

# The Effect of Sagittal Plane Deformities after Tibial Plateau Fractures to Functions and Instability of Knee Joint

Význam deformit v sagitální rovině u zlomenin tibiálního plató na funkci a stabilitu kolenního kloubu

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## ABSTRACT

### PURPOSE OF THE STUDY

The objective of this study is to evaluate the effect of posterior tibial slope after fracture healing on antero-posterior knee laxity, functional outcome and patient satisfaction.

### MATERIAL AND METHODS

126 patients who were treated for tibial plateau fractures between 2008–2013 in the orthopedics and traumatology department of our institution were evaluated for the study. Patients were treated with open reduction and internal fixation, arthroscopy assisted minimally invasive osteosynthesis or conservative treatment.

### RESULTS

Mean posterior tibial slope after the treatment was  $6.91 \pm 5.11$  and there was no significant difference when compared to the uninvolved side  $6.42 \pm 4.21$  ( $p = 0.794$ ). Knee laxity in anterior-posterior plane was  $6.14 \pm 2.11$  and  $5.95 \pm 2.25$  respectively on healthy and injured side. The difference of mean laxity in anterior-posterior plane between two sides was statistically significant.

### DISCUSSION

In this study we found no difference in laxity between the injured and healthy knees. However Tegner score decreased significantly in patients who had greater laxity difference between the knees. We did not find significant difference between fracture type and laxity, IKDC functional scores independent of the ligamentous injury.

### CONCLUSION

In conclusion despite coronal alignment is taken into consideration in treatment of tibial plateau fractures, sagittal alignment is reasonably important for stability and should not be ignored.

**Key words:** knee, tibial fracture, fracture fixation.

## INTRODUCTION

Fractures of proximal tibia affect function and stability of knee joint. The objective of surgical treatment in proximal tibial fractures is to regain and preserve normal knee functions (23). Anatomical restoration of tibial joint surface and obtaining ligamentous stability are necessary for a painless functional knee joint with a preserved mechanical axis (2, 6, 10, 11, 12, 20).

Vast majority of tibial plateau fractures result from high energy accidents such as traffic accidents and fall from height (8, 13). Varus and valgus scissoring forces accompanying axial compression results in ligament and meniscal injuries in up to 50% of the cases (8, 16).

Therefore treatment of ligamentous instability needs special attention in management of tibial plateau fractures.

Disruption of posterior tibial slope which is necessary for normal range of motion and ligament function is another ignored topic in tibial plateau fractures (15, 21). Changes in normal posterior tibial slope may affect tibial scissoring forces, anterior tibial translation and the force on anterior cruciate ligament (ACL). Therefore increment of posterior tibial slope may lead to ACL injuries (4, 14, 15).

The objective of this study is to evaluate the effect of posterior tibial slope after fracture healing on antero-posterior knee laxity, functional outcome and patient satisfaction.

## MATERIAL AND METHODS

Hospital records of 126 patients who were treated for tibial plateau fractures between 2008–2013 in the orthopedics and traumatology department of our institution were evaluated for the study. Of these 32 (16 females, 16 males) patients who attended follow-up visits regularly for at least 12 months were analyzed retrospectively on electronical charts. Patients with trauma of the contralateral knee joint, knee osteoarthritis, inflammatory arthropathy, previous knee surgery were excluded. Patients gave written informed consent and were informed about the treatment and post-operative rehabilitation before the treatment.

Patients were treated with open reduction and internal fixation, arthroscopy assisted minimally invasive osteosynthesis (18) or conservative treatment (Table 1). Patients who were surgically treated were recommended a hinged knee brace and range of motion exercises for knee was started on the second post-operative day. Fracture healing and posterior tibial slope were evaluated on roentgenograms. One and only orthopedist evaluated posterior tibial slope according to technique described by Utzschneider et al. using NovaPACS Diagnostic Viewer 7.5.5.14 (NovaRad Corporation, USA), (22). Tibial anterior translation was evaluated by another orthopedist that is blinded to roentgenogram findings using digital arthrometer (Kneelax MR Systems, Haarlem, The Netherlands). International Knee Documentation Committee (IKDC) knee evaluation form and Tegner knee score were used for clinical and functional evaluation (5, 7). Fracture classification was made according to Schatzker classification (17). SPSS version 16.0 (SPSS, Chicago, USA) was used for statistical analyses. The relation between fracture type, anterior translation, posterior tibial slope, range of motion, IKDC and Tegner knee scores were analyzed using Spearman non-parametric correlation test.

## RESULTS

Mean age of the study patients were 50 (ranged between 29–72) and mean follow-up duration was 34.1 months (ranged between 12–58 months). Tibial fractures were on the right knee in 16 (50%) patients. Most of the patients had Schatzker type-3 fractures (n:12, 37.5%). There were accompanying fractures in 5 patients.

The most applied treatment was open reduction, internal fixation and grafting with autogenously iliac bone (n:15, 46.8%). (Table 2). Immobilization was

Table 2. Distribution of applied treatment procedures

| Treatment alternative                           |                                                             |
|-------------------------------------------------|-------------------------------------------------------------|
| Open reduction-internal fixation                | 15 (46.8%)                                                  |
| Arthroscopy assisted minimal invasive procedure | 9 (28.1%) – cannulated screw<br>4 (12.5%) – screw and plate |
| Conservative treatment (cast)                   | 4 (12.5%)                                                   |

recommended to all patients for two months. Patients were requested to attend follow-up visits on second week, sixth week, third month, sixth month and first year in the post-operative period.

The knee flexion was statistically significantly decreased on the affected side compared to the healthy side ( $100.16 \pm 16.14^\circ$  versus  $110.16 \pm 13.11$ ,  $p < 0.001$ ). Mean IKDC and Tegner scores were  $67.83 \pm 19.98$  and  $87.22 \pm 14.48$  respectively. IKDC ( $p = 0.001$ ) and Tegner scores ( $p = 0.003$ ) tend to increase as the amount of knee flexion increased.

When the relation between fracture type and radiological and functional parameters is evaluated; there was no relation between fracture type and slope, laxity, IKDC Score. However increase of fracture type was correlated with significant decrease in Tegner score ( $p = 0.045$ ), and flexion angles ( $p = 0.021$ ).

Mean posterior tibial slope after the treatment was  $6.91 \pm 5.11$  and there was no significant difference when compared to the uninjured side  $6.42 \pm 4.21$  ( $p = 0.794$ ). Mean posterior tibial slope was significantly higher in patients with higher posterior tibial slope on the uninjured side ( $p = 0.001$ ). Posterior tibial slope after the treatment and posterior tibial slope difference did not affect functional scores (IKDC score  $p = 0.903$ , Tegner score  $p = 0.523$ , range of motion  $p = 0.994$ ). (Table 3).

Knee laxity in anterior-posterior plane was  $6.14 \pm 2.11$  and  $5.95 \pm 2.25$  respectively on healthy and injured side. The difference of mean laxity in anterior posterior plane between two sides was statistically significant ( $1.89 \pm 1.53$ ,  $p = 0.036$ ). There was no correlation between laxity and age, fracture type, range of motion, functional knee scores, posterior tibial slope. However Tegner scores were significantly lower in patients with higher difference between laxity of two knees ( $p = 0.03$ ). (Table 3).

## DISCUSSION

The main goal in treatment of tibial plateau fractures is to obtain painless, stabile knee joint with a functional range of motion (23). Anatomical restoration of tibial joint surface is necessary to achieve treatment goal (10, 20). Proximal sagittal plane is as important as coronal plane deformities when evaluating anatomical reduction radiologically.

It is documented in many previous biomechanical and clinical trials that anatomical posterior slope of proximal tibia in sagittal plane is very important in transfer of weight, sagittal plane stability and normal range of motion (1, 2, 8, 9, 13, 15, 16, 21). However up to our knowledge there are no studies in literature investigating

Table 1. Distribution of fracture types according to Schatzker classification

| Schatzker classification |            |
|--------------------------|------------|
| Type I                   | –          |
| Type II                  | 9 (28.1%)  |
| Type III                 | 12 (37.5%) |
| Type IV                  | –          |
| Type V                   | 6 (18.7%)  |
| Type VI                  | 5 (15.6%)  |

Table 3. Measured posterior tibial slopes, laxity ratios and functional knee scores

| Patient | Involved side | Operated knee tibial slope | Healthy knee tibial slope | Slope difference | Operated knee laxity | Healthy knee laxity | Laxity difference | IKDC score | Tegner score |
|---------|---------------|----------------------------|---------------------------|------------------|----------------------|---------------------|-------------------|------------|--------------|
| 1       | R             | 68.6                       | 86                        | -18              | 5.51                 | 9.94                | -4.43             | 47.1       | 95           |
| 2       | R             | 83.5                       | 86                        | -2.4             | 7.57                 | 6.53                | 1.04              | 77         | 95           |
| 3       | L             | 93.1                       | 85                        | 8.2              | 5.1                  | 7.01                | -1.91             | 51.7       | 90           |
| 4       | L             | 86                         | 97                        | -11              | 3.47                 | 8.92                | -5.45             | 86.2       | 96           |
| 5       | R             | 82.5                       | 87                        | -4               | 5.71                 | 7.5                 | -1.79             | 94.3       | 100          |
| 6       | R             | 91.5                       | 74                        | 17.3             | 7.11                 | 7.11                | 0                 | 94.3       | 100          |
| 7       | L             | 78.3                       | 78                        | 0.2              | 10.2                 | 8.12                | 2.08              | 89.7       | 95           |
| 8       | R             | 87.1                       | 85                        | 2.6              | 6.19                 | 4.55                | 1.64              | 88.5       | 100          |
| 9       | L             | 87.3                       | 84                        | 3.6              | 7.65                 | 7.9                 | -0.25             | 87.4       | 100          |
| 10      | L             | 84.2                       | 87                        | -2.9             | 7.45                 | 5.73                | 1.72              | 63.2       | 86           |
| 11      | R             | 75.5                       | 81                        | -5.3             | 4.39                 | 5.31                | -0.92             | 85.1       | 81           |
| 12      | R             | 85.8                       | 85                        | 0.6              | 10                   | 2.76                | 7.24              | 32.2       | 66           |
| 13      | R             | 85.7                       | 81                        | 5.1              | 8.57                 | 11.2                | -2.63             | 48.3       | 81           |
| 14      | L             | 86.6                       | 83                        | 4                | 4.58                 | 4.45                | 0.13              | 60.9       | 97           |
| 15      | L             | 84.9                       | 80                        | 4.9              | 4.69                 | 6.21                | -1.52             | 65.5       | 95           |
| 16      | R             | 81.5                       | 81                        | 0.8              | 3.57                 | 4.97                | -1.4              | 96.6       | 100          |
| 17      | L             | 75.1                       | 88                        | -13              | 4.08                 | 4.93                | -0.85             | 49.4       | 87           |
| 18      | R             | 84.8                       | 85                        | -0.3             | 3.18                 | 3.76                | -0.58             | 40.2       | 66           |
| 19      | R             | 82.3                       | 80                        | 2.5              | 6.82                 | 7.02                | -0.2              | 74.7       | 100          |
| 20      | R             | 80.3                       | 82                        | -2.1             | 7.57                 | 6.53                | 1.04              | 39.1       | 77           |
| 21      | L             | 84.5                       | 89                        | -4.4             | 7.65                 | 8.88                | -1.23             | 71.3       | 91           |
| 22      | L             | 75.9                       | 89                        | -13              | 7.35                 | 5.85                | 1.5               | 78.2       | 91           |
| 23      | L             | 80.4                       | 83                        | -2.7             | 4.9                  | 3.16                | 1.74              | 70.1       | 89           |
| 24      | L             | 86.2                       | 85                        | 1.6              | 4.71                 | 3.27                | 1.44              | 56.3       | 92           |
| 25      | R             | 78.8                       | 81                        | -2.4             | 3.89                 | 6.37                | -2.48             | 73.6       | 95           |
| 26      | R             | 78.6                       | 78                        | 0.4              | 10.2                 | 8.12                | 2.08              | 55.2       | 78           |
| 27      | L             | 79.5                       | 81                        | -1.4             | 7.57                 | 6.53                | 1.04              | 58.6       | 66           |
| 28      | L             | 83.8                       | 83                        | 0.7              | 3.57                 | 4.97                | -1.4              | 90.8       | 94           |
| 29      | R             | 82.6                       | 81                        | 2                | 0.9                  | 2.99                | -2.09             | 81.6       | 91           |
| 30      | L             | 86.4                       | 80                        | 6.4              | 6.01                 | 2.8                 | 3.21              | 27.6       | 40           |
| 31      | R             | 88.8                       | 86                        | 3.2              | 7.29                 | 6.03                | 1.26              | 47.1       | 57           |
| 32      | L             | 88.7                       | 86                        | 2.7              | 3.13                 | 7.29                | -4.16             | 88.9       | 100          |

the effect of post-traumatic sagittal plane deformities on anterior posterior stability of knee and functional results.

Streubel et al. demonstrated change of posterior tibial slope reaching 20° in a series of 74 patients with tibial plateau fractures (21). Barei et al. reported normal posterior tibial slope in 72.4% of 83 patients with complex tibial plateau fractures (2). We achieved posterior tibial slope similar to uninvolved knee ( $p = 0.794$ ) and no functional differences between two knees. This implies the functional success of anatomical plane reposition and involved knee behaves similar to the healthy one.

Jansen et al. reported tendency towards instability in pivot shift test after tibial plateau fractures (10). Rademakers et al. reported anteroposterior laxity more than 14% of the patients who were followed for 14 years (12). In this study we found no difference in laxity between the injured and healthy knees. However Tegner score decreased significantly in patients who had greater laxity difference between the knees. Despite absence of correlation between laxity and posterior tibial slope, minimization of instability via anatomical reposition of posterior tibial slope is necessary for a functional knee. There are studies reporting increased ligamentous and meniscal injury as the Shatzker degree of fracture increases (19). On the other hand there are also studies reporting absence of correlation between fracture type and ligamentous, meniscal injury (3, 24). We did not

find significant difference between fracture type and laxity, IKDC functional scores independent of the ligamentous injury.

Range of motion is an indicator of functional recovery after tibial plateau fractures (6, 20). We found higher IKDC and Tegner scores in patients with higher range of motion. However this situation is affected by fracture type and increase in Tegner scores and range of motion is significantly related to increase in fracture type.

The small number of patient group is one of the limitations of this study. Another limitation is inclusion of different fracture types. Although patients with previous ligamentous injury, knee instability, previous knee surgery, and documented ligamentous injury were excluded from the study, accompanying soft tissue injuries were not evaluated with magnetic resonance imaging before the operation because of availability and financial burden.

## CONCLUSION

Despite coronal alignment is taken into consideration in treatment of tibial plateau fractures, sagittal alignment is reasonably important for stability and should not be ignored. Further studies with homogenous fracture types and including more patients to evaluate effect of change in posterior tibial slope to knee stability after tibial plateau fractures are recommended.

**Conflict of interest:** All authors declared that they have no conflict of interest.

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