

Sport health



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Healing of acute ACL rupture

managed with the Cross Bracing Protocol
– *study insights*

MEIKE VAN HAERINGEN, University of Amsterdam (2024 SMA & ACSEP Conference – ASICS Best Poster in Clinical Sports Medicine)



What do we know about ACL healing?

An acute complete anterior cruciate ligament (ACL) rupture is a devastating injury and often accompanied with concomitant injuries such as meniscus lesions, articular cartilage damage, subchondral bone impaction and collateral ligament injuries. Moreover, ACL rupture has potentially devastating long-term consequences such as tibiofemoral instability, decreased activity participation, an increased risk of developing knee osteoarthritis, and impaired long-term knee-related Quality of Life (QOL).

Current treatment strategies are surgical reconstruction of the ACL followed by rehabilitation or rehabilitation alone which are based on the assumption that a ruptured ACL has limited healing capacity. However, studies have shown that the ACL has a rich blood supply, and that ruptured ACLs undergo the typical phases of the healing process after injury similar to the medial collateral ligament (MCL), albeit at a slower healing rate.

The KANON trial has demonstrated spontaneous ACL healing on MRI in about one-third of patients managed with rehabilitation alone. In addition, those with a healed ACL reported better patient reported outcomes compared to the non-healed and ACL and ACL surgery groups at 2 years follow up. In view of these findings the novel Cross Bracing Protocol (CBP) has been developed by Dr Mervyn Cross and Dr Tom Cross and utilizes the orthopaedic principles of “anatomical reduction” and “immobilisation” of injured ACL tissue to facilitate ACL healing. Previous research has shown that the ACL is shortest at 90°-135° of knee flexion and that the gap distance between the torn ligament ends is a critical barrier to healing. Based on this, the CBP recommends immobilising the knee at 90° knee flexion approximating the ruptured

ACL epi-ligamentous tissues, reducing the gap distance in an attempt to support the healing process across the ligament.

Findings from the first 80 patients with ACL rupture managed with the novel CBP showed promising outcomes, with 90% of people achieving a continuous ACL (signs of healing) 3 months after injury. In addition, a spectrum of ACL healing was observed on 3-month MRI and patients with higher volume and better aligned ACL healing (a taut and thick ligament) reported better clinical outcomes than those with less optimal ACL healing (a thin and/or elongated ligament) or no ACL healing. However, this study was limited by its small sample size, highlighting the need for further investigation in a larger cohort to continue exploring the potential for ACL healing with this novel non-surgical treatment strategy.

Furthermore, these promising findings raise new questions, such as: *Who is most suitable for the CBP? And do certain “patient” and “MRI factors” – including the nature of the ACL rupture – play a role in the quality of ACL healing?* Currently, we do not know the answers to the above intriguing questions for ACL rupture and ACL healing. Addressing these knowledge gaps through further research could inform future prognostic studies and ultimately help identify which patients would benefit most from the CBP.

Having considered all of the above, our two study aims were to:

1. Investigate ACL healing (in terms of continuity and thickness) on 3-month MRI in 235 people treated with the CBP.
2. Identify patient and MRI characteristics associated with the quality of ACL healing on 3-month MRI (continuous and thick vs. continuous and thin).

Healing of acute ACL rupture

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– study insights



Photo of me on day 1 of the CBP for my ACL injured knee.

How did we go about this?

The CBP is summarised in **Figure 1**.

We identified patients of all ages with an MRI confirmed ACL rupture, managed with the CBP between March 2016 and June 2023. Patients were considered eligible for the CBP if they presented with an MRI confirmed complete rupture of the ACL within one month of injury, and were functionally independent and capable of managing a period of knee immobilisation.

ACL healing was assessed on 3-month MRI by two radiologists after treatment with the CBP. We defined ACL healing as the presence of ACL continuity, further differentiated as either a thickened continuous ACL or a thinned continuous ACL based on the validated and published ACLOAS scoring system.

For our second aim, we chose patient and MRI characteristics based on hypothesised relationships and clinical relevance and are shown in **Figure 2**. We used univariable logistic regression analyses to assess the association between patient characteristics and acute MRI characteristics and the quality of ACL healing on 3-month MRI (continuous and thick versus continuous and thin).

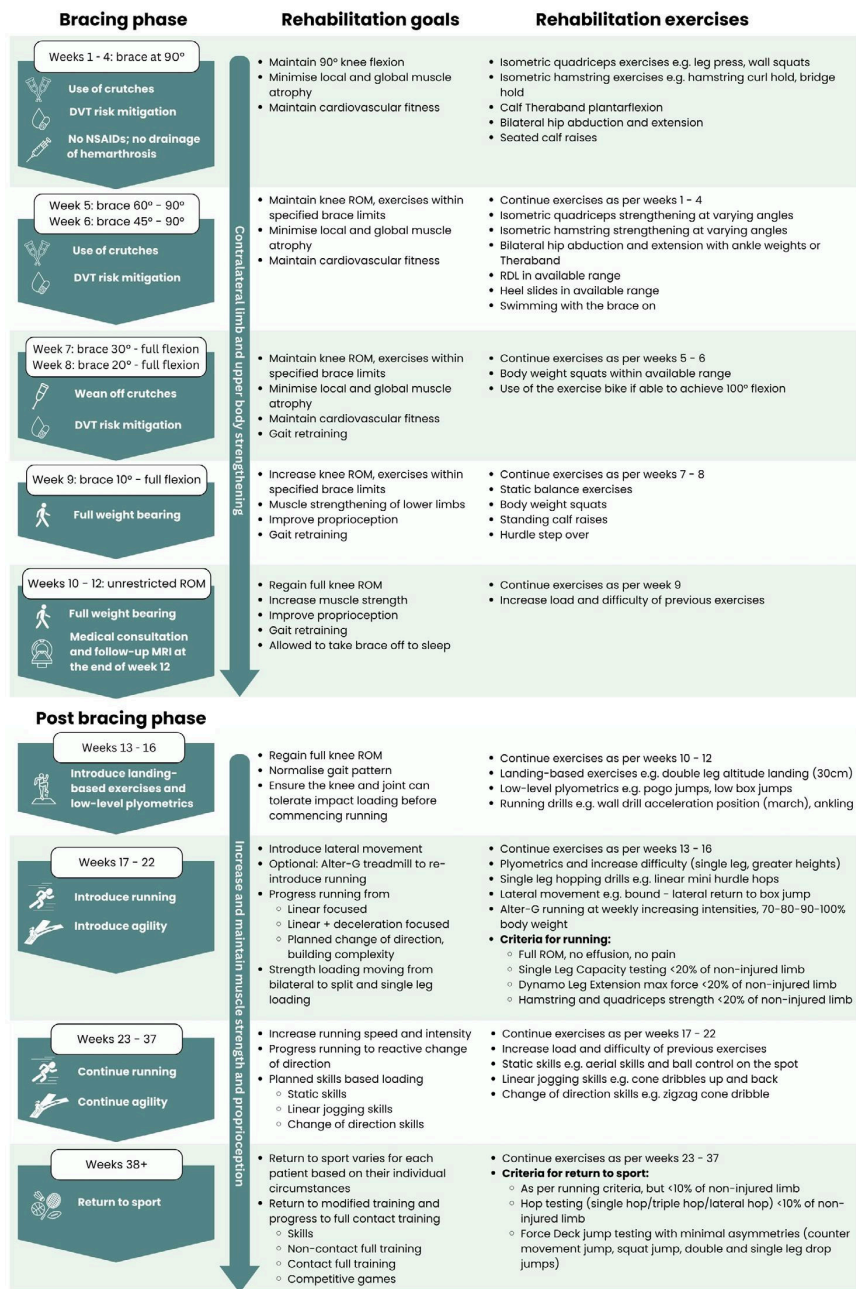


Figure 1. Summary of the Cross Bracing Protocol.



The KANON trial has demonstrated spontaneous ACL healing on MRI in about one-third of patients managed with rehabilitation alone.

Patient factors	Acute MRI factors
• Age	• Partial avulsion of the femoral origin
• Gender	• Displacement of ACL tissue
• Private health insurance	• Medial collateral ligament injury
• Time from injury to brace	• Meniscus injury
• Mechanism of injury	• Posterolateral corner injury
• Pre-injury level of sport	
• Hypermobility	
• Haemarthrosis	

Figure 2. Baseline patient and MRI characteristics included in the univariable logistic regression analyses.

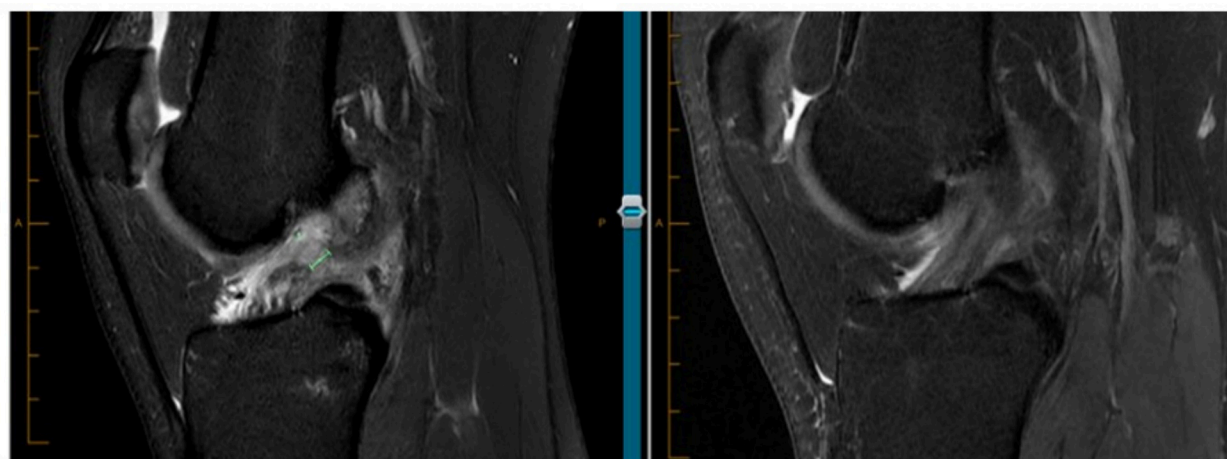
WHAT DID WE FIND?

ACL healing

We invited 275 eligible patients of which 235 patients provided consent for participation in this study. We found signs of ACL healing (ACL-continuity) on 3-month MRI in 95% of the patients. Looking at the quality of ACL healing, we found that 63% had a thickened continuous ACL, 33% a thinned continuous ACL, and 5% a discontinuous or non-anatomical heal. **Figure 3** shows MRI examples of two patients with a continuous and thickened ACL heal and a continuous but thinned ACL heal after management with the CBP.

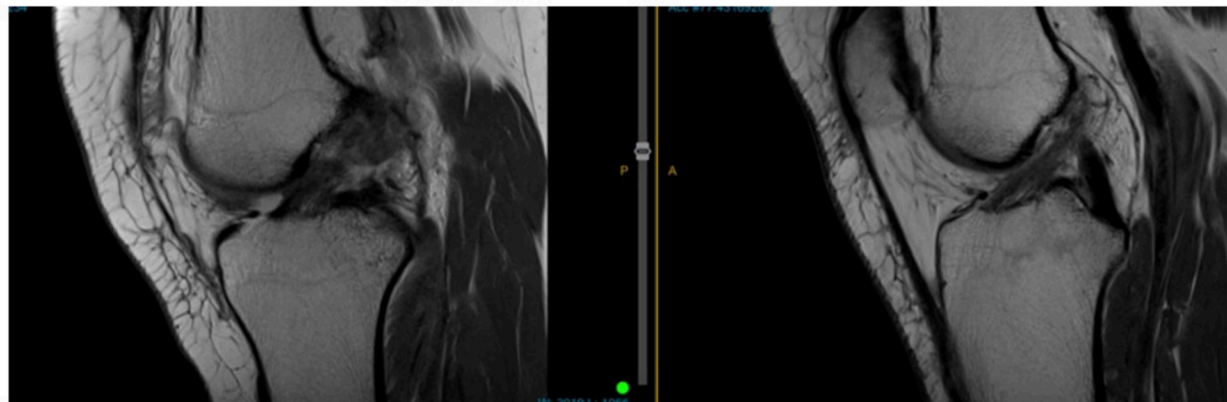
Associated factors with the quality of ACL healing

We identified factors associated with the quality of ACL healing at 3-months after management with the CBP which



Baseline MRI: acute rupture

3-month MRI: continuous thickened ACL



Baseline MRI: acute rupture

3-month MRI: continuous but thinned ACL

Figure 3. MRI images of two patients after following the Cross Bracing Protocol.

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are shown in Figure 4. We found that patients with a partial avulsion of the femoral origin, displacement of ACL tissue outside the intercondylar notch, non-contact mechanism of injury, and hypermobility were associated with achieving less optimal ACL healing (continuous and thin ACL) on 3-month MRI. On the other hand, patients who were older, with a posterolateral corner injury, and haemarthrosis were associated with achieving more ACL healing (continuous and thick ACL) on 3-month MRI.

What does this mean?

Our high healing rates provide further evidence that the ACL has the potential to heal non-surgically. Moreover, it indicates that the CBP may facilitate ACL healing, although clinical trials are needed to compare outcomes with other treatment strategies.

Findings from the first 80 patients managed with the CBP showed that those with more ACL healing on 3-month MRI had better knee function and QOL compared to those with less

or no ACL healing. However, we did not assess important long-term outcomes, including knee function, survivorship of the healed ACL, return-to-sport rates, prevalence of osteoarthritis, and long term QOL in this study. This is an interesting area for further exploration, requiring longitudinal studies to inform clinical practice.

Research on patient or MRI factors that influence ACL healing is sparse. Previous studies investigating factors affecting ACL healing included patients



**We found signs
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with partial ACL ruptures, which may have a greater healing potential due to the ACL fibres that remain in continuity acting as a construct to enable healing of the partially torn ACL elements. The CBP is the first bracing method to utilize a 90° knee flexion block to attempt to address the gap distance between ruptured ligament ends. This “reduction and immobilisation” of the ruptured ACL is what makes the CBP so novel and pioneering. Locking the knee at 90° flexion, approximates the ACL, in attempt to enable ACL tissue to bridge the gap between ligament remnants aiding ACL healing.

As shown in **Figure 4**, we found that patients with a partial avulsion of the femoral origin or displacement of ACL tissue outside the intercondylar notch were most strongly associated with less optimal ACL healing (a continuous and thin ACL) on 3-month MRI. Perhaps this is due to the anatomical challenge faced by the ACL tissue having to reattach to the femoral origin, or the displaced tissue having to reduce back into the intercondylar notch

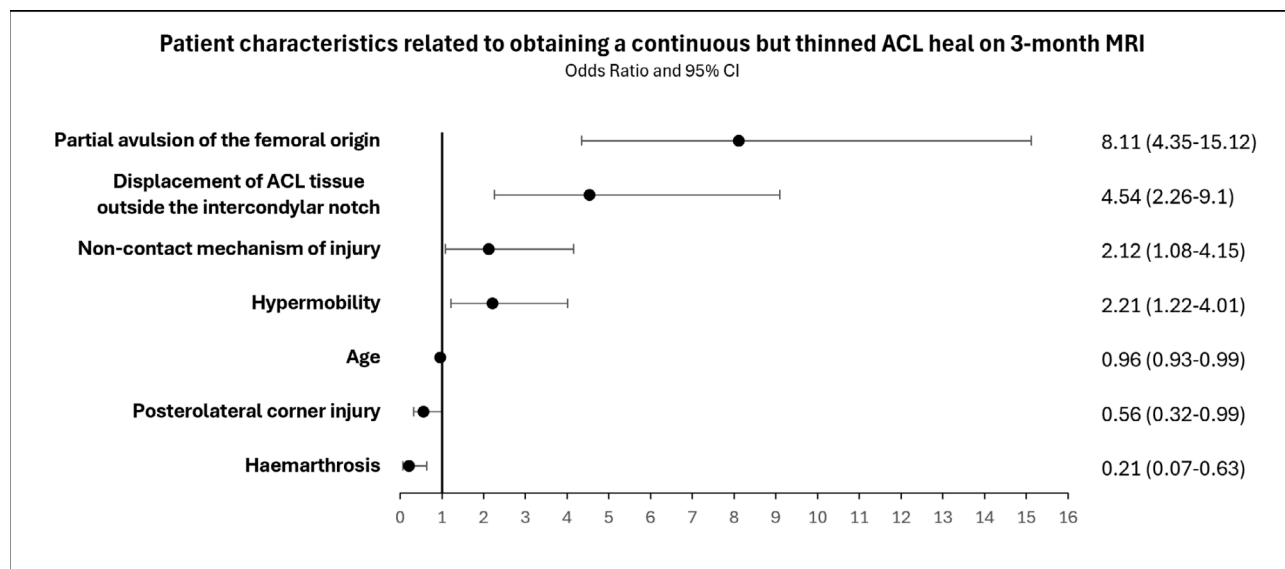


Figure 4. Forest plot demonstrating patient and MRI characteristics related to achieving a suboptimal (continuous but thinned) ACL heal on 3-month MRI



resulting in less tissue contributing to the healing process and thus the chance of obtaining a thinner “lower volume” heal. Alternatively, the avulsed and/or displaced tissue might attach to surrounding structures, such as the posterior cruciate ligament (PCL) or lateral wall (LW). Such non-anatomic ACL healing is analogous to a mal-united displaced fracture that is not anatomically reduced by an adequate closed reduction.

Our findings provide valuable preliminary insights into baseline factors related to ACL healing on 3-month MRI. However, it is important to note that our analysis assessed each “patient” and “MRI” factor independently. Future studies should explore possible interactions between these factors and the “spectrum of ACL healing,” whilst adjusting for potential confounders. This could help inform prognostic studies and improve our understanding of which patients are most suitable for the CBP.

For article references, please email info@sma.org.au

Take home messages

- Traditionally, management strategies have been based on the assumption that the ACL has limited ability to heal.
- This study provides further evidence that ACL ruptures can heal non-surgically.
- The CBP might be a valuable non-surgical treatment option with potential to aid ACL healing, but clinical trials are needed to compare outcomes with other treatments.
- This study identified factors associated with ACL healing quality at 3-months after CBP management, for exploration in further studies.
- In the future, clinicians may advise on patients' healing potential based on their characteristics and the nature of their ACL injury. This may help inform treatment decisions between surgical and non-surgical management for acute ACL rupture.

About the Authors



Meike van Haeringen is a 4th year medical student at the University of Amsterdam in the Netherlands. She is an elite athlete with a history of ACL injuries. In 2023 she completed her research thesis on ACL healing and the Cross Bracing Protocol as a part of her Master's degree through an exchange at The Centre for Health Exercise and Sports Medicine at the University of Melbourne.



Dr Tom Cross is a specialist who has practised sports medicine for the past 28 years. Over that period, he completed 5 years of specialist post-graduate training in sport & exercise medicine and gained fellowship to the Australasian College of Sport & Exercise

Physicians (ACSEP). He has worked with many professional sport teams including as head doctor to the Sydney Swans for 5 years. He pioneered the Cross Bracing Protocol alongside his father Dr Mervyn Cross.



A/Prof Steph Filbay is an NHMRC Emerging Leadership Fellow, Dame Kate Campbell Fellow, and Principal Research Fellow at the University of Melbourne. She leads a research team focused on improving outcomes for people with ACL injury and post-traumatic knee osteoarthritis.

She has presented her research over 100 times across 10 countries. She has received numerous awards and grants, including a recent NHMRC Investigator Grant to fund 5 years of research aimed at improving outcomes for people with ACL injury and post-traumatic knee osteoarthritis.