale KJ, Park MJ, Tjoumakaris FP. Physical Examination for Meniscus Tears. In: Kelly J, editor. Meniscal Injuries. New York, USA: Springer; 2014. p. 9-20.

20. Hwang YG, Kwoh CK. The METEOR trial: no rush to repair a torn meniscus. Cleve Clin J Med. 2014;81(4):226-32. doi:10.3949/ccjm.81a.13075.

21. Roos EM, Roos HP, Lohmander LS, Ekdahl C, Beynnon BD. Knee Injury and Osteoarthritis Outcome Score (KOOS)—development of a self-administered outcome measure. J Orthop Sports Phys Ther. 1998;28(2):88-96. doi:10.2519/jospt.1998.28.2.88.

22. Ingelsrud LH, Terwee CB, Goncalves RS, Roos EM. Minimal important change for the knee injury and osteoarthritis outcome score (KOOS) in patients with knee osteoarthritis. Osteoarthritis Cartilage. 2014;22:S179-S80. doi:10.1016/j.joca.2014.02.338.

23. Binkley JM, Stratford PW, Lott SA, Riddle DL. The Lower Extremity Functional Scale (LEFS): scale development, measurement properties, and clinical application. Phys Ther. 1999;79(4):371-83.

24. Mehta S, Fulton A, Quach C, Thistle M, Toledo C, Evans N. Measurement properties of the lower extremity functional scale: a systematic review. Physiother. 2015;101:e992-e3. doi:10.2519/jospt.2016.6165.

25. Collins NJ, Misra D, Felson DT, Crossley KM, Roos EM. Measures of knee function: International Knee Documentation Committee (IKDC) Subjective Knee Evaluation Form, Knee Injury and Osteoarthritis Outcome Score (KOOS), Knee Injury and Osteoarthritis Outcome Score Physical Function Short Form (KOOS‐PS), Knee Outcome Survey Activities of Daily Living Scale (KOS‐ADL), Lysholm Knee Scoring Scale, Oxford Knee Score (OKS), Western Ontario and McMaster Universities Osteoarthritis Index (WOMAC), Activity Rating Scale (ARS), and

Tegner Activity Score (TAS). Arthritis Care Res (Hoboken). 2011;63(S11):S208–S28. doi:10.1002/acr.20632.

26. Hartman L. Indirect Technique. Handbook of Osteopathic Technique: Springer; 1997. p. 31-8.

27. Tozzi P. Selected fascial aspects of osteopathic practice. J Bodyw Mov Ther. 2012;16(4):503-19. doi:10.1016/j.jbmt.2012.02.003.

28. Jones LH, Kusunose RS, Goering EK. Jones Strain-Counterstrain Boise ID: Jones Strain-Counterstrain Inc; 1995.

29. Chila AG. Foundations of Osteopathic Medicine. Philadelphia USA: Lippincott, Williams and Wilkins; 2011.

30. Webb TR, Rajendran D. Myofascial techniques: what are their effects on joint range of motion and pain? - A systematic review and meta-analysis of randomised controlled trials. J Bodywork Movement Thera. 2016. doi:10.1016/j.jbmt.2016.02.013.

31. Cavanaugh JT, Killian SE. Rehabilitation following meniscal repair. Curr Rev Musculoskelet Med. 2012;5(1):46-58. doi:10.1007/s12178-011-9110-y.

32. Brukner P, Khan KM. Clinical Sports Medicine. 4th ed. Sydney, Australia: McGraw Hill; 2012.

33. Carnes D, Mars TS, Mullinger B, Froud R, Underwood M. Adverse events and manual therapy: a systematic review. Man Ther. 2010;15(4):355-63. doi:10.1016/j.math.2009.12.006.

34. Paanalahti K, Holm LW, Nordin M, Asker M, Lyander J, Skillgate E. Adverse events after manual therapy among patients seeking care for neck and/or back pain: a randomized controlled trial. BMC Musculoskelet Disord. 2014;15(77). doi:10.1186/1471-2474-15-77.

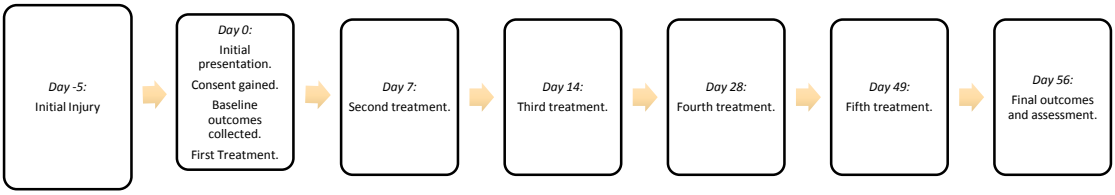
35. Wong CK. Strain counterstrain: current concepts and clinical evidence. Man Ther. 2012;17(1):2-8. doi:10.1016/j.math.2011.10.001.

36. Zein-Hammoud M, Standley PR. Modeled Osteopathic Manipulative Treatments: A Review of Their in Vitro Effects on Fibroblast Tissue Preparations. The Journal of the American Osteopathic Association. 2015;115(8):490-502. doi:10.7556/jaoa.2015.103.

37. Roberts E, Delgado Nunes V, Buckner S, Latchem S, Constanti M, Miller P, et al. Paracetamol: not as safe as we thought? A systematic literature review of observational studies. Ann Rheum Dis. 2016;75(3):552-9. doi:10.1136/annrheumdis-2014-206914.

38. Sachs CJ. Oral Analgesics for Acute Nonspecific Pain. American Family Physician. 2005;71(5):913-8.

Figure 1 – Timeline of data collection and treatment.



<InlineImage1>

Table 1. Summary of the physical examination at the initial consultation.

Observation/Inspection	• Marked oedema of left tibiofemoral joint with associated bruising • Antalgic posture. Patient weight-bearing to the right, and unable to fully extend left knee • Gait: noticeable limp

Active Range of Motion	• Decreased left knee flexion (to approximately 90 degrees) with pain at end-range • Decreased extension (to approx. 160 degrees) with pain at end-range • Full internal and external rotation range of motion, with pain at end range. • Unable to perform squat movement
Passive Range of Motion	• Decreased left knee flexion and extension with pain at end range ('oedematous' end feel) • Full internal and external rotation range of motion, with pain at end range.
Palpation	• Familiar pain on palpation of medial joint line. • Increased tone in local musculature (hamstrings, popliteus, gastrocnemius)

Orthopaedic testing (19)	• Positive McMurray's test (pain and clicking)
	• Positive Thessaly's test (pain and clicking)
	• Positive Apley's test
	• Negative tests
	  o Medial collateral stress test
	  o Lateral collateral stress test
	  o Anterior to posterior tibial glide (Posterior cruciate ligament stress test)
	  o Posterior to anterior tibial glide (Anterior cruciate ligament stress test)

Table 2. Patient-reported outcome measure scores.

Outcome	Pre-Treatment	Post- Treatment	Difference	MDC_{90}
KOOS				
- Pain	36/100	89/100	53	6-6.1 pts (25)
- Symptoms	32/100	93/100	61	5-8.5 pts (25)
- ADLs	62/100	99/100	37	7-8 pts (25)
- Sport/Rec	5/100	90/100	85	5.8-12 pts (25)
- QoL	25/100	75/100	50	7-7.2 pts (25)
LEFS	31/80	74/80	43	9 pts (23)
VAS	7/10	1/10	6	

ADLs: Activities of daily living, QoL: Quality of life, MDC_{90}: Minimum detectable change (90% confidence), KOOS: Knee Injury and Osteoarthritis Outcome Score, LEFS: Lower Extremity Functional Scale, VAS: visual analogue scale

Table 3. Patient rehabilitation program over 8 weeks.

Stage	Goals	Type of exercise/activity	Frequency and Volume
Initial Week 1-2	Reduce oedema Begin to restore joint range of motion Maintain/increase cardiovascular fitness	Rest. Ice. Compression. Elevation.	As frequently as practical.
	Decrease muscular tension	Terminal Knee Extension exercises.	3 sets x 10 reps. 3 times per week, with 1/2-day rest between.
		Foam rolling of calves, hamstrings and quadriceps.	3 times per week, for 30-60 seconds per muscle group
		Swimming.	2 sessions per week, for 15-30 mins each
Intermediate Week 2-5	Continue to restore joint range of motion Increase cardiovascular fitness Begin restoration of strength Improve lower limb proprioception Improve lumbopelvic and talocrural biomechanics and control.	Knee ROM exercises.	4 times per week. Moving from maximum pain-free flexion to extension.
		Gluteal activation exercises (Clams).	3 sets x 15 reps. 3 days per week with 1/2-day rest between.
		Box Squat to 120 degrees of knee flexion.	3 sets x 10 reps. 3 days per week with 1/2-day rest between.
		Swimming.	2 sessions per week, for 30-40 mins each

		Foam rolling of calves, hamstrings and quadriceps.	3 times per week, for 30-60 seconds per muscle group
		Ankle dorsiflexion mobilization.	90 seconds (30 seconds in three separate planes of movement) daily.
		Single leg balance exercises.	3 sets of 30 second balances. 4 days per week.
Advanced Week 6-8	Increase cardiovascular fitness Begin restoration of strength Improve lower limb proprioception Improve lumbopelvic and talocrural biomechanics and control.	Front squats.	3 sets x 10 reps. 3 days per week with 1/2-day rest between. (approx. 30-40% max weight).
		Lunges.	3 sets x 10 reps. 4 days per week with 1-day rest between. Body weight only initially, then progress gradually.
		Load acceptance jumps.	From a 1ft box, anterior movement only. 3 sets x 10 reps. 3 days per week with 1/2-day rest between.
		Ankle dorsiflexion mobilization.	90 seconds (30 seconds in three separate

	planes of movement) daily.
Banded crab walks	3 sets of 20 metre walks. 3 days per week with 1/2 day rest between.
Single leg balance exercises, with anterior-posterior torso movement.	3 sets of 30 second balances. 4 days per week.
Running.	Straight line on grass. Begin at 10-15 mins and progress as injury allows. 3 days per week.
Running progression.	3 days per week. One session of as long a run as fitness permits. One session of 10, 30 second sprints followed by one minute rest – decreasing rest as fitness allows. One session of agility running drills focussing on change of direction around cones. Increasing

			speed and rate of direction change as injury permits.
Return to Sport Week 8+ (Some of the return to sport phase was managed by the medical staff of the patients football club)	Restore full cardiovascular fitness Restore full agility Regain sport specific skills (eg. Kicking and tackling) Begin team based training under contact.	Skill drills Team Training	Kicking, Marking and Handball drills as per coach instructions. Gradual introduction to contact training, increasing as strength, fitness and player confidence improves. Preventative hyperextention limiting taping of the knee advised.