RESEARCH STUDY PROTOCOL

1. RESEARCH STUDY DETAILS

TITLE: Clinical and Radiological Outcomes of Isolated Meniscal Repair

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Principal Investigator: Mr Ross Radic
Perth Orthopaedic and Sports Medicine Centre
31 Outram Street
West Perth, WA, 6005

Co-Investigators: Dr Shreya Pal
Perth Orthopaedic and Sports Medicine Centre
31 Outram Street
West Perth, WA, 6005

Dr Jay Ebert
School of Human Sciences (Exercise and Sport Science)
University of Western Australia
35 Stirling Highway
Crawley, WA, 6009

Research Study Summary

This study seeks to investigate the post-operative clinical and radiological outcomes of isolated meniscal repair surgery. Patient outcomes will include a range of patient-reported outcome measures (PROMs) and the assessment of meniscal healing via Magnetic Resonance Imaging (MRI).

2. STUDY RATIONALE

The menisci within the knee are integral to knee joint health and function, playing a crucial role in load-bearing, load transmission and shock absorption, as well as lubrication and nutrition of articular cartilage [1]. Meniscal injuries are one of the most common injuries assessed by orthopaedic surgeons [2], with a yearly incidence of 60 to 70 per 100,000 population, with it being particularly common amongst the young and active demographic [3]. They are generally caused via cutting or twisting movements, hyperextension or actions of great force [4], particularly those encountered during sport.

In the presence of symptomatic and painful knee meniscal injuries, despite the high prevalence of meniscectomy (whereby the damaged and/or torn aspect of the meniscus is simply debrided and removed) there is good evidence to suggest that total or partial

meniscectomy is highly deleterious, inducing the development of premature osteoarthritis [5, 6]. Additionally, partial meniscectomy poses biomechanical consequences secondary to decreased contact area and increased overall laxity of the knee [7]. Therefore, meniscal repair (whereby the damaged and/or torn aspect of the meniscus is repaired) is now more commonly employed to restore the natural function of the meniscus [8], with repair considered important in reducing the risk of early degenerative changes [3, 9, 10].

Meniscal repair can be achieved via suture techniques delivered via inside-out, outside-in or all-inside techniques, which are determined by the tear type, orientation and location [9, 11, 12]. Outcomes after meniscal repair surgery are generally encouraging [7, 13-15], though limited published evidence still exists. Furthermore, meniscal repair may often be reported in the presence of concomitant surgery such as anterior cruciate ligament reconstruction (ACLR), and limited published research is available on isolated meniscal repair for symptomatic meniscal tears. Post-operative evaluation of meniscal repair has traditionally been based on clinical assessment at follow-up. A repaired meniscus was considered 'healed' if there was an absence of effusion or joint line tenderness and a negative McMurray's test [16]. However, there was no guarantee that clinically asymptomatic patients may have incompletely healed or non-healed menisci. Second look arthroscopy was considered an objective means of evaluating repaired menisci, though largely unethical in a patient who is progressing well clinically. Owing to the expensive and invasive nature of this, MRI has been proposed as a useful tool, with a sensitivity of 92% and a specificity of 99% for the radiological evaluation of meniscal healing [17].

Therefore, given the important role of meniscal surgical repair in restoring normal knee mechanics and loading characteristics, the high prevalence of symptomatic meniscal tears, and the relative lack of published research in patients embarking on isolated meniscal repair, this research study seeks to ascertain the post-operative clinical and radiological outcome of patients undergoing varied meniscal repair surgical techniques (dictated by the nature, type and severity of the meniscal tear) for symptomatic and painful meniscal tears.

3. RESEARCH STUDY OUTCOMES

Primary hypothesis:

- Patients will significantly improve in clinical outcomes following isolated meniscal repair surgery.

The primary aim will be to investigate:

- Post-operative clinical outcomes via commonly employed PROMs of pain, symptoms, function and activity, following isolated meniscal repair surgery.

Secondary aims will be to investigate:

- Quality of meniscal healing on post-operative magnetic resonance imaging (MRI).
- The association between clinical and MRI-based meniscal healing outcomes.
- Peri- and post-operative complications, knee re-injury and re-operation rates.

4. RESEARCH STUDY DESIGN

Patient Consent and Recruitment

This research study will seek to evaluate the post-operative status of patients that have undergone isolated meniscal repair surgery, under the management of Mr Ross Radic at the Perth Orthopaedic and Sports Medicine Centre. Therefore, patients who have already fulfilled the criteria for surgery and undergone surgery for their symptomatic and painful knee meniscal tears as per their routine clinical pathway, will be invited to participate.

However, specific to this study a number of additional inclusion (and exclusion) criteria must be fulfilled, as outlined below.

Inclusion criteria:

- Isolated meniscal repair surgery (irrespective of tear type).

Exclusion criteria:

- The meniscal repair is combined with another knee surgery (or surgeries), such as ligament reconstruction.
- Degenerative changes of the knee (osteoarthritis) were present at the time of meniscal repair.
- Concurrent chondral or osteochondral injury was present at the time of meniscal repair.
- The individual is unable or unwilling to sign the Patient Informed Consent, specific to this study, and approved by the Institutional Ethics Review Board.

Study Sample

Patients that will be recruited have already undergone meniscal repair surgery.

Between March 2016 and February 2020, a total of 72 patients underwent meniscal repair in isolation, or combined with another surgery (Figure 1). Of these, 56 patients underwent isolated meniscal repair and will be invited to participate in the current study.

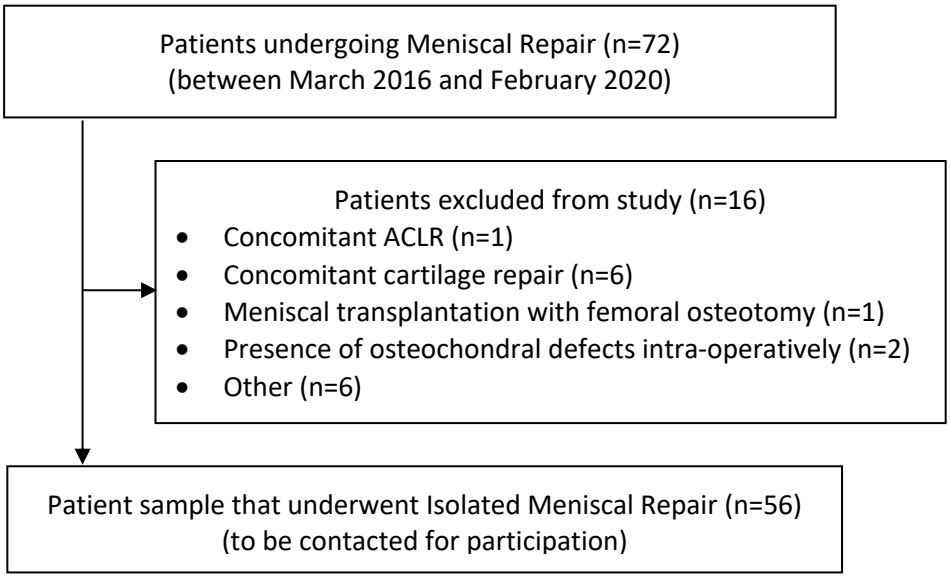

Figure 1. Patient sample available for study participation.

Surgical Technique & Rehabilitation

Under general anaesthetic, arthroscopy of the knee was performed assessing all compartments of the knee. For the current study, other (incidental) injury to the knee was excluded, thereby confirming isolated meniscal tear causing the patients symptoms. The meniscal tear size and type was assessed, and the most appropriate repair method was utilised to achieve stable meniscal repair and restore meniscal function to the knee. Stimulation techniques such as meniscal tear debridement, capsular pie-crusting, notch microfracture and/or platelet rich plasma (PRP) injections if utilised were recorded in the operative data.

Meniscal repair methods undertaken in the current patient cohort (which have been described in various literature and surgical techniques previously) included:

- all-inside meniscal repair
- inside-out meniscal repair
- outside-in meniscal repair
- transosseous meniscal root repair

Post operatively, patients were managed according to their post-operative protocol defined by the intra-operative findings and stability of the meniscus.

Patient Evaluation

Clinical Review

Firstly, a number of patient-reported outcome measures (PROMs) will be undertaken pre-surgery and at 12 and 24 months post-surgery. These will include the:

1. International Knee Documentation Committee (IKDC) Subjective Knee Form [18] – this will be used to evaluate patient-perceived symptoms, physical function and sporting activity, scored from 0-100 with higher scores indicating a better score.
2. Lysholm Knee Score (LKS) - this will be used to evaluate pain, symptoms, swelling, knee instability, difficulty with activities of daily living and sport.
3. Tegner Activity Score (TAS) – this will be used to assess the level of activity/sports the patient is currently participating in [19].

MRI Review

MRI will be employed in all patients at a minimum 12 months post-surgery to evaluate the presence of healing (or failure). MRI outcome will be evaluated based on a previously published scoring tool that evaluates MRI signal grade [17, 20]. This includes: 1) Grade 0, defined as a normal meniscus (the meniscus demonstrates low signal intensity, 2) Grade 1, defined as an irregularly marginated intrameniscal Signal (the signal did not abut or communicate with an articular surface), Grade 2, defined as a linear signal that did not abut or communicate with an articular surface, and 4) Grade 3, defined as a linear signal intensity that abutted or communicated with an articular surface.

Planned Data and Statistical Analysis

Firstly, the mean (SD, range) of all subjective PROMs collected will be presented for the designated post-operative time-points. Repeated measures Analysis of Variance (ANOVA) will be employed to evaluate change over the pre- and post-operative timeline in all PROMs. The number (and type) of surgical (intra-operative) complications, post-operative adverse events and re-injuries will be presented. The status of meniscal healing as demonstrated on MRI (at a minimum 12 months) will be reported. While the aforementioned MRI meniscal healing classification system will be employed, this may change depending on other MRI-based scoring tools that may emerge in time. Where appropriate, statistical analysis will be performed using SPSS software (SPSS, Version 23.0, SPSS Inc., USA), while statistical significance was determined at $p<0.05$.

5. DATA MANAGEMENT AND RECORD KEEPING

The storage and disposal of data will comply with the guidelines set forth by the University of Western Australia, in accordance with the Western Australian University Sector Disposal Authority. All paper records will be kept under lock and key in a metal filling cabinet at the Perth Orthopaedic and Sports Medicine Centre (place of clinical and research work of Mr Ross Radic, the Chief Investigator in this study). Data will also be entered into a password protected electronic spreadsheet (which will also permit later data analysis) to be held at the Perth Orthopaedic and Sports Medicine Centre, in “re-identifiable” (coded) format. The research-specific database will be coded to protect the anonymity of the participant. The research-specific database will only be accessible to the research team, and again once entered this data will be de-identified (coded). Records will be kept for a minimum 7 years following project completion (or until the youngest participant turns 25 years of age, whichever is later, as per the Western Australian University Sector Disposal Authority). Data

will then be securely erased as per the procedures adopted by the University of Western Australia in accordance with the Western Australian University Sector Disposal Authority. There will be no patient interviews undertaken and/or recorded specifically for this study, while no intellectual property will be created with the outcomes of this project.

6. PUBLICATION AND RESULTS DISSEMINATION

It is anticipated that the results of this research study will be published and/or presented in a variety of forums. In any publication and/or presentation, information will be provided in such a way that the participant cannot be identified. Only mean (pooled) results will be disseminated, rather than individual results. Upon completion of the study, and the ethical dissemination of results (through published scientific means of data release), the pooled results in this published format can be provided to participants. It is important to note that this study does not involved the collection of genomic data, and the evaluations undertaken are routinely undertaken in these patients as part of standard care.

7. REFERENCES

1. Makris, E.A., P. Hadidi, and K.A. Athanasiou, *The knee meniscus: structure-function, pathophysiology, current repair techniques, and prospects for regeneration.* Biomaterials, 2011. **32**(30): p. 7411-31.
2. McDermott, I.D. and A.A. Amis, *The consequences of meniscectomy.* J Bone Joint Surg Br, 2006. **88**(12): p. 1549-56.
3. Krych, A.J., et al., *Arthroscopic repair of isolated meniscal tears in patients 18 years and younger.* Am J Sports Med, 2008. **36**(7): p. 1283-9.
4. Greis, P.E., et al., *Meniscal injury: I. Basic science and evaluation.* J Am Acad Orthop Surg, 2002. **10**(3): p. 168-76.
5. Burks, R.T., M.H. Metcalf, and R.W. Metcalf, *Fifteen-year follow-up of arthroscopic partial meniscectomy.* Arthroscopy, 1997. **13**(6): p. 673-9.
6. Manzione, M., et al., *Meniscectomy in children: a long-term follow-up study.* Am J Sports Med, 1983. **11**(3): p. 111-5.
7. Eberbach, H., et al., *Sport-specific outcomes after isolated meniscal repair: a systematic review.* Knee Surg Sports Traumatol Arthrosc, 2018. **26**(3): p. 762-771.
8. Fillingham, Y.A., et al., *Inside-Out Versus All-Inside Repair of Isolated Meniscal Tears: An Updated Systematic Review.* Am J Sports Med, 2017. **45**(1): p. 234-242.
9. Spalding, T., I. Damasena, and R. Lawton, *Meniscal Repair Techniques.* Clin Sports Med, 2020. **39**(1): p. 37-56.
10. Lucas, G., et al., *Isolated meniscal injuries in paediatric patients: outcomes after arthroscopic repair.* Orthop Traumatol Surg Res, 2015. **101**(2): p. 173-7.
11. Makris, et al., *The knee meniscus: Structure–function, pathophysiology, current repair techniques, and prospects for regeneration.* Biomaterials, 2011. **32**(30): p. 7411-7431.
12. D., M.I. and A.A. A., *The consequences of meniscectomy.* The Journal of Bone and Joint Surgery. British volume, 2006. **88-B**(12): p. 1549-1556.
13. Kurzweil, P.R., et al., *Repair of horizontal meniscus tears: a systematic review.* Arthroscopy, 2014. **30**(11): p. 1513-9.

14. Chung, K.S., et al., *A meta-analysis of clinical and radiographic outcomes of posterior horn medial meniscus root repairs.* Knee Surg Sports Traumatol Arthrosc, 2016. **24**(5): p. 1455-68.
15. Samuelsen, B.T., et al., *Comparative Outcomes of All-Inside Versus Inside-Out Repair of Bucket-Handle Meniscal Tears: A Propensity-Matched Analysis.* Orthop J Sports Med, 2018. **6**(6): p. 2325967118779045.
16. Barrett, G., *Clinical results of meniscus repair in patients 40 years and older.* Arthroscopy, 1998. **14**(8): p. 824-829.
17. Miao, Y., et al., *MRI signal changes in completely healed meniscus confirmed by second-look arthroscopy after meniscal repair with bioabsorbable arrows.* Knee Surgery, Sports Traumatology, Arthroscopy, 2009. **17**(6): p. 622-630.
18. Lentz, T.A., et al., *Return to preinjury sports participation following anterior cruciate ligament reconstruction: contributions of demographic, knee impairment, and self-report measures.* J Orthop Sports Phys Ther, 2012. **42**(11): p. 893-901.
19. Collins, N.J., et al., *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 Suppl 11**: p. S208-28.
20. Crues, J.V., 3rd, et al., *Meniscal tears of the knee: accuracy of MR imaging.* Radiology, 1987. **164**(2): p. 445-8.