Return to running following knee osteochondral repair using an anti-gravity treadmill: A case report.

ABSTRACT

Background: The purpose of this study was to assess the impact of an anti-gravity treadmill return to running programme on self-efficacy and subjective knee function following knee osteochondral surgery. **Case Description:** A 39-year-old otherwise healthy female endurance runner with a left knee femoral cartilage grade 3-4 defect 3cm^2. The patient underwent single step arthroscopic microfracture with Bone Marrow Aspirate Concentrate. An AlterG® anti-gravity treadmill was used to manipulate loading during a graduated phased return to running over 8 weeks. Self-efficacy was evaluated using the Self-Efficacy for Rehabilitation outcomes scale (SER) and the Knee Self-Efficacy Scale (K-SES). Subjective knee function was evaluated using the Knee Injury and Osteoarthritis Outcome Score (KOOS) and International Knee Documentation Committee Subjective Knee Form (IKDC). **Outcomes:** The programme resulted in improvements in SER (57%), K-SES present (89%) and K-SES future (65%) self-efficacy domains. The IKDC score demonstrated a clinically important improvement with an increase from 62.1 in week 1 to 86.2 in week 8 (39%). Only the KOOS Sport/Rec subscale showed a clinically important improvement from week 1 to week 8. **Discussion:** The programme resulted in improved knee and rehabilitation self-efficacy and subjective knee function following osteochondral repair of the knee. This case report illustrates the importance of considering self-efficacy in rehabilitation after knee osteochondral surgery and highlights the potential role for anti-gravity treadmills in enhancing self-efficacy and subjective knee function in preparation for a return to sport.

KEYWORDS

rehabilitation; knee osteochondral repair; self-efficacy; patient reported outcomes

BACKGROUND

Osteochondral defects of the knee are a frequent cause of pain and reduced function, especially in active people. Surgical techniques to repair osteochondral damage have been shown to improve function and relieve pain.[30] However, rehabilitation after osteochondral surgery is lengthy due to the new tissue taking up to 3 years to mature.[22] The neo-cartilage tissue is not as durable as mature tissue and therefore loading needs to be controlled in the rehabilitation process. The timing of a return to running after osteochondral surgery varies depending on individual and surgical factors but is generally between 6 to 12 months post-surgery.[27]

Anti-gravity treadmills are being increasingly used after knee surgery to reduce ground reaction forces during walking and running to facilitate postoperative rehabilitation.[4, 9] Muscle activity decreases as body weight decreases on an anti-gravity treadmill, but the percentage change in muscle activity is less than the percentage change in body weight.[25] It is possible to achieve target knee forces during rehabilitation using an anti-gravity treadmill.[32] Anti-gravity treadmills have been shown to be safe and feasible to use in early rehabilitation following total knee replacement.[4] However, there are no studies on the use of anti-gravity treadmills in a knee osteochondral population despite their increasing inclusion in rehabilitation guidelines.

Patient reported outcome measures (PROMs) are routinely used to measure a person's health status at a point in time and as primary end points in clinical trials.[3] Subjective measures of knee function are important in the assessment of outcome following injury or surgery as they provide the patient's perspective of their health

status. The International Knee Documentation Committee Subjective Knee Form (IKDC) and the Knee Osteoarthritis Outcome Score (KOOS) have both been found to be reliable, valid and responsive PROMs in patients who have undergone cartilage repair surgery.[33]

Rehabilitation programmes do not always address the psychosocial factors inherent in return to sport. Athletes may have doubts about their readiness to return to their sport and fears about possible reinjury.[8] Self-efficacy is a key component within the theoretical framework of social cognitive theory (SCT) where it is the *"perceived* capability of a person to perform a specific action required to achieve a concrete *goal"*.[2] This is a highly pertinent concept for orthopaedic rehabilitation which is founded on specific actions being taken to achieve functional goals. Self-efficacy is temporal and is consequently open to change during the rehabilitation process.[46] Self-efficacy beliefs have been found to influence rehabilitation outcome after total joint arthroplasty.[29, 45] Self-efficacy has only been evaluated in anti-gravity treadmill rehabilitation in a single case study where it was found that general self-efficacy was elevated after a 6 week anti-gravity treadmill rehabilitation programme for an amputee.[26] To date, there have been no studies on the role of either, general or domain specific self-efficacy, in rehabilitation after knee osteochondral repair.

This case report uses the CARE guidelines[12] to present the rehabilitation details and self-efficacy and subjective knee function outcome measures during an 8 week anti-gravity treadmill rehabilitation programme for a female runner 9 months post-osteochondral repair knee surgery. Full ethics committee approval and patient informed consent were gained. The use of anti-gravity treadmills is a new rehabilitative approach and with the increasing importance of individualised care, this

case report will help to provide a greater understanding of the patient experience that is highly relevant to orthopaedic rehabilitation practice.

The purpose of this study was to assess the impact of an anti-gravity treadmill return to running programme on self-efficacy and subjective knee function following knee osteochondral surgery. It is hypothesised that the use of an anti-gravity treadmill will have a positive influence on knee and rehabilitation self-efficacy and subjective knee function.

METHODS

CASE DESCRIPTION

HISTORY

The patient was a 39-year-old (height 167cm; weight 60.3kg) otherwise healthy female endurance runner who had been participating in 10K to marathon distance running events for the past 6 years. The patient is a fore-foot runner and averaged 26 miles per week at an average pace of 7.5 to 8 minutes per mile prior to injury in February 2015. The patient had been experiencing knee symptoms for several years prior to February 2015. The patient was initially advised not to run for 6 months and then, as there was no improvement, was advised to stop running altogether. Running was such a major contributor to the patient's quality of life that, from her perspective, stopping running was not an option and a second orthopaedic opinion was sought. The patient was found to have a left knee femoral cartilage grade 3-4 defect 3cm^2 and a grade 1 lateral tibial cartilage defect. The patient underwent single step arthroscopic osteochondral repair surgery in September 2015 comprising

microfracture and Bone Marrow Aspirate Concentrate (BMAC)[5, 14] as shown in Figure 1.

FIGURE 1. Single-step arthroscopic osteochondral repair. (A) Osteochondral defect on medial femoral condyle. (B) Osteochondral defect being prepared to receive BMAC therapy. (C) Osteochondral repair underway with BMAC and fibrin.

Post-operatively, the patient was partial weight-bearing for 2 weeks then as tolerated whilst wearing an Ossur Rebound® cartilage brace with medial hinge. The patient underwent a comprehensive postoperative rehabilitation programme including swimming, cycling and leg strengthening exercises. The ultimate goal from the patient's perspective was to return to running. At nine months following surgery, the patient had full range of knee motion and no knee pain and was referred to our specialist sports rehabilitation clinic to facilitate a return to full weight bearing (FWB) running at 12 postoperative months.

INTERVENTION

Maturation of the new tissue can take up to three years[22], so optimising loading following osteochondral surgery is an important part of the rehabilitation process.[13, 28] The ability to run on a treadmill at 8km/h for more than 10 minutes is one of the criteria for progression from rehabilitation Phase 2 (Matrix production and

organisation) to Phase 3 (Repair cartilage maturation) following knee osteochondral repair.[28] An AlterG® Anti-Gravity Treadmill P200 model was used to manipulate loading during a graduated phased return to running.[7] The AlterG treadmill has been found to have minor deviations in unloading but these are less than 5% for 40-90% body weight[24] which is less than the typical deviations in accuracy in partial weight bearing with crutches after cartilage repair of the knee.[10]

WEEK	Percentage Body Weight (%)	Running Speed (km/hr)	Running Time (Mins)	Rating of Perceived Exertion (RPE)
1	30	6.7	5	7
2	30	7.2	10	7
3 Session 1	40	7.6	10	8
3 Session 2	40	7.7	15	9
4 Session 1*	50	7.5	15	9.5
4 Session 2	50	8.0	20	11
5 Session 1	60	8.3	20	11.5
5 Session 2	60	8.0	25	11.5
6 Session 1	70	7.5	25	11
6 Session 2*	70	7.1	30	11.5
7	80	8.0	30 mins alternating 5 mins running & 5 mins walking	11
8*	80	7.5	30 mins alternating 5 mins running & 5 mins walking	10

* Outcome measurements recorded

TABLE 1. Anti-gravity treadmill rehabilitation programme parameters

The programme comprised of 12 antigravity treadmill sessions over an 8-week period taking the patient from 30% to 80% bodyweight as detailed in Table 1. The patient wore the Ossur Rebound® cartilage brace and the same running shoes during every session. The patient maintained their home exercises (including swimming, cycling and leg strengthening) as previously prescribed. Each treadmill session started with a 5 minute 100% body weight self-paced walking warm up and ended with a 5 minute 100% body weight self-paced walking cool down. A visual

analogue scale pain score was asked before, during and after each session. The patient was advised to stop if at any time during a session she experienced knee pain, but at no time during the programme was any pain reported.

Increasing running speed rather than increasing per cent body weight has been shown to have the strongest effect on the maximum plantar forces.[42] The load through the plantar surface of the foot is an indirect measure of ground reaction forces through the lower limbs. Therefore, as graduated loading of the knee was important in this rehabilitation programme, the running speed was controlled by using a self-selected pace with the patient advised to keep her rating of perceived exertion (RPE) at a light level (under 12) throughout every session. The use of the Borg RPE scale was selected as research has shown that RPE values do not require adjustment in a lowered body weight environment.[18]

OUTCOMES

SELF-EFFICACY FOR REHABILITATION OUTCOMES SCALE (SER)

The SER is a 12-item measure developed according to Bandura's guidelines for assessing participants' beliefs about their abilities to perform activities in rehabilitation.[29, 37] The SER was designed specifically for patients undergoing lower limb orthopaedic surgery[45] and has been used in ligament reconstruction[6] and joint replacement[23] but it has not been previously used in a knee osteochondral repair population. The mean SER scores are shown in Figure 2.

KNEE SELF-EFFICACY SCALE (K-SES)

The Knee Self-Efficacy Scale (K-SES) is a 22-item measure used to determine perceived knee function self-efficacy both in the present (K-SES$_{PRESENT}$) and for the future (K-SES$_{FUTURE}$).[39] Internal locus of control is related to more proactive health behaviours and has been shown to be an important factor in determining K-SES$_{PRESENT}$ but not K-SES$_{FUTURE}$.[38] Knee-related function in sports and recreation has been shown to be a factor in knee self-efficacy.[38] The K-SES has not been evaluated in a population of people who have undergone knee osteochondral repair but has been shown to demonstrate good responsiveness for patients with an ACL injury[41] and it is considered preferable to use rather than a general self-efficacy score.[19] The mean K-SES$_{PRESENT}$ and K-SES$_{FUTURE}$ scores are shown in Figure 2.

KNEE INJURY AND OSTEOARTHRITIS OUTCOME SCORE (KOOS)[11, 17, 35]

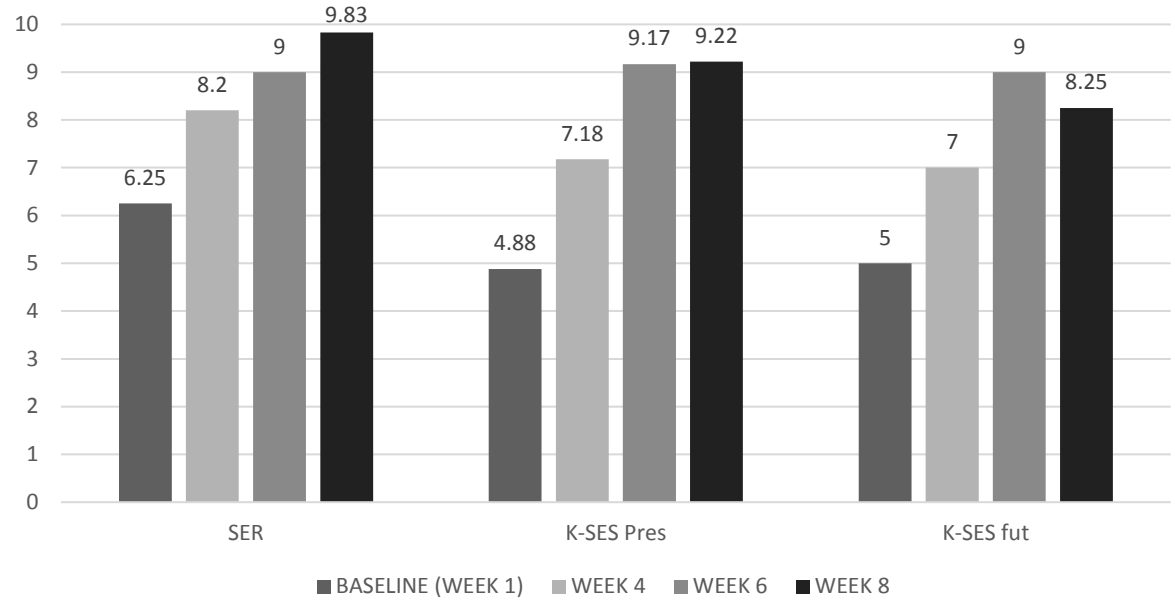
The KOOS is a patient-reported outcome measure that was developed to evaluate symptoms and function in people with a range of knee injuries. The KOOS comprises 42 items containing 5 separately scored subscales that represent different health dimensions with a higher score indicating a greater level of function.[35] The KOOS has been identified as fulfilling the basic requirements for reliability, validity, and responsiveness in cartilage repair patients.[33] The minimal perceptible clinical improvement (MPCI) of the KOOS was initially purported to be 8-10 points.[34] However, a recent study in knee cartilage repair patients has shown that the MCID varies across the KOOS subscales: Symptoms (9); Pain (14); Activities of Daily Living (ADL) (10); Sports and Recreation (Sport/Rec)(28); and Quality of Life (QoL)(28).[20]

INTERNATIONAL KNEE DOCUMENTATION COMMITTEE SUBJECTIVE KNEE FORM (IKDC)

The IKDC is a patient reported outcome designed to measure symptoms, function and sports activity in people with a range of knee conditions.[21] The IKDC consists of 18 items and is scored by calculating the difference between the raw score and lowest possible score and then dividing this difference by the range of possible scores multiplied by 100. A higher IKDC score indicates a greater level of function and lower level of knee symptoms. The IKDC has been identified as fulfilling the basic requirements for reliability, validity, and responsiveness in cartilage repair patients.[33] Normative data for the IKDC has shown a mean score of 87.6 (age 18-50).[1] A change in the IKDC score greater than 20.5 means that the individual is likely to perceive themselves as improved.[33] The minimum clinically important difference (MCID) for the IKDC after surgery for focal articular cartilage defects was found to be 6.3 at 6 months and 16.7 at 12 months postoperatively.[15] Normative data has been established for the IKDC for age and gender for the US population.[1]

RESULTS

The scores for the SER and K-SES are shown in Figure 2 where there was a 57% increase in SER, 89% increase in K-SES Present and 65% increase in K-SES future self-efficacy domains from baseline to week 8 of the programme.

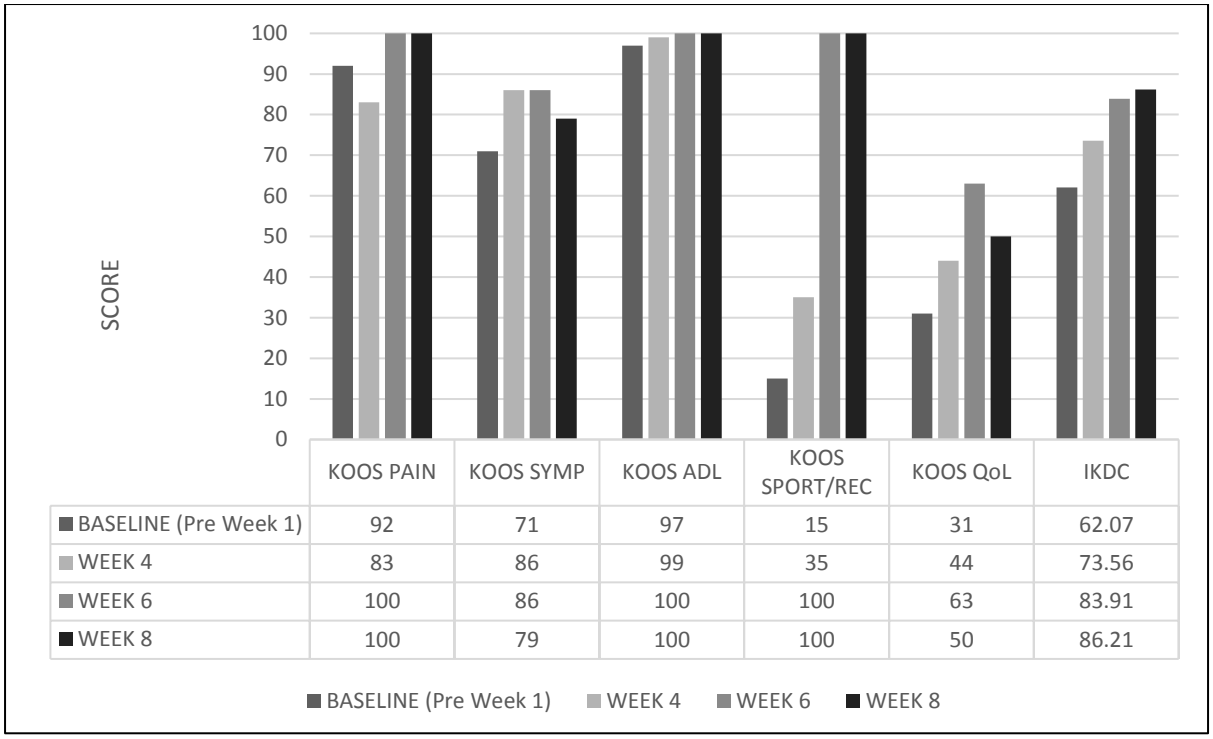


SER, Self-efficacy for Rehabilitation Scale; K-SES, Knee Self-Efficacy Scale Present Future

FIGURE 2. Self-efficacy scores across the 8-week anti-gravity treadmill programme on a scale of 0-10 where a higher score indicates a greater level of self-efficacy for the respective domains.

The KOOS subscale and IKDC scores are shown in Figure 3. The IKDC percentile placements for this patient were 20th, 30th, 45th and 45th for weeks 1, 4, 6 and 8 respectively. There was a 24.14 point improvement in the IKDC from baseline to week 8 of the programme.

Following the 8 weeks of rehabilitation with the anti-gravity treadmill the patient was advised that she could gradually introduce running exercise but to restrict or avoid running on pavements.



KOOS, Knee Osteoarthritis Outcome Score; ADL, Activity of Daily Living; Sport/Rec, Sport and Recreation; QoL, Quality of Life; IKDC, International Knee Documentation Committee Subjective Form

FIGURE 3. KOOS and IKDC Patient reported outcomes of knee function

DISCUSSION

The main findings from this case report were that an 8-week anti-gravity treadmill programme resulted in large improvements in rehabilitation (57% increase), knee present (89% increase) and knee future (65% increase) self-efficacy domains. Prior studies have reported an association between postoperative self-efficacy and improved functional recovery outcomes among individuals who have undergone hip or knee replacement.[29, 31, 43] Increased self-efficacy for rehabilitation has been shown to contribute to improved knee function following ACL reconstruction[6] and knee replacement surgery.[23] In the present case, at 9 months post BMAC surgery knee self-efficacy was lower than females 4 months post ACL reconstruction[41] and the

SER score only indicated a moderate belief in ability to perform activities in rehabilitation. The patient's experience of preparing for the first session reflects these levels of belief where she was "really looking forward to getting started but also slightly nervous" and that "this is not something I want to rush as I believe we have made such good progress". However, after moving from 30 to 40% body weight the patient stated *"yesterday's session felt good and I haven't had any adverse reaction or swelling"* suggesting that the patient's self-efficacy beliefs were open to change. After the completion of the 8 week programme, the K-SES was higher for both present and future knee self-efficacy than patients who were 12 months post ACL reconstruction surgery.[40] The increase in knee self-efficacy in the present may have been a reflection of the patient's perception that they had a greater sense of control of their return to running rehabilitation. Knee self-efficacy for the future experienced a slight drop at the end of the last session, this was not unexpected, and was likely to be due to the patient reaching the transition point from supervised to independent rehabilitation.

In terms of patient-reported knee function, a 39% improvement was found in the IKDC score (Figure 3) with the 8-week score being comparable with previously reported normative data.[1] The 24.14 point improvement in the IKDC is higher than previously reported 6 and 9 month MCIDs for focal articular cartilage repair surgery[15], indicating that the patient was likely to have perceived themselves as improved.[33] On the basis of the reported MCIDs for each of the KOOS subscales[20], only the KOOS Sport/Rec subscale showed a clinically important improvement from week 1 to week 8 of the programme (Figure 3). The KOOS QoL subscale did show a clinically important improvement between week 1 to week 6 but this reduced below

the MCID level at week 8. The patient reported that the reduction in KOOS QoL from week 6 to week 8 was as a result of her having a greater awareness of her knee (Q1) due to having to wear the knee brace as she increased activity level. Future studies should continue data collection past the return to running to assess if any reductions in self-efficacy at the point of transition to independent training return to the higher level. The lack of clinically important levels of improvements in the Pain, Symptoms and ADL subscales are likely to reflect the previously reported ceiling effects of these subscales[36, 44] and this supports using only the Sport and QoL subscales in the later stages of return to sport rehabilitation.

Return to sport is one of the main motivations for having knee osteochondral surgery, however, the actual return to sports rate after surgery is often lower than expected.[16] Typically, for non-elite sports participants, physical therapy resources are concentrated on the early and mid-stages of rehabilitation after knee osteochondral surgery and often do not address the psychosocial factors inherent in a return to sport. This case report illustrates the importance of considering self-efficacy in rehabilitation after knee osteochondral surgery and highlights the potential role for anti-gravity treadmills in enhancing self-efficacy in preparation for a return to sport. However, although case reports have the ability to guide rehabilitation in clinical practice[12], they do not allow the determination of any cause-effect relationships or generalisation to wider populations. It is therefore not possible to determine from this case report whether the improvements in self-efficacy and subjective knee function were primarily the result of the anti-gravity treadmill intervention, the supervised rehabilitation sessions and/or the addition of a further 2 months of time post-surgery. Future studies should look to evaluate the role of these

factors by comparing standard care with standard care plus an anti-gravity treadmill programme in patients with knee cartilage lesions. Additionally, the psychometric properties of the K-SES and the SER have not been evaluated for a knee osteochondral surgery population and this also provides opportunity for further studies.

CONCLUSION

The main finding of this case report was the demonstration that an 8-week anti-gravity treadmill programme resulted in improved knee and rehabilitation self-efficacy and subjective knee function following osteochondral repair of the knee. This case report illustrates the importance of considering self-efficacy in rehabilitation after knee osteochondral surgery and highlights the potential role for anti-gravity treadmills in enhancing self-efficacy and subjective knee function in preparation for a return to sport. Further studies are warranted to explore the mechanisms through which self-efficacy interventions may influence functional outcomes and return to sport after osteochondral knee surgery.

References

1. Anderson AF, Irrgang JJ, Kocher MS, Mann BJ, Harrast JJ. The International Knee Documentation Committee subjective knee evaluation form: Normative data. *Am J Sports Med*. 2006;34:128-135.
2. Bandura A. Self-efficacy: Toward a unifying theory of behavioural change. *Psychol Rev*. 1977;84:85-100.
3. Black N. Patient reported outcome measures could help transform healthcare. *BMJ*. 2013;346:f167.
4. Bugbee WD, Pulido PA, Goldberg T, D'Lima DD. Use of an anti-gravity treadmill for early postoperative rehabilitation after total knee replacement: A pilot study to determine safety and feasibility. *Am J Orthop (Belle Mead NJ)*. 2016;45:E167-173.
5. Chahla J, Dean CS, Moatshe G, Pascual-Garrido C, Serra Cruz R, LaPrade RF. Concentrated bone marrow aspirate for the treatment of chondral injuries and osteoarthritis of the knee: A systematic review of outcomes. *Orthop J Sports Med*. 2016;4:DOI: 10.1177/2325967115625481.
6. Chmielewski TL, Zeppieri G, Lentz TA, et al. Longitudinal changes in psychosocial factors and their association with knee pain and function after anterior cruciate ligament reconstruction. *Physical Therapy*. 2011;91:1355-1366.
7. Chun J, Mishra D. *Guidelines for Using the AlterG: Patients with Orthopedic Problems*. AlterG; 2014.
8. Clement D, Arvinen-Barrow M, Fetty T. Psychosocial responses during different phases of sport-injury rehabilitation: a qualitative study. *J Athl Train*. 2015;50:95-104.
9. Eastlack RK, Hargens AR, Groppo ER, Steinbach GC, White KK, Pedowitz RA. Lower body positive-pressure exercise after knee surgery. *Clin Orthop Rel Res*. 2005;213-219.
10. Ebert JR, Ackland TR, Lloyd DG, Wood DJ. Accuracy of partial weight bearing after autologous chondrocyte implantation. *Arch Phys Med Rehabil*. 2008;89:1528-1534.
11. Engelhart L, Nelson L, Lewis S, et al. Validation of the Knee Injury and Osteoarthritis Outcome Score subscales for patients with articular cartilage lesions of the knee. *Am J Sport Med*. 2012;40:2264-2272.
12. Gagnier JJ, Kienle G, Altman DG, et al. The CARE guidelines: consensus-based clinical case reporting guideline development. *BMJ case reports*. 2013;Oct 23:1-4.
13. Glasgow P, Phillips N, Bleakley C. Optimal loading: key variables and mechanisms. *Brit J Sports Med*. 2015;49:278-279.
14. Gobbi A, Karnatzikos G, Scotti C, Mahajan V, Mazzucco L, Grigolo B. One-step cartilage repair with bone marrow aspirate concentrated cells and collagen matrix in full-thickness knee cartilage lesions: Results at 2-year follow-up. *Cartilage*. 2011;2:286-299.
15. Greco NJ, Anderson AF, Mann BJ, et al. Responsiveness of the International Knee Documentation Committee Subjective Knee Form in comparison to the Western Ontario and McMaster Universities Osteoarthritis Index, Modified Cincinnati Knee Rating System, and Short Form 36 in patients with focal articular cartilage defects. *Am J Sport Med*. 2010;38:891-902.
16. Hambly K. Activity profile of members of an online health community after articular cartilage repair of the knee. *Sports Health*. 2011;3:275-282.

17. Hambly K, Griva K. IKDC or KOOS? Which measures symptoms and disabilities most important to postoperative articular cartilage repair patients? *Am J Sports Med*. 2008;36:1695-1704.
18. Hoffman MD, Donaghe HE. Physiological responses to body weight--supported treadmill exercise in healthy adults. *Arch Phys Med Rehabil*. 2011;92:960-966.
19. Hott A, Liavaag S, Juel NG, Brox JI. Study protocol: a randomised controlled trial comparing the long term effects of isolated hip strengthening, quadriceps-based training and free physical activity for patellofemoral pain syndrome (anterior knee pain). *BMC Musculoskelet Disord*. 2015;16:40.
20. Howard J, Whale Conley CE, Mattacola CG, Lattermann C. *Minimal clinically important differences for the Knee Injury Osteoarthritis Outcomes Score (KOOS) among knee cartilage patients*. Sorrento, Italy: 2016.
21. Irrgang JJ, Anderson AF, Boland AL, et al. Development and validation of the International Knee Documentation Committee subjective knee form. *Am J Sports Med*. 2001;29:600-613.
22. King PJ, Bryant T, Minas T. Autologous chondrocyte implantation for chondral defects of the knee: indications and technique. *J Knee Surg*. 2002;15:177-184.
23. Magklara E, Burton CR, Morrison V. Does self-efficacy influence recovery and well-being in osteoarthritis patients undergoing joint replacement? A systematic review. *Clin Rehabil*. 2014;28:835-846.
24. McNeill DK, de Heer HD, Bounds RG, Coast JR. Accuracy of unloading with the anti-gravity treadmill. *J Strength Cond Res*. 2015;29:863-868.
25. Mercer JA, Applequist BC, Masumoto K. Muscle activity while running at 20%-50% of normal body weight. *Res Sports Med*. 2013;21:217-228.
26. Mikami Y, Fukuhara K, Kawae T, Kimura H, Ochi M. The effect of anti-gravity treadmill training for prosthetic rehabilitation of a case with below-knee amputation. *Prosthet Orthot Int*. 2015;39:502-506.
27. Mithoefer K, Hambly K, Della Villa S, Silvers H, Mandelbaum BR. Return to sports participation after articular cartilage repair in the knee: scientific evidence. *Am J Sports Med*. 2009;37:suppl 167S-176S.
28. Mithoefer K, Hambly K, Logerstedt D, Ricci M, Silvers H, Della Villa S. Current concepts for rehabilitation and return to sport after knee articular cartilage repair in the athlete. *J Orthop Sports Phys Ther*. 2012;42:254-273.
29. Moon LB, Backer J. Relationships among self-efficacy, outcome expectancy, and postoperative behaviors in total joint replacement patients. *Orthop Nurs*. 2000;19:77-85.
30. Mundi R, Bedi A, Chow L, et al. Cartilage restoration of the knee: A systematic review and meta-analysis of level 1 studies. *Am J Sport Med*. 2016;44:1888-1895.
31. Orbell S, Johnston M, Rowley D, Davey P, Espley A. Self-efficacy and goal importance in the prediction of physical disability in people following hospitalization: a prospective study. *Br J Health Psychol*. 2001;6:25-40.
32. Patil S, Steklov N, Bugbee WD, Goldberg T, Colwell CW, Jr., D'Lima DD. Anti-gravity treadmills are effective in reducing knee forces. *J Orthop Res*. 2013;31:672-679.
33. Roos EM, Engelhart L, Ranstam J, et al. ICRS recommendation document: Patient-reported outcome instruments for use in patients with articular cartilage defects. *Cartilage*. 2011;2:122-136.

34. Roos EM, Lohmander LS. The Knee injury and Osteoarthritis Outcome Score (KOOS): from joint injury to osteoarthritis. *Health Qual Life Outcomes*. 2003;1:64.
35. 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;28:88-96.
36. Steinhoff AK, Bugbee WD. Knee Injury and Osteoarthritis Outcome Score has higher responsiveness and lower ceiling effect than Knee Society Function Score after total knee arthroplasty. *Knee Surgery, Sports Traumatology, Arthroscopy*. 2014;1-7.
37. Stevens M, van den Akker-Scheek I, van Horn JR. A Dutch translation of the Self-Efficacy for Rehabilitation Outcome Scale (SER): a first impression on reliability and validity. *Patient Educ Couns*. 2005;58:121-126.
38. Thomee P, Wahrborg P, Borjesson M, Thomee R, Eriksson BI, Karlsson J. Determinants of self-efficacy in the rehabilitation of patients with anterior cruciate ligament injury. *J Rehabil Med*. 2007;39:486-492.
39. Thomee P, Wahrborg P, Borjesson M, Thomee R, Eriksson BI, Karlsson J. A new instrument for measuring self-efficacy in patients with an anterior cruciate ligament injury. *Scand J Med Sci Sports*. 2006;16:181-187.
40. Thomee P, Wahrborg P, Borjesson M, Thomee R, Eriksson BI, Karlsson J. A randomized, controlled study of a rehabilitation model to improve knee-function self-efficacy with ACL injury. *J Sport Rehabil*. 2010;19:200-213.
41. Thomee P, Wahrborg P, Borjesson M, Thomee R, Eriksson BI, Karlsson J. Self-efficacy, symptoms and physical activity in patients with an anterior cruciate ligament injury: a prospective study. *Scand J Med Sci Sports*. 2007;17:238-245.
42. Thomson A, Einarsson E, Witvrouw E, Whiteley R. Running speed increases plantar load more than per cent body weight on an AlterG(R) treadmill. *J Sports Sci*. 2016;21:1-6.
43. van den Akker-Sch I, Stevens M, Groothoff JW, Bulstra SK, Zijlstra W. Preoperative or postoperative self-efficacy: Which is a better predictor of outcome after total hip or knee arthroplasty? *Patient Educ Couns*. 2007;66:92-99.
44. van Meer BL, Meuffels DE, Vissers MM, et al. Knee injury and osteoarthritis outcome score or international knee documentation committee subjective knee form: which questionnaire is most useful to monitor patients with an anterior cruciate ligament rupture in the short term? *Arthroscopy*. 2013;29:701-715.
45. Waldrop D, Lightsey O, Ethington C, Woemmel C, Coke A. Self-efficacy, optimism, health competence and recovery from orthopaedic surgery. *J Couns Psychol*. 2001;48:233-238.
46. Wesch N, Hall C, Prapavessis H, et al. Self-efficacy, imagery use, and adherence during injury rehabilitation. *Scand J Med Sci Sports*. 2012;22:695-703.

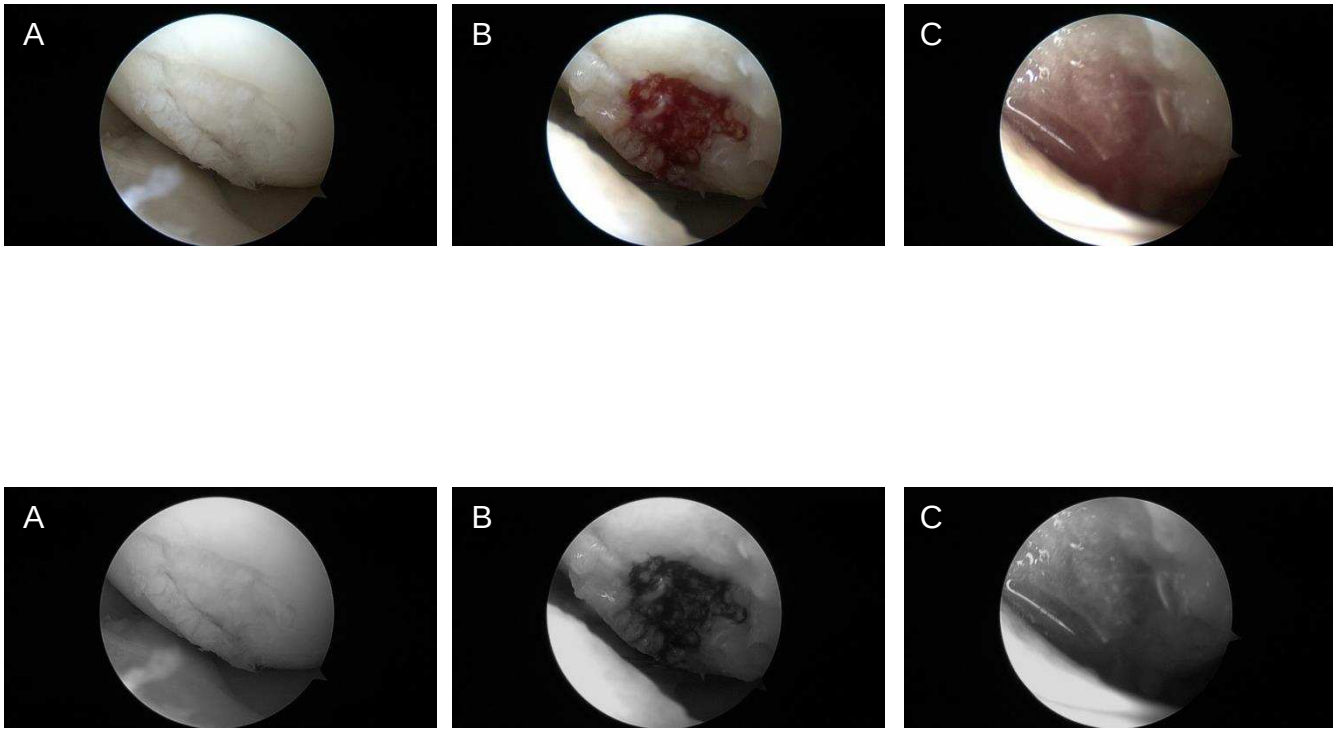


FIGURE 1. Single-step arthroscopic osteochondral repair. (A) Osteochondral defect on medial femoral condyle. (B) Osteochondral defect being prepared to receive BMAC therapy. (C) Osteochondral repair underway with BMAC and fibrin.

Figure 1. to be reproduced in color on the Web and in black and white in print