

## Peer Review File

Article information: <https://dx.doi.org/10.21037/aoj-21-32>

### Reviewer A

General comment:

There is a large black hole in the literature with relation to rehabilitation after orthopedic interventions in general, and about meniscus injuries in particular. I want to commend the authors for their efforts in highlighting important rehabilitation issues in this manuscript on rehabilitation and RTS following lateral meniscus surgery. However, I think the present manuscript is too generic and there is a lack of specificity throughout the manuscript. If I were a young doctor or physiotherapist, I would not have much new to bring into my clinical work after reading the manuscript as it is today. But I am also sure that the authors with a few major changes can make this manuscript clinically beneficial for all readers.

**Reply:** Thank you for your detailed review, please see our point-by-point responses to your comments and the requested changes in the paper.

Specific comments:

#### Comment 1:

The abstract is promising a lot, but I cannot find the promised information in the subsequent manuscript. For example, I cannot see that “key goals” and “interventions” in the different stages are specifically provided. This can be amended by adding the specific information in the subsequent manuscript.

The same issue is related to “multiple measurements”, “functional tests”, “state of the art tests”, and “optimal movement quality” – which in my opinion is not provided in sufficient detail throughout the manuscript. The abstract can however be used as it is if the authors provide the promised information in the actual manuscript.

I am aware that some of the following comments may seem too specific, however I think this manuscript is promising, and can become important for clinicians looking for guidance from experts in the area. A more detailed approach can achieve this.

**Reply 1:** In hindsight we agree that the original manuscript presented more general guidelines. The choice was made based on a lack of scientific evidence. In essence, it provides clinicians with information on WHAT to do but not HOW to do it. Based on your useful comments we now have changed the revised manuscript in which more specific details are presented. Please consider that these concepts are primarily drawn from scientific evidence and our own protocols used for patients after ACL injury. Hence, although there is no sound evidence, we feel that the presented framework provides useful information for clinicians.

#### Comment 2:

I think the introduction is well written and contains important information on the history and background which is important to know. However, I am not sure that the subheadings are necessary throughout.

**Reply 2:** We have removed the subheadings per your suggestion.

**Comment 3:**

P5, line 102: “the latter option” refers to partial meniscectomy – I think the authors means “left in situ” – please adjust

**Reply 3:** This has been changed accordingly. Thank you for pointing out this error. Moreover, we have made major changes in the section on trends in lateral meniscus surgery.

**Comment 4:**

P5, lines 111-113: Please outline why patients with lateral meniscus injuries are clinically challenging. I think this would be a good place to define RTS criteria for patients with lateral meniscus injuries. What is a non-optimal functional outcome in this context?

**Reply 4:** We have the text now to: Football players showed a shorter time to return to play for medial meniscectomy if compared to lateral [5 weeks vs 7 weeks] and a 6 times higher probability of returning to play (28). Lateral meniscus injuries are more challenging clinically, even in case of partial meniscectomy.

The reasons why athletes with lateral meniscus injuries are more challenging based on clinical experience and findings from research are related to 1) longer time to RTS, 2) higher risk for residual symptoms.

In order to clarify the RTS criteria framework we added “Return to sport criteria should be based on a complete rehabilitation progression and on passing objective clinical tests and subjective functional assessment scores”, we further develop the concept later in the text.

**Comment 5:**

P5, line 118: Please clarify if these numbers are healing rates for lateral or medial or both? This is not clear, and the referenced paper had 19 medial and 16 lateral tears.

**Reply 5:** We have now clarified this sentence. The new sentence now reads: “MRI examination six months after surgery revealed a continuous healing process and, at final follow-up, lateral menisci were classified as 62.5 % healed, 31.3% partially healed and 6.2% non-healed, while medial menisci were classified as 50.0 % healed, 38.9% partially healed and 11.1 % non-healed.”

**Comment 6:**

P5, line 119: Does the issue that the healing was not complete based on MRI at final FU have any consequence for the risk of new injury? Hence, the Aspetar research group have shown that an abnormal MRI at RTS after hamstring strain injury did not affect reinjury risk. Is this different with lateral meniscus injuries?

**Reply 6:** This is not clear at this time. For example the FU in the Willinger et al. study was only 2 years. Recent work by on anterior horn lesions in (only !) 8 patients, one patient had grade 3 signal and one had a postoperative meniscal cyst at the site of repair, with excellent patient-reported scores and no clinical signs or symptoms. In the study by Pujol et al (Pujol N, Tardy N, Boisrenoult P, Beaufils P. Magnetic resonance imaging is not suitable for interpretation of meniscal status ten years after arthroscopic repair. *Int Orthop*. 2013;37(12):2371-2376. doi:10.1007/s00264-013-2039-6) with long-term follow-up with MRI, the mean subjective IKDC and Lysholm scores of the patients with no abnormal signal on MRI were 94.7 and 99, the mean subjective IKDC and Lysholm scores of the patients with vertical abnormal signals on MRI were 99 and 100 and the mean subjective IKDC and Lysholm scores of the patients with horizontal grade 3 abnormal signals on MRI were 83.9 and 99, respectively. These abnormal vertical and/or horizontal hypersignals present on MRI 10 years after arthroscopic all-inside meniscal repair, had no subjective or objective clinical significance

**Comment 7:**

P5, lines 120-121

- Which method do you recommend for the assessment of swelling /effusion in decision making?

**Reply 7:** We recommend the modified stroke test (Sturgill, LP et al, 2009). We added that to the text.

**Comment 8:**

- Which method do you suggest for the assessment of joint tenderness in decision making?

**Reply 8:** We recommend the joint line tenderness test. We added that to the text.

**Comment 9:**

- Which meniscus tests do you recommend should be used in decision making?

**Reply 9:** We recommend the McMurray's test and Apley's test. We added that to the text.

**Comment 10:**

- Which clinical scores are usually used to assess patients with lateral meniscus injuries?

**Reply 10:** We recommend the IKDC, KOOS, and Tegner activity score.

**Comment 11:**

P6, line 126: Please define “a complete functional recovery”. Which criteria and tests are used to assess this?

**Reply 11:** We removed this section and we defined complete functional recovery criteria in the “CRITERIA BASED REHABILITATION” part

**Comment 12:**

P6, line 127: Please provide support for the statement that neuromuscular function (and not psychological status, muscle strength, endurance, movement quality and others) are more important. If this statement cannot be scientifically supported, I suggest it removed.

**Reply 12:** This section has now been removed.

**Comment 13:**

P6, lines 140-141: I think all agree that the long-term protection of the athlete's health is the main goal rather than short term success. It would be beneficial to the manuscript if the authors could outline examples of cases where athlete health is more important than RTS. Should for example all athletes with a lateral meniscus resection be advised to not returning to pivoting sports due to the proven elevated risk of future knee osteoarthritis. I would like to challenge the authors to include a section on ethical considerations with returning to high-level sports after major lateral meniscus injury.

**Reply 13:** Thank you for challenging us on this highly relevant topic.

A recent review by Chen et al identified that most elite athletes are not aware that sporting injuries are occupational injuries requiring behaviours determined by occupational safety and health rules. Occupational risk communication should be improved by establishing a proactive injury prevention culture and identifying clear-cut responsibilities for key stakeholders within sport organisations. Work from Bolling and colleagues showed that athletes perceive an injury only when it hampers performance. For daily coverage of athletes this means we need to inform the athlete that when pre-injury level has been reached after a lateral meniscus injury and desire is to resume full sports participation, this could have consequences for the long term health of the knee joint for example early onset of OA.

We added these considerations to the manuscript line 119-127

**Comment 14:**

P7, line 154: What are the most common muscular and neuromuscular deficits that need to be addressed? Furthermore, an elaboration on how to address the different deficits would be beneficial to the reader.

**Reply 14:** Line 140-146: The most relevant muscular and neuromuscular deficits to consider and resolve are lower extremity kinetic chain (not just knee flexors and extensors) and lumbo-pelvic-hip complex muscular strength deficits; neuromuscular inhibition (arthrogenic muscle inhibition process); basic motor patterns deficits on the frontal and the sagittal plane (limb stability, pelvis and trunk stability, shock absorption strategies) (Buckthorpe M, La Rosa G, Della Villa F. Restoring Knee Extensor Strength After Anterior Cruciate Ligament Reconstruction: A Clinical Commentary. *Int J Sports Phys Ther* [Internet]. 2019 Feb;14(1):159–72.

We added these considerations to the manuscript.

**Comment 15:**

P7, line 167: How does the fact that patients with lateral meniscus tear in combination with ACL rupture affect rehabilitation and RTS? Are different exercises needed? Is there a reduced success rate compared to patients with medial meniscus injuries? Should they expect a longer time before RTS? Please elaborate.

**Reply 15:**

- In a recent systematic of isolated meniscus tears, included were 17 studies, there were 212 (59.2%) medial meniscal repairs and 95 (26.5%) lateral meniscal repairs; however, the complication rate for medial and lateral repairs could not be individually extrapolated from the studies (Blanchard ER, Hadley CJ, Wicks ED, Emper W, Cohen SB. Return to Play After Isolated Meniscal Repairs in Athletes: A Systematic Review. Orthopaedic Journal of Sports Medicine. November 2020. doi:10.1177/2325967120962093).
- Austin and Sherman (Austin KS, Sherman OH. Complications of arthroscopic meniscal repair. Am J Sports Med. 1993;21(6):864-869) found that the complication rate was 14% for isolated meniscal repairs and also reported a 20% complication rate after a meniscal repair with a concomitant ACL reconstruction. They also found that there was an 18% complication risk in patients with isolated medial meniscal repair, and zero complications were found with isolated lateral meniscal repair.
- No different excersises are needed but the ACL rehab program should be adjusted to the meniscus repair.

We added these considerations to the manuscript.

**Comment 16:**

P8, line 178: Please define the criteria for a complete functional recovery

**Reply 16:** Return to sport should be allowed when full range of motion, strength, and movement quality have been achieved, and sport-specific fitness and on-field sport-specific training have been completed.

**Comment 17:**

P8, lines 181-182: Please provide information on what the differences in timing of recovery after different meniscus surgeries are

**Reply 17:** Thank you for underlining this point.

Wiley et al (Wiley TJ, Lemme NJ, Marcaccio S, Bokshan S, Fadale PD, Edgar C, Owens BD. Return to Play Following Meniscal Repair. Clin Sports Med. 2020 Jan;39(1):185-196. doi: 10.1016/j.csm.2019.08.002. PMID: 31767105.) show highly variable return to play times, from 7 to 9 weeks with isolated meniscectomy to 5.6 months with meniscal repair.

Relevant information has been added in the manuscript.

**Comment 18:**

P8, lines 186: Please provide information on which location and which size of tears that will significantly change the rehabilitation program. For instance, the readers

might be interested in the differences between a posterior lateral meniscus root repair and a lateral meniscus bucket handle repair.

**Reply 18:** Thank you for underlining this point, giving us the opportunity to expand this part of the manuscript.

Despite the absence of evidence-based protocols specific to the type of meniscal surgery, readers will now be able to receive some information on common approaches suggested in the literature, mostly on anatomical, pathophysiological, and biomechanical bases. “Because of the lack of evidence-based protocols specific to the type of meniscal surgery, it is difficult to provide strong recommendations on post-surgical rehabilitation protocols specific to the type of meniscal surgery (Harput G, Guney-Deniz H, Nyland J, Kocabey Y. Postoperative rehabilitation and outcomes following arthroscopic isolated meniscus repairs: A systematic review. *Phys Ther Sport*. 2020 Sep;45:76-85. doi: 10.1016/j.ptsp.2020.06.011.).

However, some anatomical, biomechanical, pathophysiological, and clinical-based studies allow some advice to be provided. (Sherman SL, DiPaolo ZJ, Ray TE, Sachs BM, Oladeji LO. Meniscus Injuries: A Review of Rehabilitation and Return to Play. *Clin Sports Med*. 2020 Jan;39(1):165-183. doi: 10.1016/j.csm.2019.08.00

We added text Line 149-163

A recent systematic review showed that the highly variable postoperative rehabilitation protocols found in the literature did not influence failure rates, patient reported outcomes nor return to sports rate following arthroscopic isolated meniscal tear repair (Harput G, Guney-Deniz H, Nyland J, Kocabey Y. Postoperative rehabilitation and outcomes following arthroscopic isolated meniscus repairs: A systematic review. *Phys Ther Sport*. 2020 Sep;45:76-85. doi: 10.1016/j.ptsp.2020.06.011.), and time post-surgery has been shown as the most used criterium in RTS decision-making, rather than achievement of specific functional criteria (Harput G, Guney-Deniz H, Nyland J, Kocabey Y. Postoperative rehabilitation and outcomes following arthroscopic isolated meniscus repairs: A systematic review. *Phys Ther Sport*. 2020 Sep;45:76-85. doi: 10.1016/j.ptsp.2020.06.011.)

It has been suggested that meniscal tears with stable or unstable patterns receive different indications regarding postoperative loading in the early stages of rehabilitation (Sherman SL, DiPaolo ZJ, Ray TE, Sachs BM, Oladeji LO. Meniscus Injuries: A Review of Rehabilitation and Return to Play. *Clin Sports Med*. 2020 Jan;39(1):165-183. doi: 10.1016/j.csm.2019.08.004.).

Early weight bearing could be helpful to provide compression and reduction in more stable tear patterns (i.e. vertical longitudinal and bucket-handle tears), which may improve healing rates (Cavanaugh JT. Rehabilitation of meniscal injury and surgery. *J Knee Surg* 2014; 27(6):459–78.), thus these patients should be allowed to weight bear as tolerated as early as possible (Barber FA. Accelerated rehabilitation for meniscus repairs. *Arthroscopy* 1994;10(2):206–10.)

On the other hand, weight bearing can create distractive forces for unstable tear patterns (i.e. radial, complex, and posterior root tears) (LaPrade RF, LaPrade CM, Ellman MB, Turnbull TL, Cerminara AJ, Wijdicks CA. Cyclic displacement after meniscal root repair fixation: a human biomechanical evaluation. *Am J Sports Med.* 2015 Apr;43(4):892-8. doi: 10.1177/0363546514562554), thus non-weight bearing should be observed for several weeks (Abraham AC, Villegas DF, Kaufman KR, et al. Internal pressure of human meniscal root attachments during loading. *J Orthop Res* 2013;31(10):1507–13.) (e.g. 6 weeks of non-weight bearing followed by 3 weeks of progressive loading of a lateral meniscus root repair (Mueller BT, Moulton SG, O'Brien L, LaPrade RF. Rehabilitation Following Meniscal Root Repair: A Clinical Commentary. *J Orthop Sports Phys Ther.* 2016 Feb;46(2):104-13. doi: 10.2519/jospt.2016.6219))

Likewise, knee flexion in strengthening exercises should be carefully controlled, mostly after unstable tear patterns repairs (i.e., radial and root), since early progression toward high knee flexion angles (e.g., beyond 30° in lateral meniscus posterior horn repairs (Mueller BT, Moulton SG, O'Brien L, LaPrade RF. Rehabilitation Following Meniscal Root Repair: A Clinical Commentary. *J Orthop Sports Phys Ther.* 2016 Feb;46(2):104-13. doi: 10.2519/jospt.2016.6219)) was shown to lead to higher peak pressures, which may be harmful to meniscal healing (Starke C, Kopf S, Lippisch R, et al. Tensile forces on repaired medial meniscal root tears. *Arthroscopy* 2013;29(2):205–12.)

However, early knee flexion ROM in more stable tear patterns (e.g., vertical meniscus tear repairs) has been shown to enhance healing, thus these restrictions may not be necessary (Lind M, Nielsen T, Fauno P, et al. Free rehabilitation is safe after isolated meniscus repair: a prospective randomized trial comparing free with restricted rehabilitation regimens. *Am J Sports Med* 2013;41(12):2753–8.).

Accelerated rehabilitation protocols after meniscal repair (i.e. time to RTS between 3 and 4 months after surgery) have been suggested to be relatively safe for vertical longitudinal and horizontal cleavage tear patterns treated with stable fixation (Sherman SL, DiPaolo ZJ, Ray TE, Sachs BM, Oladeji LO. Meniscus Injuries: A Review of Rehabilitation and Return to Play. *Clin Sports Med.* 2020 Jan;39(1):165-183. doi: 10.1016/j.csm.2019.08.004.), since it seemed that they were not associated with higher failure rates than ‘restricted’ rehabilitation protocols (i.e. time to RTS higher than 4 months after surgery), that should be preferred for radial, root, and complex meniscal repairs (Spang III RC, Nasr MC, Mohamadi A, DeAngelis JP, Nazarian A, Ramappa AJ. Rehabilitation following meniscal repair: a systematic review. *BMJ Open Sport Exerc Med.* 2018 Apr 9;4(1):e000212. doi: 10.1136/bmjsem-2016-000212).”

**Comment 19:**

P9, line 201: Please indicate which objective data that should be used in this justification process.

**Reply 19:** Thank you for bringing up this clinical relevant point. Line 204-206: Our

rehabilitation protocol is divided into functional steps, consisting of treatment goals and specific interventions. To proceed from one step to another, patients should pass established clinical and functional criteria [green traffic lights]

This concept has been presented in previous papers on RTS after ACLR(38,39) and the same principles apply to every sport patient following knee surgery.

**Comment 20:**

P9, line 204: I think the reader could be interested in a couple of examples (green traffic lights)

**Reply 20:** Line 206-215 For example, entrance criteria to start on-field rehabilitation are: (1) no knee pain or swelling, (2) no subjective knee instability, (3) negative knee laxity tests with concomitant ACLR,(4) a minimum of 80% limb symmetry during isokinetic assessment of knee flexor and extensor strength, (5) good movement quality (ideally, assessed qualitatively with video analysis) in basic foundation movement exercises, and (6) ability to run aerobically for greater than 10 minutes at 8 km/h with normalized running mechanics (ideally, assessed qualitatively with video analysis).

**Comment 21:**

P9, lines 210 and 211: Please provide examples of which “multiple measurements” and “functional tests” the authors would recommend.

**Reply 21:** The functional evaluation of the patient ideally comprises (I) *strength test* (e.g. knee isokinetic testing at low and high angular velocity), (II) *qualitative movement evaluation* (e.g. frontal and lateral evaluation of jumping and cutting task), (III) *cardiovascular fitness test* (e.g. aerobic and anaerobic threshold test).

**Comment 22:**

P10, lines 226 and 227: I think examples of exercises that specifically target the aim of complete extension range of motion would be beneficial for the reader.

**Reply 22:** We don't have any specific examples for ROM. As we have already added a substantial amount of text to the revised manuscript we thought that basic information on how to regain ROM is not the most important information for clinicians but rather how they can progress a patient by adhering to criteria based rehabilitation principles.

**Comment 23:**

P10, lines 237: Please provide information on how the clinician can assess movement quality. Are there any valid smartphone apps or tools that are commonly available?

**Reply 23:** We have now added information.

Line 249-252 The second key area is movement quality assessment and improvement, with targeted neuromuscular training addressing altered basic movement patterns. Technology for movement analysis is readily available clinicians using apps on smartphones (Kinovea, Hudl, Coaches Eys etc.)



**Comment 24:**

P11, lines 248-249: It would be beneficial for the reader if the authors could provide guidance on the volume, frequency and intensity of muscle strength training following lateral meniscus injuries.

**Reply 24:** Line 262-265: The text now reads: Strengthening includes isolated open chain exercises [e.g. leg extension] as well as closed chain strengthening exercises [e.g., squatting, deadlifting, step-ups, lunges](27). For a detailed overview on type of exercises and strength training parameters like volume, frequency and intensity we refer to the reader to previously published work (27).

**Comment 25:**

P12, line 266: Please describe or define basic motor patterning tasks

**Reply 25:** Thank you. We agree that clarification was needed. We have made the following changes,

Line 281-285. Furthermore, restoring symmetrical and optimal movement quality in basic motor tasks (such as walking, going up and down stairs) is important.

Importantly, failure to sufficiently resolve movement quality during basic functional tasks (when compared to highly complex sporting actions such as cutting mechanics) early post-ACLR can have marked impact on movement quality during late-stage rehabilitation and at the time of and after RTS.

**Comment 26:**

P13, line 291: Should probably be “likelihood of acore OR sub-acute overloading”.

**Reply 26:** This has been changed accordingly. Thank you for pointing out this error.

**Comment 27:**

P13, lines 296-298: Again, I think this manuscript is in need of a more detailed definition of “state of the art tests” and “optimal movement quality”.

**Reply 27:** We have provided more specific information in previous sections including some examples. For example, we conduct a Movement Analysis Test (M.A.T.) that consists of 2D frontal and lateral evaluation of six sport-specific patterns with high speed cameras and is exported to software for movement analysis.

The series of six movements are evaluated according to five objective criteria. The result is considered optimal if the test score is  $\geq 90\%$ .

For a more detailed overview, the interested reader is referred to Buckthorpe et al.(37,47)

**Comment 28:**

I am not fully aware of the journal policy, but in my opinion this section should be written as a section with text and not as a string of bullet points. I suggest changing the heading to “Clinical relevant summary” and that the authors write a summary of the main clinical message to be drawn from the manuscript.

**Reply 28:** Per your recommendation we have changed this accordingly

## **Reviewer B**

### **Comment 1:**

I thank the authors for the opportunity to review this paper. The paper attempts to summarise the current trends and literature on rehabilitation and return to sport following lateral meniscus surgery. The authors have raised some excellent points that should be considered in the rehabilitation process. I would like to see further specific guidelines of outcome measures to be used at each stage of rehabilitation which was best done in the mid-stage rehabilitation section. I have also made some specific suggestions below.

**Reply 1:** Thank you for your detailed review, please see our point-by-point responses to your comments and the requested changes in the paper.

### **Comment 2:**

50 – add (RTS)

**Reply 2:** This was done, thank you.

### **Comment 3:**

78 – add the age of ‘young athletes’

**Reply 3:** High school athletes in this study (Mitchell J, Graham W, Best TM, et al. Epidemiology of meniscal injuries in US high school athletes between 2007 and 2013. *Knee Surg Sports Traumatol Arthrosc* [Internet]. 2016 Mar 27;24(3):715–22). Later in the text, we specified young and active population involves people between ages of 18-39 based on a review of the literature. (Gee SM, Tennent DJ, Cameron KL, et al. The Burden of Meniscus Injury in Young and Physically Active Populations. *Clin Sports Med*. 2020 Jan;39(1):13–27.) We added that information, thank you.

### **Comment 4:**

86 – is this direct or indirect contact? E.g is it due to a direct tackle or input that causes the individual to land and twist their knee?

**Reply 4:** This point is not clearly specified in the article, We speculate that player-to-player contact includes both direct and indirect contacts

### **Comment 5:**

99 – would it be possible to have a sentence describing current recommendations on non-surgical treatment or the option for delayed surgery?

**Reply 5:** This is an excellent point. We have added some findings from a recent systematic review on this topic. For acute root tears, treatment options include arthroscopic repair, meniscectomy and non-surgical approach. In all three groups, improvement can be expected after 12 months. Based on available evidence, it was suggested that arthroscopic repair may have a better protective role in terms of slowing down the onset of osteoarthritis.

### **Comment 6:**

Return to sport

109 – it would be helpful to define age if the young athlete

**Reply 6:** The mean age was 25.4 years and was added in the manuscript.

**Comment 7:**

116 – what was the follow up time for return to sport?

**Reply 7:** The follow-up was 6 months

**Comment 8:**

135 – Is it possible to present current trends on non-surgical management and also clarify that there is a trend to keeping as much of the meniscus as possible with any surgical intervention due to their protective role in the knee and to lower the risk of OA.

**Reply 8:** Line 85-86 Thank you for highlighting this important point. We have added this to the text.

**Comment 9:**

158 – Can it really be said that Lateral meniscus injuries are always more challenging? How can this claim be made and after softening the language it would be helpful to state why the lateral meniscus injuries can be more challenging.

**Reply 9:** Line 145-147: We have brought up this as RTS time are longer and a 6 times lower likelihood for lateral meniscus compared to medial tears based on the current literature.

**Comment 10:**

161 – There is data presented about lateral meniscus injury with ACL rupture but could it first be stated the current trends in isolated lateral meniscus repair?

**Reply 10:** We have revised this entire section. The first paragraph now states: Findings from a recent systematic review reported highly variable postoperative rehabilitation protocols following isolated meniscus repair (29). Despite the variability in the rehabilitation protocols, there were no differences in failure rates, patient reported outcomes and RTS rates for vertical meniscus tears (29). The evidence from this systematic review is inconclusive as 78% of the studies were retrospective, involved for the majority vertical longitudinal tears of the medial meniscus and lacked details for the rehabilitation (29)

**Comment 11:**

Early-stage rehabilitation

- Pain, swelling, range of motion, strength are the key areas to address in this stage with a focus on quadriceps strength. Are there more specific guidelines about how to maintain quadriceps strength for example the use of closed vs open chain exercises and specific precautions that need to be considered? E.g time frames of open chain exercises can be recommended to be limited until 3 months following reconstruction. This would depend on the type of meniscus surgery but is it possible to provide

guidance on how this should be approached or specific restrictions in the literature following lateral meniscus surgery?

**Reply 11:** Line 270-276 Thank you for raising this important point. In a recent systematic review by Harput et al (Phys Ther Sport 2020) Open kinetic chain strengthening can be started for the quadriceps at 6 weeks, not for hamstrings, and progressive starting at 12 weeks. Leg press and squatting should not exceed 90 degrees of knee flexion in the first 3 months (Harput)

Unfortunately the literature doesn't provide us any clear evidence as most studies were retrospective in design.

**Comment 12:**

- While protecting the knee is recognized for this stage of rehabilitation, is there specific literature to guide restrictions following lateral meniscus surgery. For example, squat depth in the early phase that could guide decisions along with that of each individual surgeon.

**Reply 12:** Please refer to the reply of the previous comment.

**Comment 13:**

Mid-stage rehabilitation

- This section best uses objective criteria and identifies three key focus areas of rehabilitation.

**Reply 13:** The section has now been organized according to the three key areas.

**Comment 14:**

- Could the specific outcomes identified such as line 245 state the population group that had benefits of 20% knee extensor strength of the other side?

**Reply 14:** These include jump distance and biomechanics.

**Comment 15:**

Late-stage rehabilitation

- Is there further consideration of outcomes such as Limb symmetry index of >90-95 at this stage in a similar way that it has been described in the ACL literature that could assist in guiding objective outcome measures for return to sport?

**Reply 15:** The limb symmetry index for strength should be 100% (Buckthorpe). However, strength is only one of the criteria, as for example, movement quality and physical endurance are other important factors that are considered in RTS decision making. We have outlined this in the revised manuscript.

**Comment 16:**

- The same as per above. Is it recommended that specific hop testing is used to demonstrate quality of movement and LSI like recommendations used in ACLR return to sport?

**Reply 16:** We conduct a Movement Analysis Test (M.A.T.) that consists of 2D

frontal and lateral evaluation of six sport-specific patterns with high speed cameras and is exported to software for movement analysis.

The series of six movements are evaluated according to five objective criteria. The result is considered optimal if the test score is  $\geq 90\%$ .

**Comment 17:**

Figure 2 – This is helpful to demonstrate the need for motor control in rehabilitation. It looks like an impressive feedback system for the patient. Is it possible to describe the set up of the system used so it could be replicated in other clinics?

**Reply 17:** Thanks for your comment. It is possible to describe a little bit more the setup without going into all the specific details. We expanded in the picture heading: “Figure 2. ... to on field rehabilitation. The patient is performing a single leg squatting task with proper frontal plane alignment in a indoor space dedicated to motor learning (Isokinetic Green Room) consisting in a system of high speed cameras, force platform and a video-wall to ensure comprehensive biofeedback”.

**Comment 18:**

Figure 3 – what sport is this specific for? Or is it for any field-based sport? There is multiple equipment of uneven surfaces on the ground but is there a more specific explanation that could be added to the description to make it's inclusion worthwhile?

**Reply 18:** Based on your comment we decided to change the figure to a one more dedicated to football

**Comment 19:**

Final considerations

- There is no specific mention of time frames and specific outcome measures in this section. Is it possible to provide specific outcome measures guidelines for each stage of rehabilitation what can be summerised in the final considerations section?

**Reply 19:** The time frames are very different between athletes. Our rehabilitation programs are centered around a criteria approach.

We have provided a lot of details in the respective sections and feel this may interfere with the overall key point that we have listed in the final section.

**Comment 20:**

- Strengthening precautions are identified as important but as per above can the literature guide this more than individual surgeon recommendations?

**Reply 20:** Please refer to the previous comment. Unfortunately, the current body of knowledge is largely based on retrospective studies.

**Comment 21:**

- Could a final comment be made about healing time of the meniscus and need to protect it or that the use of objective measures, pain and swelling can guide this.

**Reply 21:** We have added line 96-100 information about the importance of the clinical examination. This has been summarized in the final section of the manuscript.