Tibiofemoral Contact Mechanics following Simple Sutures vs. Modified Mason-Allen sutures vs. All-inside Fixation for Medial Meniscus Posterior Root Tears in Porcine Model

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Medial Meniscal posterior root tear (MMPRT)

Avulsion injury or Radial tear of meniscus occurring in the bony attachment

Introduction

Root tear ➔ Disrupting the circumferential fibers of meniscus

➡️ Leading to loss of hoop tension & load-sharing ability

➡️ Pathological loads ➔ Progression of arthritis

Root repair ➔ Restoring the hoop tension & meniscal function

➡️ Preventing the progression of arthritic changes

➡️ Mid- and long-term results are valuable
Several biomechanical studies in meniscal root repair had been reported. However, most of them investigated suture construct with different suture methods. (load to failure, stiffness, cyclic loading...) 

< Complex suture patterns with locking mechanisms are best >

Comparative outcomes of tibiofemoral contact mechanics according to suture methods has been still unknown. 

Pullout repair with Non-locking vs Pullout repair with locking vs All-inside fixation (suture device)
We hypothesized that better tibiofemoral contact mechanics (peak contact pressure, contact surface area) following root repair using different suture techniques.

**Purpose:**

The present study aimed to compare tibiofemoral contact mechanics (peak contact pressure, contact surface area) following root repair using different suture techniques.

1. Pullout fixation using simple sutures

2. Pullout fixation using modified Mason-Allen sutures

3. All-inside fixation using Fast-fix 360 device

We hypothesized that:

- Modified Mason-Allen sutures (with locking) > Simple sutures or All-inside fixation

**better tibiofemoral contact mechanics**

(peak contact pressure, contact surface area)
7 fresh knee specimens from Yorkshire pigs

- Body weight: $110 \pm 2$ kg
- Dissected free of Skin, Subcutaneous tissues, Muscle, Patella
- Preserved: Femur, Tibia, ACL, PCL, MCL, LCL

The molded resin (Vertex™) encased the femur and tibia

Transverse incision on anter & post meniscotibial portions

Capacitive pressure sensor (Novel GmbH, Germany)
- positioned between meniscus and tibial plateau

Sutures were applied between sensor and joint capsule to secure the sensor in position during testing
Biomechanical testing

- Hydraulic compression machine (model 8511; Instron Inc, MN, USA)
- Four different flexion angles (0°, 30°, 60°, 90°) – random sequence
- Under axial compression loads of up to 1000 N applied at 50 N/s
- Pressure mapping program (Pliance-X 32 bit; Novel GmbH, Germany)
  a) Peak contact pressure (PCP, kPa)
  b) Contact surface area (CSA, cm²)
- Mean value of the three measurements was recorded

<Statistical analysis>
- SPSS version 21.0 for Windows (SPSS Inc., Chicago, IL, USA)
- The Wilcoxon signed rank test
  - to compare measurements between the root conditions at the same flexion.
Fixation techniques

Intact MM

VS

MM root tear

Pullout fixation with simple sutures (No. 2 Fiberwire)

Pullout fixation with Modified Mason-Allen Sutures (No. 2 Fiberwire)

All-inside fixation with Fastfix 360 (S&N)
1. Significantly increased PCP after root tear
2. Significantly decreased PCP after root repair
3. No difference of PCP among repair methods

*a* $P < 0.05$ compared with the normal meniscus
*b* $P < 0.05$ compared with the root tear
*c* $P < 0.05$ compared with simple sutures
*d* $P < 0.05$ compared with modified Mason-Allen sutures
*e* $P < 0.05$ compared with All-inside fixation (Fastfix™ 360)

* It was impossible to assess peak contact pressure because of the detection limit of the capacitive contact sensor.
Results (Contact surface area)

1. Significantly decreased CSA after root tear
2. Significantly increased CSA after root repair
3. Mason-Allen is significantly better CSA than simple or all-inside in 0°, 30°, 90° flexion angles
4. Simple sutures is significantly better CSA than all-inside in 90° flexion angles
• Peak contact pressure (PCP) & Contact surface area (CSA)
  - improved significantly following fixation, regardless of the fixation method.

• PCP & CSA did not recover to the levels noted in the normal meniscus following any type of fixation.

• Among the fixation methods evaluated in this time zero study, modified Mason-Allen sutures provided superior contact surface area compared to simple sutures or all-inside fixation.

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Limitations

1. Porcine knees

2. *In vitro* biomechanical experiment & time zero results

3. Limited number of specimens

4. Clinical cases where an all-inside fixation is feasible may be small, so that such a procedure may be uncommon in clinical practice.

5. Suture materials used in pullout fixation (No 2. FiberWire®) & all-inside fixation (ULBRABRAID™ 2-0) were different.
Conclusions

1. Root repair can improve tibiofemoral contact mechanics (Peak contact pressure, Contact surface area)

2. However, it is difficult to restore biomechanics completely.

3. Complex suture patterns with locking mechanisms can be recommended in root repair.

Thank you for your kind attention