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# Effect of intraoperative soft tissue balance on postoperative recovery of ambulatory and balancing function in posterior-stabilized total knee arthroplasty

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Conflict of Interest: None

**Title**: Effect of intraoperative soft tissue balance on postoperative recovery of ambulatory and balancing functions in posterior-stabilized total knee arthroplasty

Abstract

**Background:** The effectiveness of total knee arthroplasty (TKA) on ambulatory and balancing function recovery should be quantitatively investigated. The present study aimed to evaluate ambulatory function using 3m-timed up and go (TUG) test and balancing function using one-leg standing time (ST) from before and after TKA, and to analyze the effects of intraoperative soft tissue balance on the postoperative improvement of their functions after TKA.

**Methods:** The study included 65 patients with varus-type knee osteoarthritis who underwent primary posterior-stabilized (PS) TKA. The TUG test and ST were performed preoperatively, 1 month and 12 months after TKA. The intraoperative soft tissue balance, medial and lateral joint looseness (MJL, LJL) were evaluated with both femoral trial in place and patellofemoral joint reduced using the OFR tensor® with the knee at 0, 10, 30, 45, 60, 90, 120, and 135°. The influences of MJL and LJL on the improvement in TUG test time and ST and the 2011 Knee Society Knee Scoring System (2011 KSS) 12 months after TKA were investigated.

**Results:** The mean TUG test times and ST were 12.7 and 13.1, 13.5 and 15.4, and 10.9 and 19.2 seconds preoperatively, 1 month and 12 months after TKA, respectively. The MJL at 10, 30 and 90° flexion was significantly negatively correlated with improvement in the TUG test time and the MJL at 0° flexion was significantly negatively correlated with improvement in the ST. However, the LJL was not significantly correlated with improvement in the TUG test time and the ST. The MJL at 45, 60, and 90° flexion was significantly negatively correlated with the 12-month postoperative score on the activities subscale of the 2011 KSS.

**Conclusions:** The higher intraoperative medial knee stability may be associated with the better postoperative improvement in ambulatory function and activities subscale of the 2011 KSS after PS-TKA.

## Introduction

In 2006, the Japanese Orthopaedic Association proposed a new clinical entity of musculoskeletal ambulation disability symptom complex (MADS) to define the elderly population with a high risk of falls and ambulatory disability caused by musculoskeletal disorders. In 2007, the Japanese Orthopaedic Association proposed locomotive syndrome as a high-risk state involving a bedridden condition that requires nursing care, if there is a decline in musculoskeletal function [1]. The diagnosis of MADS is based on either or both of decreased independence in daily life and deterioration of walking and balancing functions caused by musculoskeletal disorders (Table 1). The evaluation involves 2 simple performance tests; MADS is diagnosed if the 3-m timed up and go (TUG) test time is not less than 11 seconds and/or the one-leg standing time (ST) with open eyes is less than 15 seconds [2].

Osteoarthritis (OA) of the knee is one of the major causes of MADS. The number of elderly patients requiring total knee arthroplasty (TKA) is expected to increase worldwide. Therefore, the effectiveness of TKA for ambulatory function should be investigated in elderly people. The 2011 Knee Society Knee Scoring System

(2011 KSS) is considered important after TKA to quantify subjective patient outcomes, satisfaction, expectations and physical activities [3]. Accurate alignment of the knee implant and adequate soft tissue balance are important for achieving success in TKA [4-6]. Intraoperative evaluation is extremely important to achieve adequate soft tissue balance. To enable evaluation during TKA under more physiological joint conditions, an offset-type tensor has been developed to allow surgeons to assess soft tissue balance after reduction of the patellofemoral (PF) joint, as well as with the femoral component in place [7, 8]. The acquisition of the soft tissue balance also remains largely dependent on the experience and skill of the surgeon with few objective guides [9]. Several reports have indicated that soft tissue balance influences clinical outcome after TKA. Balance allows lateral laxity similar to that in the normal knee [10], and some authors have noted that slight lateral laxity is acceptable after TKA [11, 12]. On the other hand, previous studies showed that medial instability after TKA causes postoperative knee pain [13] and absence of physiological movement [14]. However, there have been no detailed reports of how intraoperative soft tissue balance affects ambulatory and balancing functions and patient-based evaluation after TKA.

The present study aimed to evaluate the change in ambulatory and balancing functions from before to after TKA in elderly patients, and to investigate the effects of intraoperative soft tissue balance on improvement in postoperative ambulatory and balancing functions, using the TUG test and ST, and postoperative patient-based evaluation after TKA. It was hypothesized that ambulatory and balancing functions would improve after TKA, and that intraoperative medial stability and lateral laxity of the knee affect improvement of postoperative ambulatory and balancing functions and postoperative patient-based evaluation.

## Materials and Methods

Between August 2012 and March 2015, 155 primary TKAs were performed. According to posterior cruciate ligament (PCL) condition with relatively better active range of motion (ROM) more than -10°~120° without posterior instability, 76 knees were assigned to cruciate-retaining TKA; the other 79 knees without functional PCL and with severe bone defect in the elderly were assigned to posterior-stabilized (PS) TKA (NexGen LPS Flex, fixed bearing type, Zimmer, Inc, Warsaw, IN, USA). Among these, we excluded patients less than 65 year-old (6 patients) and those with valgus-type knee OA (8 patients). As a result, this prospective study included 65 elder patients more than 65 year-old (55 women and 10 men) with varus-type knee OA who underwent primary PS-TKA. The mean age of the patients was 75.7 years (range, 65–88 years), and the mean preoperative coronal alignment was 13.8° in varus (range, 6.0–29.1°). The postoperative mean hospital stay for rehabilitation was 24.6 days (range, 15–44 days). The hospital ethics committee approved the study protocol, and the patients provided informed consent for participation.

Offset Repo-Tensor® (OFR tensor; Zimmer, Inc.)

This device was designed to permit surgeons to measure ligament balance (varus angle) and joint center gap (joint component gap), both before and after femoral trial prosthesis placement, under a constant joint distraction force [7, 15]. Joint distraction forces ranging from 20 lbs. (9.1 kg) to 60 lbs. (27.2 kg) can be accurately exerted between the seesaw and platform plates, using a specially made torque driver that can limit the maximum torque value. Once the joint is appropriately distracted, attention is focused on 2 scales that correspond to the tensor: the angle between the seesaw and platform plates (°, positive value in varus) and the distance (mm) between the center midpoints of the upper surface of the seesaw plate and the proximal tibial cut. The angular divisions and distance are graded in 1° and 1 mm increments, respectively. In primary in vitro experiments, the error of joint distraction was within ± 3%. By measuring these angular deviations and distances under a constant joint distraction force, we were able to measure the ligament balance and joint center gap, respectively.

Intraoperative measurement

TKAs were performed with a modified gap-balancing technique. After inflating the air tourniquet to 280mmHg at the start of the procedure, a medial parapatellar arthrotomy was performed. Both the anterior cruciate and posterior cruciate ligaments were resected. A distal femoral osteotomy was performed perpendicular to the mechanical axis of the femur, according to preoperative long leg radiographs. Thereafter, a proximal tibial osteotomy was performed with 10mm bone resection from the lateral tibial plateau perpendicular to the mechanical axis in the coronal plane and with 7° of posterior inclination along the sagittal plane, using the extramedullary guide. The medial soft tissue release was performed step-by-step using a spacer block corresponding to a 10mm polyethylene insert in which residual lateral laxity was allowed within approximately 5° to avoid medial instability. Following these procedures, a gap measurement was performed between the osteotomized surfaces in extension, and between posterior femoral condyles and tibial osteotomized surface in flexion. A distraction force of 40 lbs. was loaded and the joint center gap and varus ligament balance were measured both in extension and flexion, respectively. The osteotomies of posterior femoral condyles were performed to preserve medial stability of the knee at extension and flexion with allowing lateral laxity, and create equal extension and flexion trapezoidal osteotomy gaps. The external rotation angle of the posterior femoral condyle was determined by the varus angle difference between flexion and extension so that varus ligament balance at extension matched the varus ligament balance at flexion. Measurement of the original anteroposterior size of the femur is performed using a center pivot type femoral sizer after determining the external rotation angle. We determined the size of the femoral component and anteroposterior position so that the center gap at flexion after the posterior femoral condylar osteotomy was equivalent to the center gap at extension [16]. After each osteotomy, the tensor was fixed to the proximal tibia and the femoral trial prosthesis was fitted. The joint distraction force was set at 40 lbs. in all patients. This joint distraction force was loaded several times until the joint component gap remained constant, in order to reduce any error resulting from creep elongation of the surrounding soft tissues. Then, the ligament balance (varus angle in °) and joint component gap (in mm) with the knee at 0° (full extension), 10° (extension), 30°, 45°, 60° (midrange flexion), 90° (flexion), and 120°, 135° (deep flexion) were measured with a reduced PF joint. Medial compartment gap and lateral compartment gap at each flexion angle were calculated from the measured joint component gap and varus angle using trigonometric functions (Fig. 1) [15]. To perform these measurements with a reduced PF joint, the medial parapatellar arthrotomy was temporarily repaired with proximal and distal sutures to the connection arm of the tensor. During each measurement, the thigh and knee were aligned in the sagittal plane to eliminate the external load on the knee at each flexion angle. Medial joint looseness (MJL) and lateral joint looseness (LJL) were defined as “medial compartment gap - polyethylene insert thickness” and “lateral compartment gap - polyethylene insert thickness,” and were calculated with the knee at each flexion angle.

Measurement of the TUG test time and ST

The TUG test was used to evaluate ambulatory ability in order to diagnose MADS. The TUG test was performed preoperatively, 1 month and 12 months after TKA. The test measures the time taken to rise from a chair, walk straight 3 meters, turn around, walk back, and sit down on the chair. The time was also measured from the seated position with a stopwatch started on the command of “ready go,” and stopped when the seated position was regained. The fastest time of 3 trials was chosen, and the time was recorded to the nearest 0.1 second.

The ST was used to evaluate balancing ability in order to diagnose MADS. The ST on the operative side was also performed preoperatively, 1 month and 12 months after TKA. The test measures the duration of one-leg standing with eyes open, hands placed on hips, with one foot raised more than 5 cm above the other foot. The longest time of 3 trials was chosen, and the time was recorded to the nearest 0.1 second.

### The 2011 KSS

The 2011 KSS mainly consists of 2 parts: a surgeon-derived score and a patient-derived score. The surgeon-derived score refers to the objective knee indicator score of the 2011 KSS, which includes alignment, instability, and ROM of the knee. The patient-derived score of the 2011 KSS has the following 4 subscales: symptoms (pain scale), patient satisfaction, patient expectations, and functional activities.

## Statistical analysis

All values were expressed as a mean ± standard error. The results were analyzed statistically using a statistical software package (Statview 5.0: Abacus Concepts, Inc., Berkeley, CA, USA). The TUG test and ST results were compared among the 3 time periods using repeated measures analysis of variance. We reviewed the MJL and LJL at each flexion angle that affected the improvement in the TUG test time and ST 12 months after TKA using simple linear regression models and Pearson's correlation coefficient. We also reviewed the MJL and LJL at each flexion angle that affected postoperative patient-based evaluation of the score for ROM in the objective knee indicators subscale, symptoms subscale, patient satisfaction subscale, and functional activities subscale of the 2011 KSS. $P<0.05$ was considered statistically significant. A statistical power analysis was performed prior to the study, which was expected to require a power of 0.8, based on a prespecified significance level of $\alpha < 0.05$ and assuming a medium effect size (effect size = 0.30) using G power 3 [17]. The estimated sample size was 64.

## Results

### Change in ambulatory function (TUG) and balancing function (ST)

The mean TUG test times are shown in Fig. 2A. The mean TUG test time was significantly lower 12 months after TKA compared to preoperatively and 1 month postoperatively. There was no significant difference between mean preoperative and 1-month postoperative TUG test times (Fig. 2A). The mean STs on the operative side are shown in Fig. 2B. There was no significant difference in the ST among the 3 time periods (Fig. 2B).

### Effects of the MJL and LJL on improvement in the TUG test time and ST

The mean MJL and LJL are shown in Table 2A. The MJL at 10, 30 and 90° of flexion was significantly negatively correlated with the improvement in the TUG test time. The LJL was not significantly correlated with the improvement in the TUG test time at any flexion angle (Table 2B). The correlations between MJL at 10° and 90° to the TUG recovery time were shown in Figure 3. The MJL at 0° of flexion was significantly negatively correlated with the improvement in the ST. The LJL was not significantly correlated with the improvement in the ST at any flexion angle (Table 2C).

## Effects of the MJL and LJL on postoperative patient-based evaluation

The mean scores for ROM in the objective knee indicators subscale, symptoms subscale, patient satisfaction subscale, and functional activities subscale of the 2011 KSS are shown in Table 3A. MJL and LJL were not significantly correlated with the postoperative scores for ROM in the objective knee indicators subscale and symptoms subscale at any flexion angle (Table 3B, C). The MJL was not significantly correlated with the postoperative score on the patient satisfaction subscale at any flexion angle. However, the LJL at 30° of flexion was significantly negatively correlated with the postoperative score on the patient satisfaction subscale (Table 3D). The MJL at 45, 60, and 90° of flexion was significantly negatively correlated with the postoperative score on the functional activities subscale. The LJL was not significantly correlated with the postoperative score on the functional activities subscale at any flexion angle (Table 3E).

# Discussion

The most important finding in this study was that ambulatory function improved 12 months after TKA and intraoperative medial stability at 10, 30, and 90° of flexion improved the TUG test time 12 months after TKA, thus supporting the hypothesis. However, intraoperative lateral laxity did not improve the TUG test time, thus contradicting the hypothesis. The intraoperative medial stability at 0° of flexion improved the ST 12 months after TKA, thus supporting the hypothesis. However, balancing function did not improve 12 months after TKA and intraoperative lateral laxity did not improve the ST, thus contradicting the hypothesis. In postoperative patient-based evaluation, the intraoperative medial stability at 45, 60, and 90° of flexion was related to good postoperative functional activity, thus supporting the hypothesis. However, postoperative functional activity was not correlated with lateral laxity, thus contradicting the hypothesis. Furthermore, postoperative ROM, symptoms (pain), and patient satisfaction were not correlated with intraoperative medial stability and lateral laxity, thus contradicting the hypothesis. The importance of the medial stability of the knee has been reported in recent years. Liebs et al. assessed the significance of an asymmetric extension gap on routine radiographs after TKA [13], and found that a gap of ≥1.5 mm on the medial side was associated with increased pain at the 3- and 6-month follow-up. Nakamura et al. assessed the relationship between postoperative flexion gaps and in vivo knee kinematics [14]. The authors found that the magnitude of the medial flexion gap was crucial for postoperative knee kinematics.

Although only intraoperative medial stability at full extension was significantly correlated with improvement in the ST 12 months after TKA, intraoperative medial stability at 10, 30, and 90° of flexion improved the TUG test time 12 months after TKA, which meant that obtaining medial stability with intraoperative soft tissue balancing in TKA plays a more important role in recovery of ambulatory function (TUG test time) than balancing function (ST). The TUG test has become one of the most popular functional assessments for several reasons. First, the TUG test assesses several different mobility skills [18, 19]. Second, the TUG test requires minimal materials and setup. Furthermore, the TUG test is simple to score, requiring minimal training and no expertise in mobility analysis. Podsiadlo et al. found the TUG test to have good test-retest reliability, inter-rater reliability, and concurrent validity [20]. The TUG test has been demonstrated to predict both short- [21] and long-term function [22] following TKA. In the current study, we investigated the change in preoperative ambulatory function at 1 and 12 months after TKA. The results showed that ambulatory function did not improve early after TKA. However, ambulatory function improved 12 months after TKA with good medial stability.

It was found that a good postoperative 2011 KSS score for ROM and pain could not always be obtained if intraoperative medial stability was obtained. However, postoperative functional activity, with walking, standing, routine activity, advanced activity, and discretionary activity as criteria were significantly related to intraoperative medial stability from midrange flexion to flexion. This result suggested that medial stability of the knee was also important in daily activities as well as in TUG. Nevertheless, the relationship between intraoperative medial stability and postoperative patient satisfaction did not show the hypothesized results, possibly because intraoperative medial stability was not significantly correlated with postoperative ROM and pain. Furthermore, although understood from the results, postoperative patient satisfaction might be low if MJL was not only too loose but also too tight. It was also thought to be important that LJL of midrange flexion did not become too loose because LJL at 30° of flexion was significantly negatively correlated with the postoperative scores for patient satisfaction.

This study has some limitations. First, the data were obtained for PS-TKA; therefore, the results may differ from data obtained for cruciate-retaining TKA. Second, the TUG test and ST were only performed preoperatively, 1 month and 12 months after TKA. Longer-term investigations of the change in the TUG test and ST are necessary. Third, we did not evaluate the relationship between postoperative soft tissue balance and improvement in postoperative ambulatory and balancing functions Finally, we did not evaluate the relationship between postoperative soft tissue balance and postoperative patient-based evaluation. These should be investigated in a future study.

## Conclusions

Balancing function did not improved 12 months after TKA, however, ambulatory function improved 12 months after PS-TKA. The higher intraoperative medial knee stability may be associated with better postoperative improvement in ambulatory function and better postoperative functional activity after PS-TKA.

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**Figure captions**

Figure 1: Medial compartment gap and lateral compartment gap.

Medial compartment gap and lateral compartment gap were calculated from the measured joint component gap (CG) and varus angle (θ) using trigonometric functions.

Figure 2: The mean 3-m timed up and go (TUG: Figure 2A) test times and one-leg standing time (ST: Figure 2B) at preoperatively, 1 month and 12 months after total knee arthroplasty. The markers showed the mean values.

Figure 3: Effects of the medial joint looseness (MJL) at 10° and 90°on the improvement of the 3-m timed up and go (TUG) test time.

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**Tables**

Table 1: Diagnosis criteria of musculoskeletal ambulation disability symptom complex (MADS).

Table 2A: The mean ± standard error of medial joint looseness (MJL) and lateral joint looseness (LJL).

Table 2B: Effects of the medial joint looseness (MJL) and lateral joint looseness (LJL) on the improvement of the 3-m timed up and go (TUG) test time.

The MCG at 10, 30, 60 and 90° flexion was significantly negatively correlated with the improvement in the TUG test time.

Table 2C: Effects of the medial joint looseness (MJL) and lateral joint looseness (LJL) on the improvement of the one-leg standing time (ST) with eyes open.

The MCG at 0° flexion was significantly negatively correlated with the improvement in the ST.

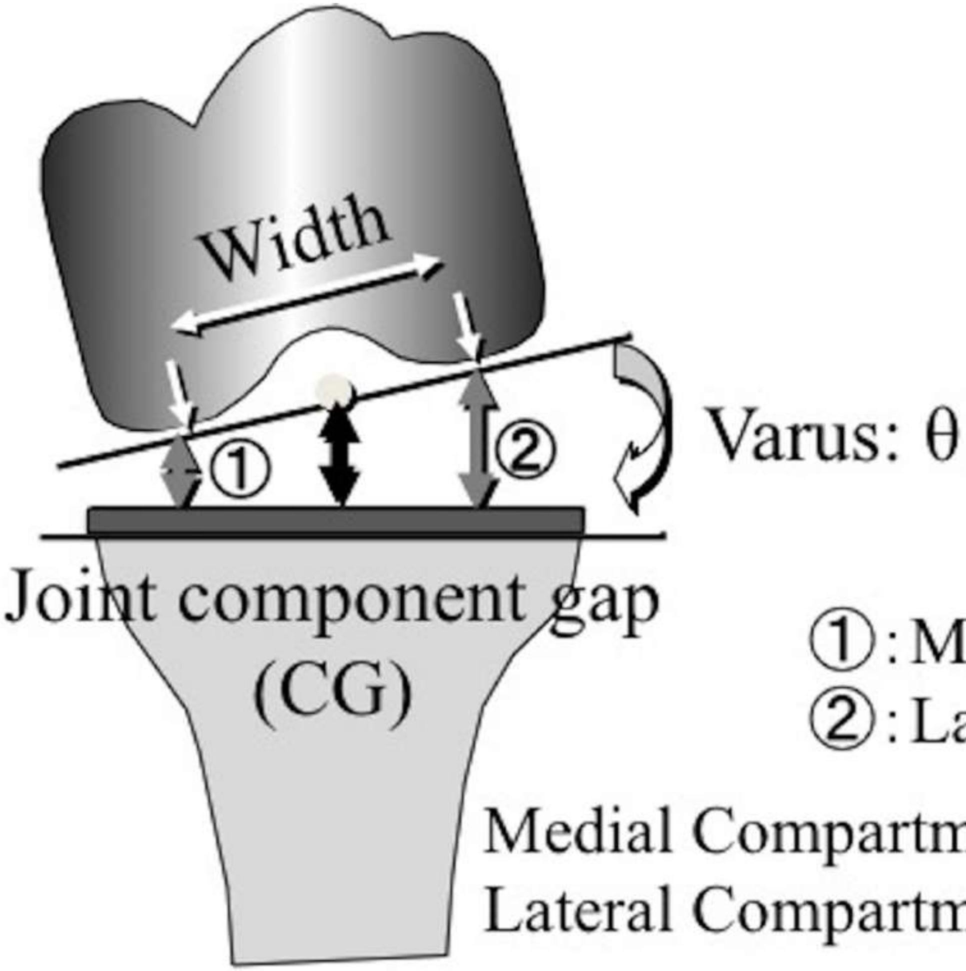
Table 3A: The mean scores of the 2011 Knee Society Knee Scoring System.

Table 3B: Effects of the medial joint looseness (MJL) and lateral joint looseness (LJL) on the postoperative scores for range of motion in the objective knee indicators subscale.

Table 3C: Effects of the medial joint looseness (MJL) and lateral joint looseness (LJL) on the postoperative scores for symptoms subscale.

Table 3D: Effects of the medial joint looseness (MJL) and lateral joint looseness (LJL) on the postoperative scores for the patient satisfaction subscale.

Table 3E: Effects of the medial joint looseness (MJL) and lateral joint looseness (LJL) on the postoperative scores for the functional activities subscale.




①: Medial Compartment Gap

②: Lateral Compartment Gap

$$\text{Medial Compartment Gap} = \text{CG} - 1/2\{\text{width} \times \sin(\theta)\}$$

$$\text{Lateral Compartment Gap} = \text{CG} + 1/2\{\text{width} \times \sin(\theta)\}$$

Figure 1

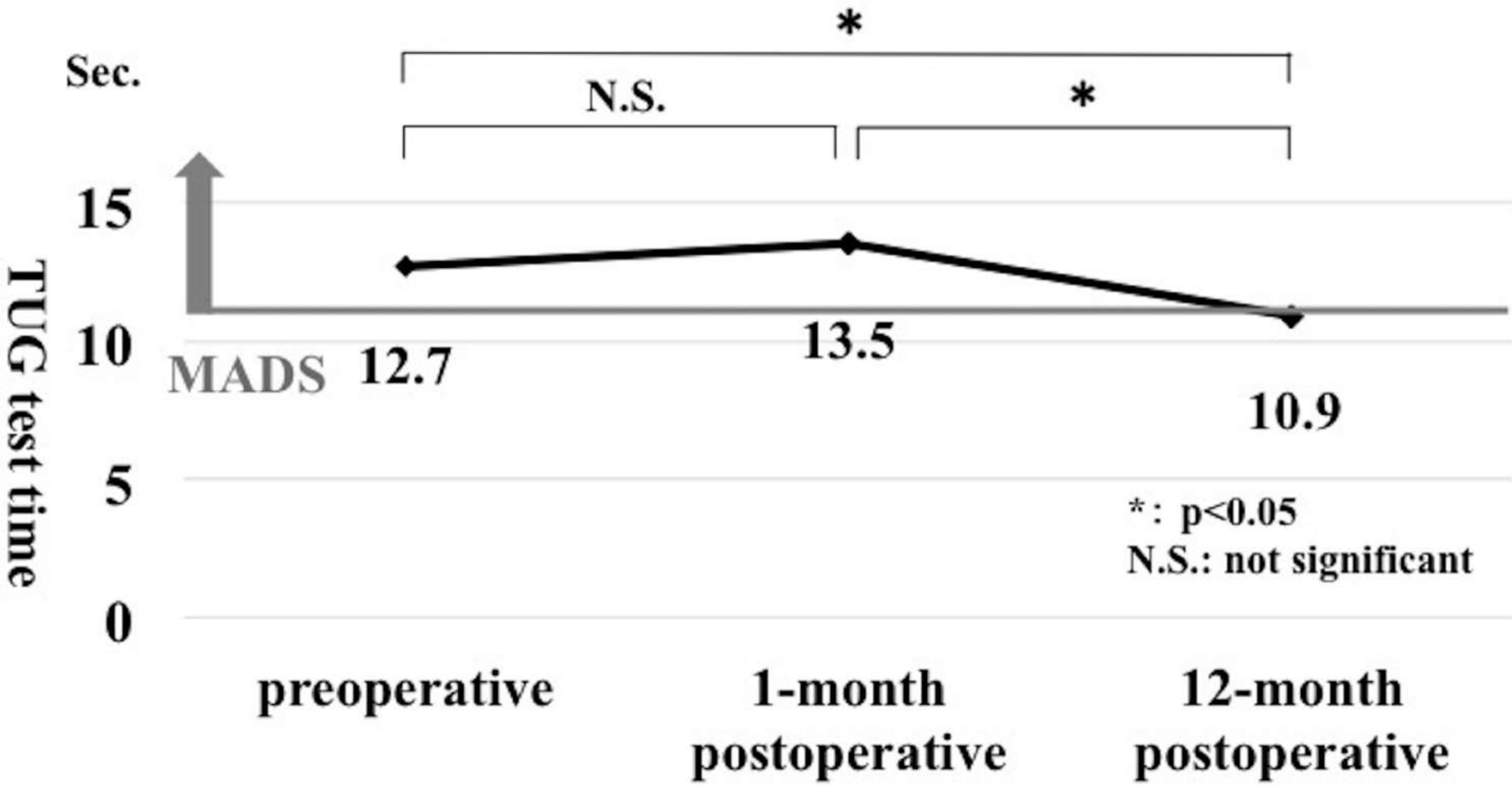
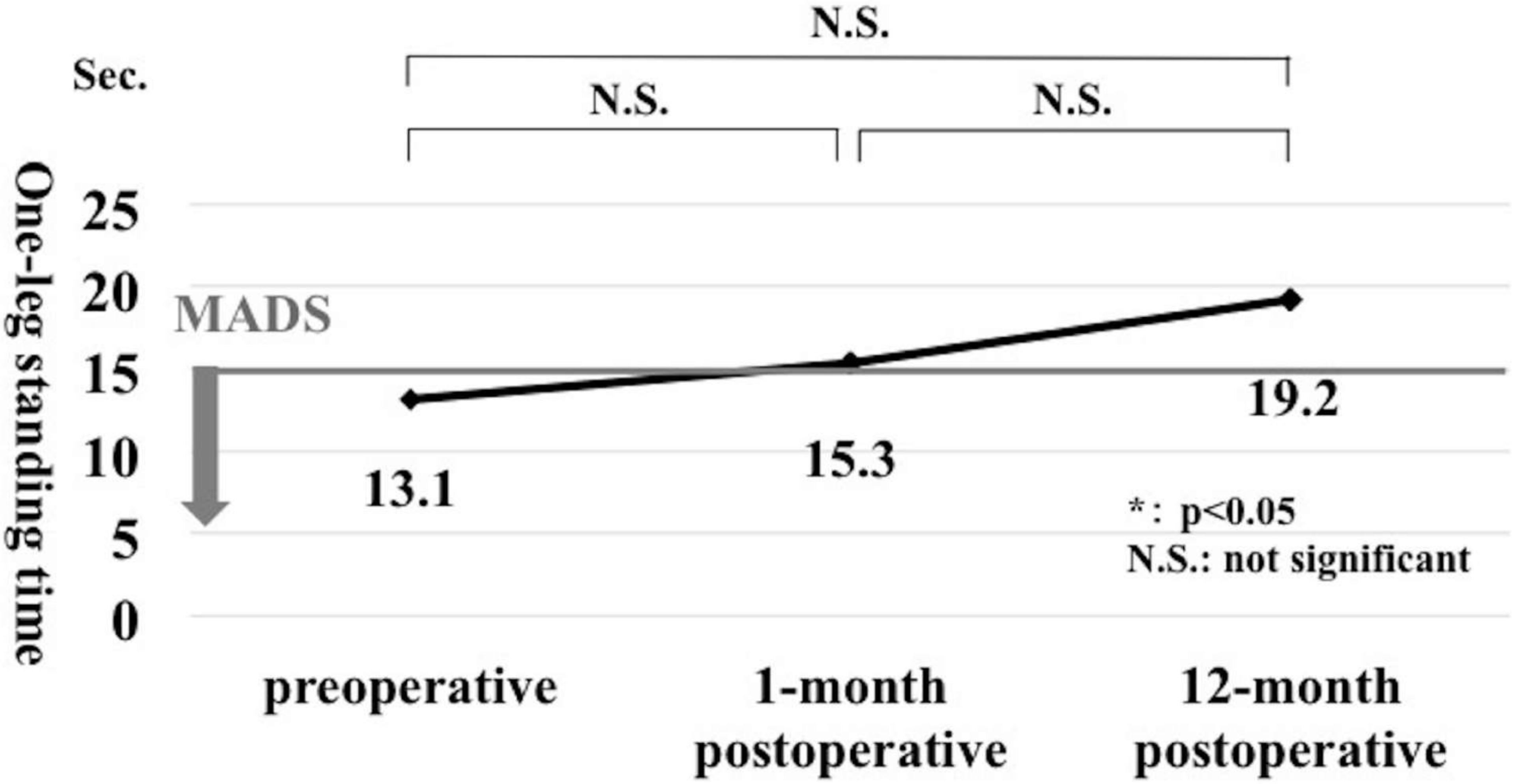

*
Sec.
N.S.
*
15
10
5
0
TUG test time
MADS
12.7
13.5
10.9
*: p<0.05
N.S.: not significant
preoperative
1-month postoperative
12-month postoperative

Figure 2A



N.S.
Sec.
N.S.
N.S.
One-leg standing time
25
20
15
10
5
0
MADS
19.2
15.3
13.1
*: p<0.05
N.S.: not significant
preoperative
1-month postoperative
12-month postoperative


Figure 2B

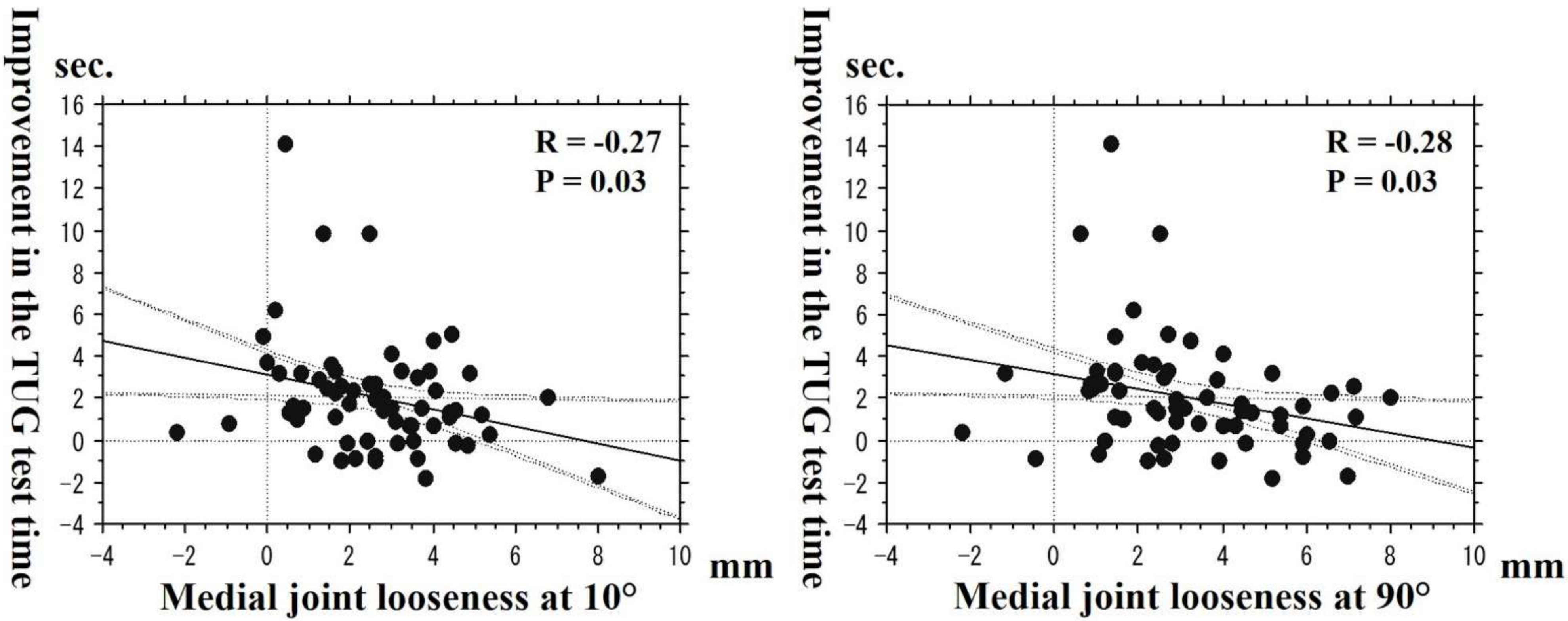

Improvement in the TUG test time
sec.
R = -0.27
P = 0.03
mm
Medial joint looseness at 10°
Improvement in the TUG test time
sec.
R = -0.28
P = 0.03
mm
Medial joint looseness at 90°

Figure 3

# Table 1

Diagnosis of MADS requires fulfillment of (2) or (3) in addition to (1)

(1) Eleven orthopaedic disorders or conditions that impair movement

1. Vertebral compression fracture and various spinal deformities (kyphotic spine, severe lumbar kyphosis and scoliosis etc.)
2. Lower extremity fracture (femoral neck fracture etc.)
3. Osteoporosis
4. Osteoarthritis (hip joint, knee joint etc.)
5. Lumbar spinal canal stenosis
6. Spinal disorder (cervical myelopathy, spinal cord injury etc.)
7. Neuromuscular disease
8. Rheumatoid arthritis and various arthritis
9. Lower limb amputation
10. Musculoskeletal waste after prolonged immobility
11. High frequency falls

(2) Decreased independence, with need for support or nursing care

(3) Functional decline, as evaluated with ST and TUG

1) One-leg standing time with eyes open (ST): less than 15 seconds

2) 3m Timed up and go test (TUG): not less than 11 seconds

# Table 2A

| Flexion angle | MJL | LJL |
|---|---|---|
| 0° | 0.12 ± 0.23 | 1.96 ± 0.28 |
| 10° | 2.61 ± 0.23 | 4.75 ± 0.26 |
| 30° | 3.19 ± 0.23 | 5.81 ± 0.31 |
| 45° | 2.95 ± 0.28 | 5.94 ± 0.32 |
| 60° | 2.98 ± 0.28 | 6.13 ± 0.31 |
| 90° | 3.19 ± 0.27 | 6.30 ± 0.28 |
| 120° | 2.66 ± 0.30 | 5.57 ± 0.32 |
| 135° | 0.92 ± 0.32 | 3.23 ± 0.35 |

Mean ± standard error
MJL: Medial joint looseness, LJL: Lateral joint looseness

# Table 2B

| MJL | correlation coefficient | regression analysis p value | LJL | correlation coefficient | regression analysis p value |
|---|---|---|---|---|---|
| 0° | -0.098 | 0.464 | 0° | -0.156 | 0.231 |
| 10° | -0.269 | 0.034 * | 10° | -0.200 | 0.125 |
| 30° | -0.305 | 0.017 * | 30° | -0.166 | 0.197 |
| 45° | -0.218 | 0.089 | 45° | -0.157 | 0.222 |
| 60° | -0.232 | 0.069 | 60° | -0.160 | 0.214 |
| 90° | -0.275 | 0.030 * | 90° | -0.157 | 0.222 |
| 120° | -0.221 | 0.084 | 120° | -0.056 | 0.665 |
| 135° | -0.239 | 0.085 | 135° | -0.034 | 0.808 |

* $p<0.05$ statistically significant

MJL: Medial joint looseness, LJL: Lateral joint looseness

# Table 2C

| MJL | correlation coefficient | regression analysis p value | LJL | correlation coefficient | regression analysis p value |
|---|---|---|---|---|---|
| 0° | -0.269 | 0.041 * | 0° | -0.163 | 0.210 |
| 10° | -0.195 | 0.130 | 10° | -0.058 | 0.658 |
| 30° | -0.051 | 0.695 | 30° | 0.022 | 0.867 |
| 45° | -0.002 | 0.985 | 45° | 0.104 | 0.423 |
| 60° | -0.035 | 0.788 | 60° | 0.132 | 0.308 |
| 90° | 0.074 | 0.567 | 90° | 0.167 | 0.196 |
| 120° | -0.082 | 0.527 | 120° | 0.057 | 0.663 |
| 135° | -0.147 | 0.293 | 135° | 0.062 | 0.657 |

* $p<0.05$ statistically significant

MJL: Medial joint looseness, LJL: Lateral joint looseness

# Table 3A

| The 2011 KSS scores | 12-month postoperatively |
|---|---|
| Range of motion in objective knee indicators subscale | 21.6 ± 0.5 |
| Symptoms subscale | 19.7 ± 0.6 |
| Patient satisfaction subscale | 31.1 ± 0.8 |
| Functional activities subscale | 68.8 ± 0.6 |

Mean ± standard error

KSS: Knee Society Knee Scoring System

# Table 3B

| MJL | correlation coefficient | regression analysis p value | LJL | correlation coefficient | regression analysis p value |
|---|---|---|---|---|---|
| 0° | -0.214 | 0.203 | 0° | -0.187 | 0.268 |
| 10° | -0.249 | 0.137 | 10° | -0.156 | 0.356 |
| 30° | -0.247 | 0.140 | 30° | -0.158 | 0.351 |
| 45° | -0.256 | 0.126 | 45° | -0.169 | 0.316 |
| 60° | -0.107 | 0.527 | 60° | -0.114 | 0.502 |
| 90° | -0.004 | 0.980 | 90° | -0.011 | 0.947 |
| 120° | 0.137 | 0.420 | 120° | -0.033 | 0.846 |
| 135° | 0.179 | 0.326 | 135° | -0.059 | 0.750 |

* $p<0.05$ statistically significant

MJL: Medial joint looseness, LJL: Lateral joint looseness

# Table 3C

| MJL | correlation coefficient | regression analysis p value | LJL | correlation coefficient | regression analysis p value |
|---|---|---|---|---|---|
| 0° | 0.119 | 0.471 | 0° | 0.039 | 0.811 |
| 10° | -0.083 | 0.614 | 10° | -0.113 | 0.499 |
| 30° | -0.202 | 0.218 | 30° | -0.247 | 0.130 |
| 45° | -0.148 | 0.368 | 45° | -0.188 | 0.252 |
| 60° | -0.125 | 0.450 | 60° | -0.155 | 0.346 |
| 90° | -0.092 | 0.579 | 90° | -0.065 | 0.695 |
| 120° | -0.005 | 0.978 | 120° | -0.083 | 0.617 |
| 135° | 0.069 | 0.709 | 135° | -0.084 | 0.649 |

* $p<0.05$ statistically significant
MJL: Medial joint looseness, LJL: Lateral joint looseness

# Table 3D

| MJL | correlation coefficient | regression analysis p value | LJL | correlation coefficient | regression analysis p value |
|---|---|---|---|---|---|
| 0° | -0.064 | 0.705 | 0° | -0.186 | 0.263 |
| 10° | -0.027 | 0.871 | 10° | -0.315 | 0.058 |
| 30° | -0.101 | 0.547 | 30° | -0.332 | 0.042 * |
| 45° | -0.018 | 0.914 | 45° | -0.266 | 0.107 |
| 60° | -0.015 | 0.930 | 60° | -0.280 | 0.088 |
| 90° | 0.005 | 0.978 | 90° | -0.242 | 0.143 |
| 120° | 0.023 | 0.892 | 120° | -0.133 | 0.425 |
| 135° | 0.009 | 0.960 | 135° | -0.102 | 0.584 |

* $p<0.05$ statistically significant

MJL: Medial joint looseness, LJL: Lateral joint looseness

# Table 3E

| MJL | correlation coefficient | regression analysis p value | LJL | correlation coefficient | regression analysis p value |
|---|---|---|---|---|---|
| 0° | 0.070 | 0.678 | 0° | -0.015 | 0.928 |
| 10° | -0.142 | 0.394 | 10° | -0.225 | 0.181 |
| 30° | -0.187 | 0.261 | 30° | -0.235 | 0.155 |
| 45° | -0.355 | 0.029 * | 45° | -0.276 | 0.098 |
| 60° | -0.336 | 0.039 * | 60° | -0.266 | 0.106 |
| 90° | -0.385 | 0.017 * | 90° | -0.296 | 0.072 |
| 120° | -0.274 | 0.096 | 120° | -0.151 | 0.366 |
| 135° | -0.106 | 0.585 | 135° | -0.039 | 0.840 |

* $p<0.05$ statistically significant

MJL: Medial joint looseness, LJL: Lateral joint looseness