Short-Term Immobilization Using Semi-Rigid Casting Improves Early Tendon-to-Bone Healing in a Murine Model of Anterior Cruciate Ligament

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Presenter Disclosure Information

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Disclosure of Conflict of Interest

Yuki Suzuki

COI with regard to the current presentation

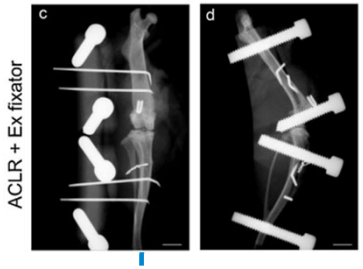
Rodeo SA: ChitogenX, Jannu Therapeutics – Ownership Interest,
Teladoc – Consultant

Introduction

- ✓ Functional recovery following ACL reconstruction surgery (ACLR) requires secure healing of the tendon graft in the bone tunnel, and early post-operative immobilization may accelerate this process.

- ✓ However, there is a lack of consensus amongst clinicians with regard to use and duration of knee immobilizers post-operatively. *Hiemstra et al., Clin J Sport Med. 2006.*

- ✓ Many animal studies focusing on post-operative immobilization have utilized external fixators (Ex-fix) and reported positive effects after ACL-R.



Introduction

- ✓ However, the Ex-fix method is rigid, invasive, and not used in ACL-R clinically.
- ✓ 3D printed semi-rigid knee cast has been utilized previously for the mouse knee
  - ✓ Non-invasive, more clinically relevant method of knee immobilization

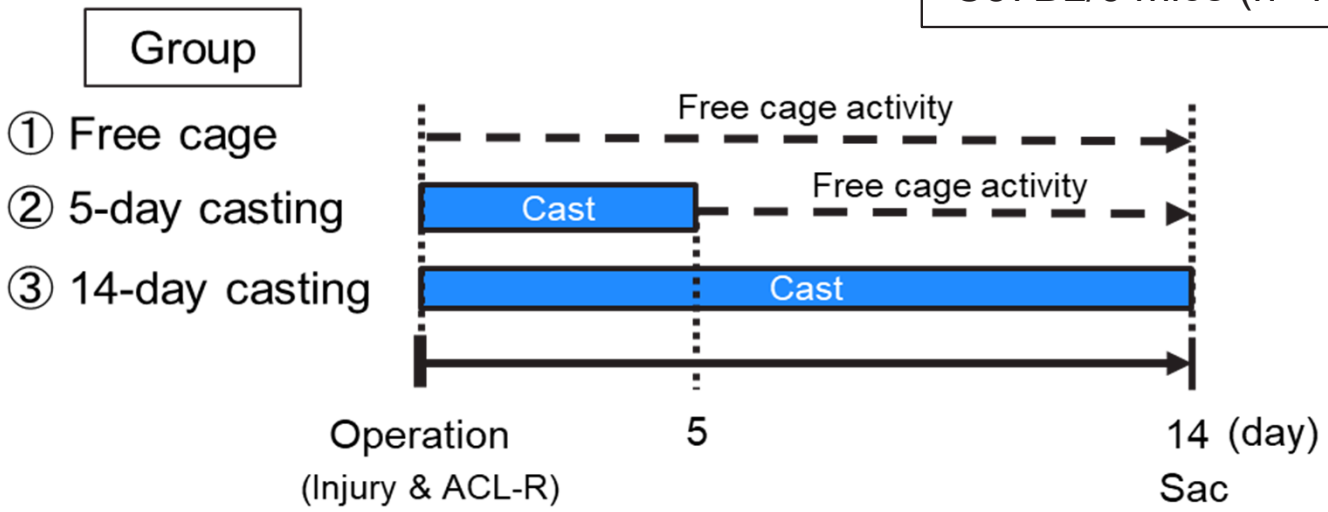
Moore LK et al. J Orthop Res 2022.

- ✓ Hypothesis
  - ✓ Short-term casting would improve early tendon-to-bone (TB) healing and functional outcomes after ACL-R.
- ✓ Aim
  - ✓ To elucidate the effects of short-term immobilization using semi-rigid casting following ACL-R in mice.

Methods

✓ Study design

C57BL/6 mice (n=15 / group) ACLR

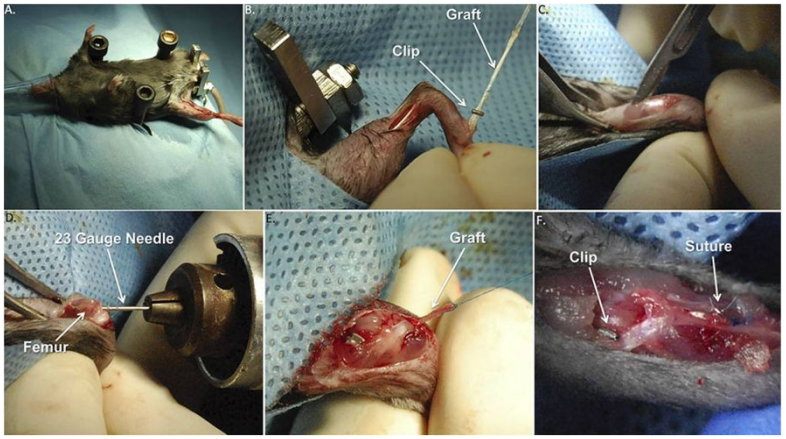


1. Primary outcomes (@day14)
   - ✓ Histology (HE staining) (n=5 /group)
     (TBTH) score
   - ✓ Micro-CT: new bone formation (n=15 /group)

2. Secondary outcomes (@day14)
   - ✓ Knee range of motio (ROM) (n=15 /group)
   - ✓ Biomechanical test (n=10 /group)
   - ✓ Gait analysis (DigiGait®) (n=15 /group)
   - ✓ qPCR analysis (n=6 /group)
     Dorsal root ganglion (DRG)
     Tibialis anterior (TA) muscle

Methods

- ✓ Surgical treatment (ACL-R) and post-operative casting

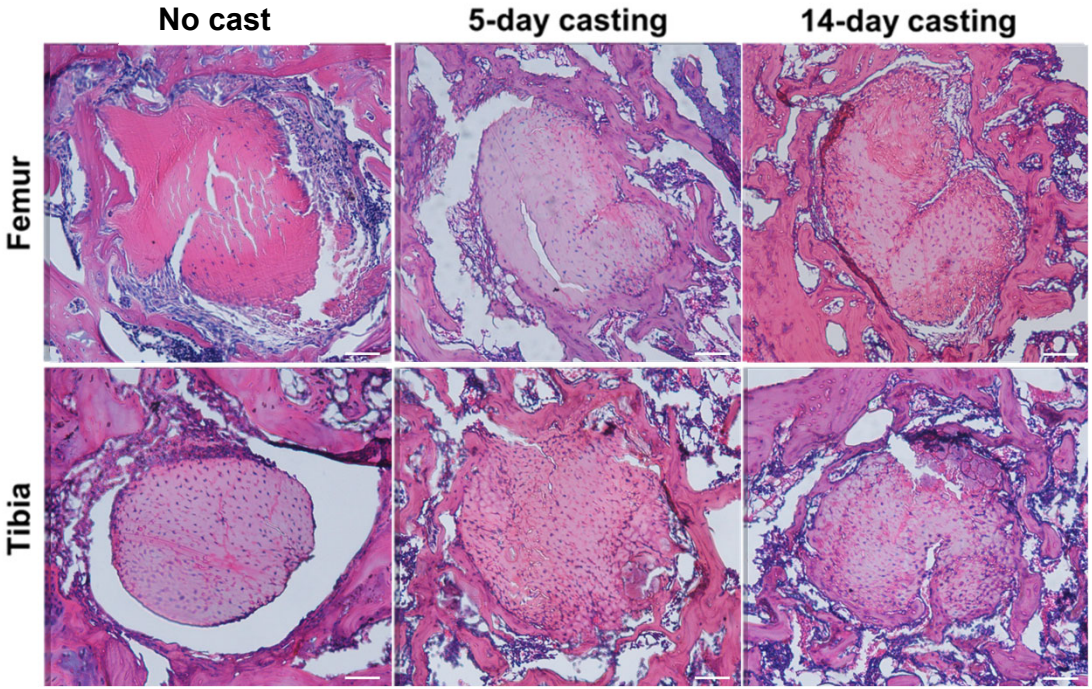


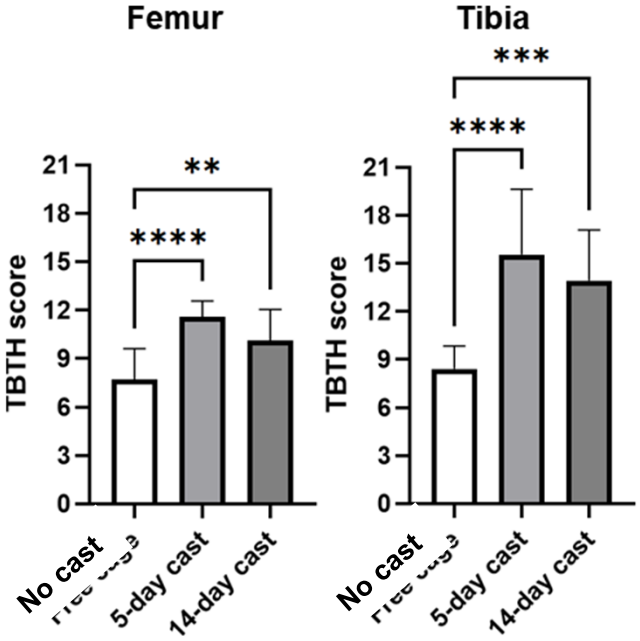
- ✓ In vivo ACL-R mouse
- ✓ Open ACL transection followed by immediate ACL-R surgery in the right knee using ipsilateral flexor digitorum longus (FDL) tendon autograft
- ✓ Semi-rigid cast applied immediately after ACL-R

Lebaschi A et al. J Knee Surg. 2017.
Camp CL et al. JBJS Am. 2017.
Deng XH et al. JBJS Am. 2018.

Results

✓ Primry outcome - Histology



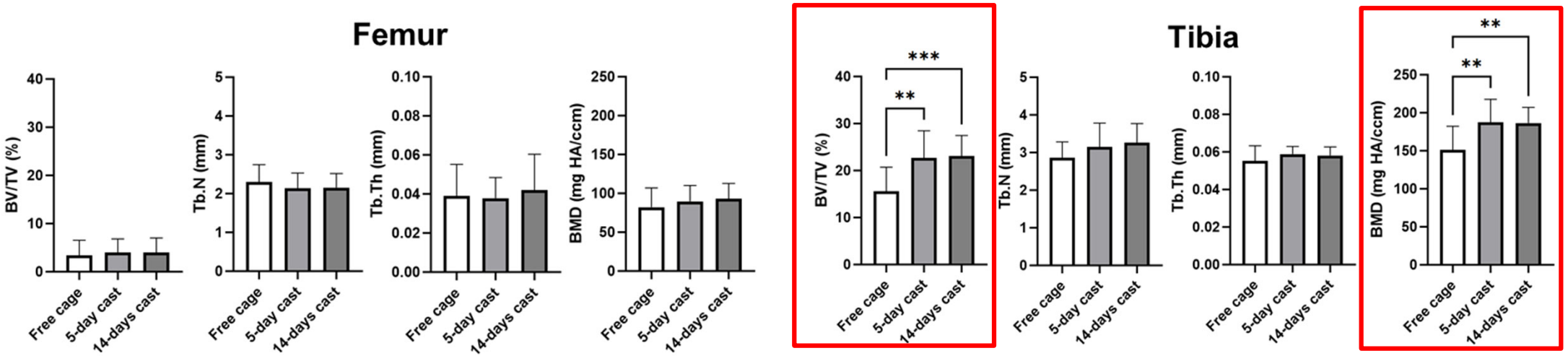


*: P<0.05
**: P<0.01
***: P<0.001
****: P<0.0001

✓ TBTH score in the tibial tunnel was higher in both casting groups compared to no casting group

Results

✓ Primry outcome – Micro-CT analysis

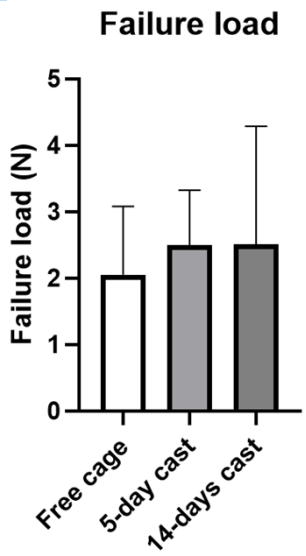


✓ In both casting groups, bone volume formation (BV/TV) and bone mineral density (BMD) in the tibial tunnel were higher than in the free cage group

Results

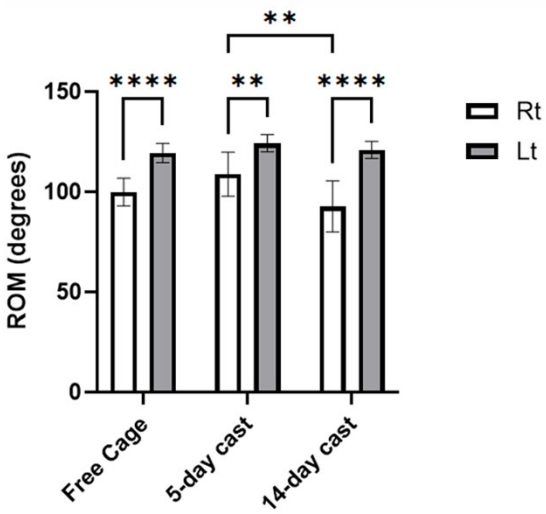
- ✓ Biomechanical test

	Tibia	Femur	Fail before test
No cast	4	3	1
5-day cast	3	5	
14-day cast	3	5	



- ✓ No statistical difference was observed among groups

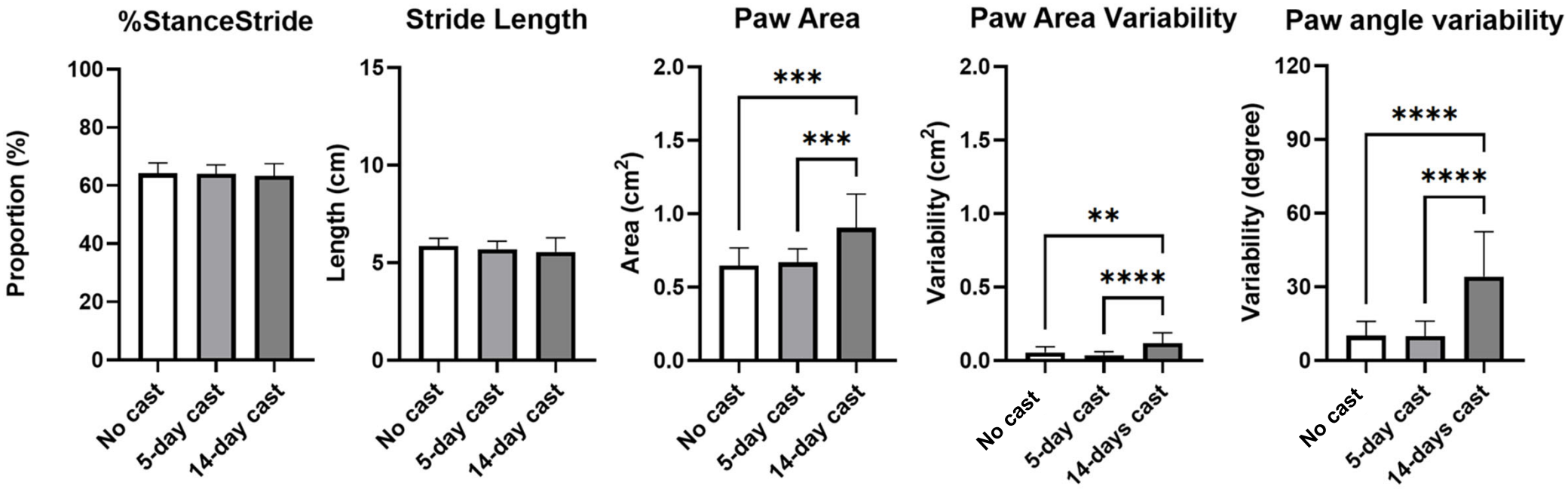
- ✓ ROM



- ✓ All groups exhibited restricted ROM compared to the contralateral knee
- ✓ 14-day casting group showed significantly less ROM than 5-day casting group

Results

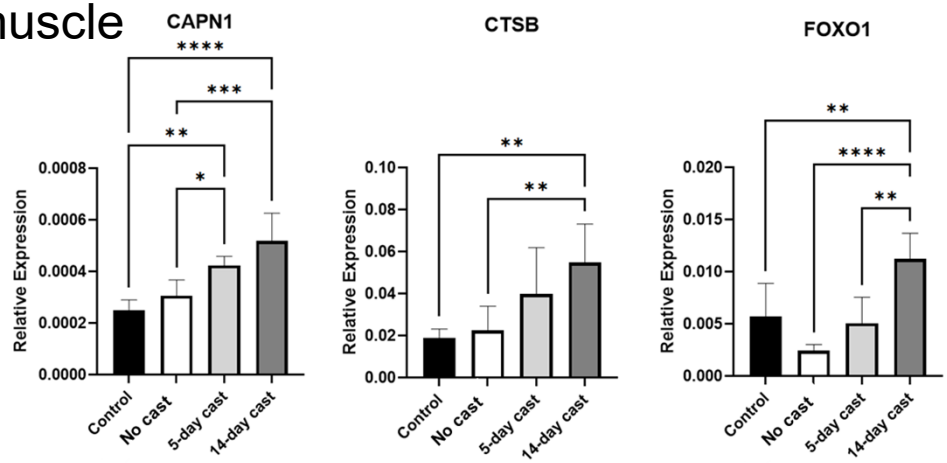
✓ Gait analysis (DigiGait®)



✓ The variability in paw area and angle of the affected limb were significantly worse in the 14-day casting group than other two groups

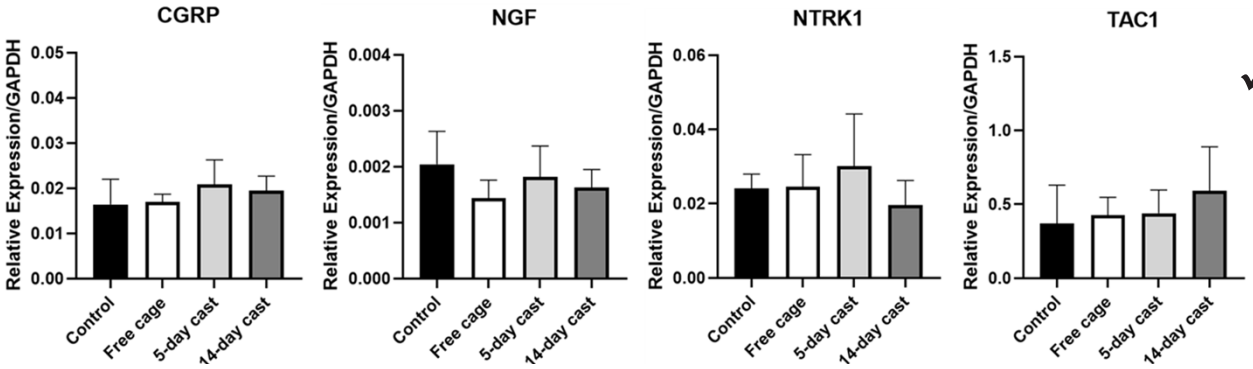
Results

- ✓ PCR analysis
  - ✓ TA muscle



- ✓ Muscle atrophy related genes were significantly high in 5 days and 14 days casting groups

  - ✓ DRG



- ✓ No significant difference were observed in DRG

Discussion

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- ✓ Effect of immobilization on TB healing after ACL-R (using Ex-fix)
  - ✓ Early immobilization diminishes macrophage accumulation and may improve TB integration histologically, but not biomechanically *Dagher E et al. CORR 2009.*
  - ✓ A short period of immobilization after ACL reconstruction might enhance graft-bone interface healing by mitigating excess MMP expression *Nakagawa Y et al. J Orthop Res 2019.*
  - ✓ Early high forces on the ACL graft appear to impair graft-tunnel osseointegration *Ma R et al. AJSM 2018.*

- ✓ Our study
  - ✓ Postoperative semi-rigid casting improves new bone formation TB healing in the bone tunnel at 2 weeks after ACL-R.

Discussion & Conclusion

HSS

- ✓ We evaluated the effects of short-term immobilization using semi-rigid casting following ACL-R in mice.
- ✓ Postoperative casting improves new bone formation within the bone tunnel and TB healing in the tibial tunnel at 2 weeks after ACL-R.
- ✓ The 14-day casting group showed significantly decreased knee ROM and impaired gait parameters.
- ✓ Genes related to muscle atrophy were upregulated in casting groups.
- ✓ Non-invasive short-term immobilization followed by free cage activity may improve TB healing while also improving ROM and some gait parameters.