Open Journal of Orthopedics, 2015, 5, 198-207
Published Online July 2015 in SciRes. http://www.scirp.org/journal/ojo
http://dx.doi.org/10.4236/ojo.2015.57027

Immediate Knee Joint Range of Motion after Stable Fixation of Tibial Plateau Fractures

Aydin Arslan[1*], Metin Polat[2], Asim Ciliz[3], Ali Utkan[3]

[1]Department of Orthopaedics, State Hospital, Malatya, Turkey
[2]Department of Orthopaedics, Cankaya Hospital, Ankara, Turkey
[3]Department of Orthopaedics, Numune Research and Training Hospital, Ankara, Turkey
Email: [*]draarslan@hotmail.com

Received 9 June 2015; accepted 21 July 2015; published 24 July 2015

Abstract

The purpose of this study was to evaluate factors that affect initiation of early postoperative range of motion (ROM) rehabilitation and to investigate whether the postoperative ROM and clinical outcomes were affected by initiation of early ROM, immobilization and other factors. We conducted a retrospective analysis of tibial plateau fractures treated using stable internal fixation between December 2003 and June 2007. The resulting degree of flexion and Rasmussen Clinical and Radiographic Scores were evaluated. Thirty-nine patients were included, and 23 patients underwent a lateral submeniscal arthrotomy for evaluation of joint surface reduction, with 6 lateral meniscus lesions identified via arthrotomy. Three lateral collateral ligament lesions, 3 medial collateral ligament lesions and 1 anterior cruciate ligament lesion were found. Meniscus and ligament lesions significantly and negatively affected the initiation of knee joint ROM. Early ROM was achieved in 26 cases and 13 patients underwent immobilization for 4 weeks. At the final evaluation, the early ROM group had 130.42˚ ± 5.50˚ of flexion, compared with 122.92˚ ± 5.28˚ in the immobilization group. Moreover, the final Rasmussen score was 25.69 ± 2.92 in the early motion group, compared with 22.61 ± 3.5 in the immobilization group. There was no difference between radiographic scores of the groups. Although the initiation of early ROM improved the clinical results, soft tissue lesions influenced initiation of early knee joint motion. Therefore, meniscus and ligament injuries should be considered as prognostic factors in similar cases.

Keywords

Tibial Plateau, Range of Motion, Stable Fixation, Meniscus, Ligament

[*]Corresponding author.

How to cite this paper: Arslan, A., Polat, M., Ciliz, A. and Utkan, A. (2015) Immediate Knee Joint Range of Motion after Stable Fixation of Tibial Plateau Fractures. *Open Journal of Orthopedics*, **5**, 198-207. http://dx.doi.org/10.4236/ojo.2015.57027

1. Introduction

Tibial plateau fractures are proximal fractures of the tibia that extend to the articular surface. These fractures constitute approximately 1.2% of all fractures and typically occur in young persons exposed to high-energy trauma, although they are also very common among elderly persons exposed to low-energy trauma [1] [2]. The mechanism of fracture is typically indirect and accompanied by axial loading, resulting in compression and angular forces that cause split or metaphyseal fractures [3]. In addition, meniscal lesions, medial and lateral collateral ligament injuries, and cruciate ligament injuries are reported with tibial plateau fractures, with rates of up to 60% [4] [5]. Vangness *et al*. reported that 47% of tibial plateau fractures were accompanied by meniscal injuries [6]. Meniscus injuries are seen mostly peripheral in tibial plateau fractures or sometimes seen as detachments. Diagnosis and treatment of meniscus lesions are critical because the meniscus tears can progress and result in poorer functional outcomes. Also ligament injuries are directly associated with severity of the fractures [7] [8].

Over the previous decades, various surgical treatment methods were successfully developed, including open reduction and stable fixation [9]. Mitchell and Shepard point out precise intra-articular reduction and stable fixation of the fragments [10], while incorrect reduction and instability can cause rapid degeneration of the articular cartilage. Similarly, other studies reported requirement for anatomic reduction and stable fixation to achieve early mobilization and determinant of functional outcomes as postoperative ROM, joint stability and pain [11]-[13]. In addition sufficient cartilage nourishment is provided with stable fixation and early ROM [11]. Volpin *et al*. reported that early motion might help prevent development of osteoarthritis [14].

We aimed to evaluate factors that affecting the initiation of early knee joint ROM and to investigate how postoperative range of motion and clinic outcomes were affected by the initiation of early ROM, immobilization, and other factors.

2. Material and Method

We retrospectively evaluated 39 cases of tibial plateau fractures treated with open reduction and stable internal fixation between December 2003 and June 2007.

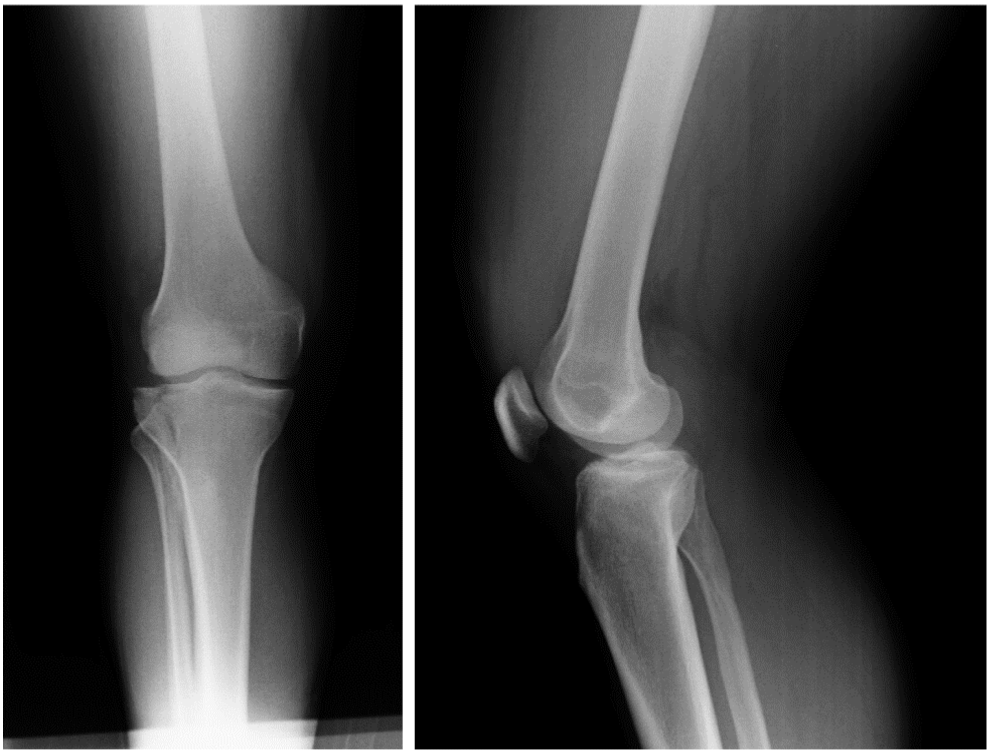
All patients were routinely examined via anterior-posterior and lateral radiography and computed tomography, and their fractures were classified according to the Schatzker system [12]. We operated on patients with clinical varus and valgus deformities and >4-mm displacement and/or depression; the surgical procedures are listed in **Table 1**. If necessary, blood transfusion and electrolyte replacement were provided, and preoperative prophylactic antibiotics were used in all cases. Additionally, low-molecular-weight heparin was used prophylactically to prevent thromboembolism in the pre/postoperative period. **Figures 1-6** demonstrate schatzker type 2 fracture in a 46-year-old patient treated with cannulated screws and grafting via lateral submenisceal arthrotomy.

After surgery, ice compression was applied to all patients for at least 48 hours postoperatively. Continuous Passive Motion Device (CPM) could not have been used since it was not available. The initiation of immediate knee joint ROM was intended for all patients, although 13 patients were unable to tolerate early knee joint ROM exercise during hospitalization. Therefore, we performed isotonic ankle and isometric quadriceps exercise for these 13 patients, as they could not tolerate passive or active knee flexion. For these patients, knee joint ROM exercises were performed at first control time (at fourth week after surgery) in physical therapy clinic by

Table 1. Operations and Schatzker fracture classification.

Operations	Schatzker fracture classification					
	Type 1	Type 2	Type 3	Type 4	Type 5	Type 6
Open reduction/screw, Buttress plate fixation	5	9	10	4	5	6
Grafting	-	4	10	1	2	1
LCL repair	-	-	-	1	1	1
MCL repair	-	1	-	-	-	-
Meniscal repair	-	1	1	2	1	1

LCL: lateral collateral ligament, MCL: medial collateral ligament.



(a) (b)

Figure 1. (a) Preoperative AP radiograph and (b) preoperative lateral radiograph of schatzker type 2 fracture in a 46-year-old male.

(a) (b)

Figure 2. (a) Postperative AP radiograph and (b) postoperative lateral radiograph of schatzker type 2 fracture in a 46-year-old male.

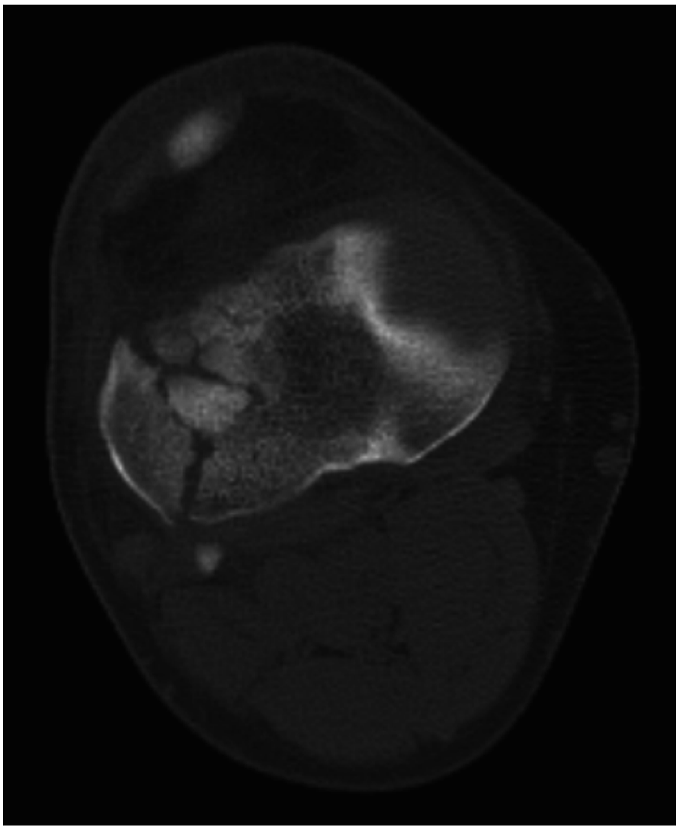
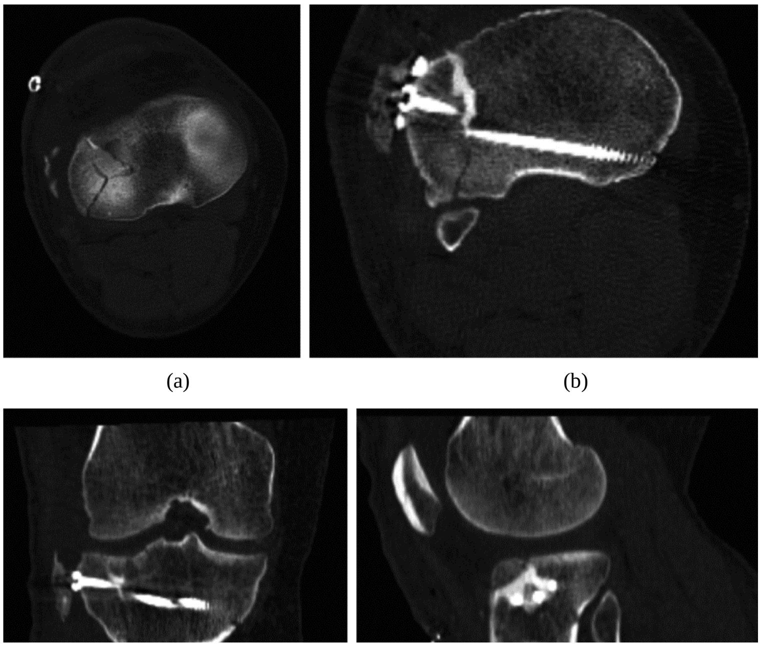


Figure 3. Preoperative transverse CT image of schatzker type 2 fracture in a 46-year-old male.



(a) (b)

(c) (d)

Figure 4. (a), (b) Postoperative transverse CT image, (c) postoperative coronal CT image, and (d) postoperative sagittal CT image of schatzker type 2 fracture in a 46-year-old male.

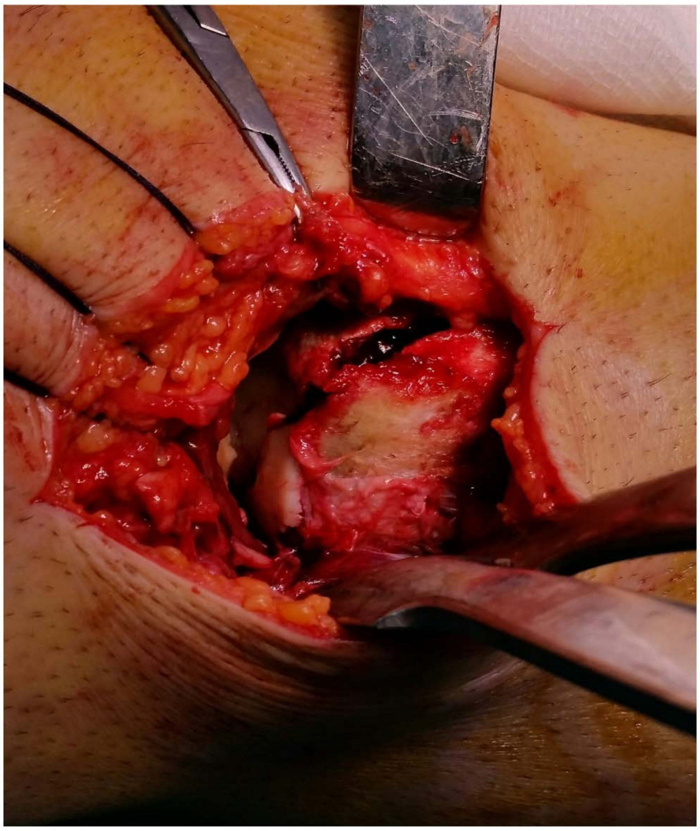


Figure 5. Lateral submenisceal arthrotomy of schatzker type 2 fracture in a 46-year-old male.

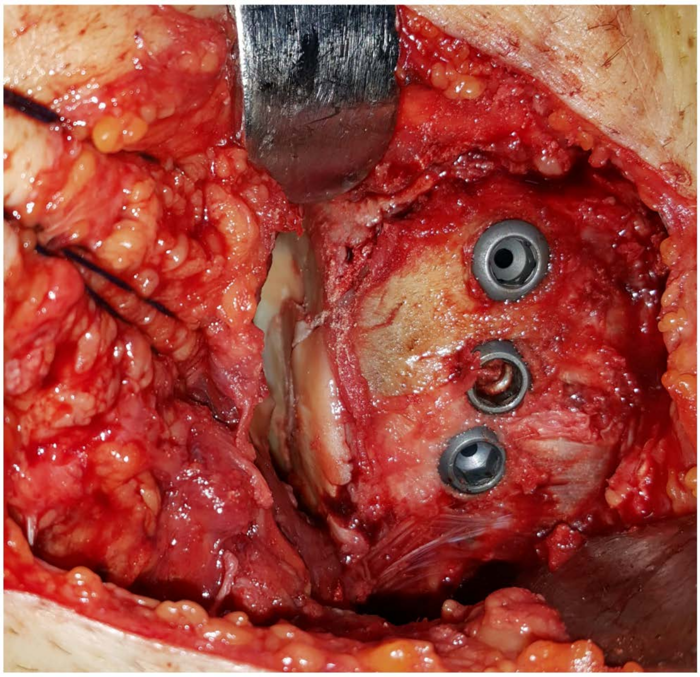


Figure 6. Lateral submeniscealarthrotomy cannulated screw fixation of schatzker type 2 fracture in a 46-year-old male.

physiotherapists. The remaining 26 patients began an immediate knee ROM program administered by physiotherapists. On the first postoperative day, isotonic ankle exercises and isometric quadriceps exercises were performed, and passive flexion was added on the second postoperative day. Assisted isotonic knee exercises were also added on a daily basis. All patients were advised home rehabilitation program. Immobilized patients were not advised to do passive and active ROM. Only isotonic ankle and isometric quadriceps exercises were advised to these 13 patients at home. All patients received a hinged knee brace for at least 6 weeks, weight bearing was begun in the twentieth postoperative week, and we aimed to achieve full weight bearing at the fourth postoperative month.

In the follow-up period, knee flexion was examined and the patients were evaluated according to the Rasmussen Clinic and Radiographic Scoring system at the final follow-up [15]. In the final analysis, the results achieved in the early motion group with those found in the immobilized group were compared.

Statistical Analysis

Logistic regression analysis was performed to determine the factors that affected the patients' ability to begin immediate knee ROM. A simple paired t-test was used to compare the degree of knee flexion in the early ROM group at first and fourth weeks after surgery. The Mann-Whitney U test was used to compare the knee flexion and Rasmussen scores for the early ROM and immobilization groups and for evaluating the effect of each fracture type on the patients' outcomes. Differences with a p-value of <0.05 were considered statistically significant, and SPSS software (version 21, SSPS Inc. Chicago, IL) was used for all analyses.

3. Results

Among the 39 patients (28 men and 11 women), the mean age was 41.6 years (range, 18 - 72 years). The causes of fracture included 22 traffic accidents, 11 falls from height, 2 sports injuries, 2 industrial accidents, and 2 falls from stairs. Surgery was performed after an average wait period of 3.5 days (range, 1 - 13 days), and the mean duration of hospitalization was 8.5 days (range, 4 - 24 days). The mean follow-up period was 2.7 years (range, 1.2 - 3.6 years).

According to the Schatzker system, 5 patients (13%) had type 1 fractures, 9 (23%) had type 2 fractures, 10 (26%) had type 3 fractures, 4 (10%) had type 4 fractures, 5 (15%) had type 5 fractures, and 6 patients (15%) had type 6 fractures. Furthermore, 2 patients had type 2 open fractures according to the Gustillo-Anderson classification.

Lateral submeniscal arthrotomy was used to evaluate the articular surface for 23 patients in whom reducing the articular surface was difficult. Six lateral meniscus injuries were diagnosed as peripheral. In addition, three medial collateral ligament (MCL) injuries, three lateral collateral ligament (LCL) injuries, and one anterior cruciate ligament (ACL) rupture were diagnosed. Among these, all meniscus and LCL lesions, and one MCL lesion were repaired. Two MCL lesions and one ACL lesion were treated conservatively. Soft tissue lesions were observed in 13 cases (33%). There were 26 patients who could tolerate early motion only three of them had lateral meniscus lesions treated surgically. On the other hand there were 13 patients who could not tolerate early motion, three of them had lateral meniscus lesions treated surgically, three of them had MCL lesions (one of them was conservatively treated and the remaining was treated surgically), three LCL lesions were surgically treated and one ACL lesion was conservatively treated. Overall there were three cases with soft tissue lesion in early ROM group and ten cases in immobilized group, respectively.

Based on our findings, whether the meniscus and ligament lesions, fracture type, age, or sex affected the patients' ability was evaluated to begin early ROM (**Table 2**). Only the presence of meniscus and ligament lesions significantly and negatively affected the patients' ability to initiate early movement ($p = 0.002$, Nagelkerke's R2 = 0.52). There was no documented hemarthrosis or application of joint aspiration in both groups.

In the early ROM group, knee flexion increased significantly between the first and fourth postoperative weeks (55.1˚ ± 9.1˚ vs. 87.5˚ ± 7.8˚, respectively; $p < 0.001$). At the twelfth postoperative week, knee flexion was significantly greater in the early ROM group than in the immobilization group (117.11˚ ± 6.62˚ vs. 104˚ ± 6.73˚, respectively; $p < 0.001$). The average time for painless full weight bearing was 16.4 (11 - 20) weeks in early ROM group and 17.1 (10 - 23) weeks in immobilized group, respectively. There was no difference in terms of healing time between the groups. After full healing, knee flexion in the early ROM group remained significantly greater than that in the immobilization group (130.42˚ ± 5.50˚ vs. 122.92˚ ± 5.28˚, respectively; $p < 0.001$). After

Table 2. The effect of various risk factors on the ability to initiate early knee joint ROM.

Risk factors	Statistical values	
	B	p-value
Meniscus and ligament injury	−2.947	0.002
Fracture type	0,106	0.728
Age	−0.020	0.638
Sex	−1.132	0.408
Constant	5,720	0,085

B: regression coefficient.

full healing, the Rasmussen Clinical score was significantly higher in the early ROM group than in the immobilization group (25.69 ± 2.92 vs. 22.61 ± 3.5, p = 0.004). There was no difference between the Rasmussen Radiological Scores of the groups.

In early ROM group 10 of 26 (38%) fractures and in immobilized group 4 of 13 (30%) were fixed only screws, respectively. The remaining fractures were fixed with plates and screws. There was no difference between the groups in terms of fixation methods.

Early stage superficial wound infections were observed in two patients. These infections were treated with dressing and antibiotics. Deep vein thrombosis was observed in two patients (including 1 case of pulmonary thromboembolism), both of these patients were successfully treated. In addition, one case of genu varum deformity with a Schatzker type 4 fracture was encountered, and for this patient, a proximal tibial osteotomy was planned after full healing. Pseudarthrosis was not observed in our study and also peroneal nerve lesions, popliteal artery injury, compartment syndrome were not observed.

4. Discussion

When treating tibial plateau fractures, the optimal surgical outcome is a stable and painless knee joint with full range of motion [1] [7] [16]. However, the severity of soft tissue injury directly correlates with the energy absorbed during the injury [17]. Furthermore, Schatzker type 2 and type 4 tibial plateau fractures are frequently associated with meniscal and ligament injuries [18]. Although ligament repair can prevent instability of the tibial plateau fracture [19] [20], acute repair of the ACL remains controversial [16] [21]. In our study, LCL injuries and one MCL injury were surgically repaired, while the ACL injury was treated conservatively. Kohut *et al*. reported that cartilage, meniscus, ligaments lesions and additionally post operative articular incongruity, axial abnormality and instability influenced the functional scores negatively [22].

Interestingly, varying prevalence (13% - 55%) is reported for meniscal lesions among cases of tibia plateau fracture [7] [23] [24]. Forman *et al*. used plain radiography, computed tomography, and submeniscal arthrotomy to evaluate patients with tibial plateau fractures, and reported that 55% of their cases involved meniscal lesions, and these authors also suggested that the depression amount was a predictor of meniscus lesions and with treatment of meniscus lesions, the outcomes would be similar to the others without meniscus injury [7]. Holt *et al*. reported that 47% of tibial plateau fracture cases included meniscus lesions [25]. They recommended MRI for planning treatment, as MRI more accurately diagnoses soft tissue injury and quantifies displacement and depression. Gardner *et al*. used MRI and found that the prevalence of soft tissue injuries was higher than that reported previously [26]. They also reported that Schatzker type 3 fractures were rare, as split components accompanied most cases. In this study, 6 (15%) meniscus lesions were repaired, which we evaluated via lateral submeniscal arthrotomy; ACL lesions were evaluated via direct visualization, while MCL and LCL lesions were evaluated by stress tests and/or direct visualization. However, MRI or arthroscopic assisted surgery was not used in the present study. Therefore, the rates of ligament and meniscal injuries may be relatively low in our study, compared to those previously reported. Moreover, our study only included patients who underwent open reduction and stable fixation, and more seriously injured patients (e.g., those requiring external fixation) were excluded. Furthermore, we could not report outcome for the meniscal lesions that were conservatively treated, as we did not examine the patients by MRI, and only did lateral submeniscal arthrotomy for the 23 patients.

Arthroscopic-assisted surgical procedures were widely used previously, as they facilitate easier diagnosis of intra-articular lesions [16]. In addition, arthroscopic-assisted techniques are minimally invasive and have a low morbidity risk [6] [16] [27]. To diagnose soft tissue injuries, MRI and arthroscopic assisted techniques are indeed useful. However, we could not use MRI and arthroscopy because of extra costs and availability issues. In addition, in cases with excessive edema around the soft tissues, MRI can provide inaccurate findings. Arthroscopy-assisted fixation has only been used effectively in simple fractures [27] and increases the operation time.

Surely, a stable knee is essential for the postoperative immediate motion, restoration of former knee function and reducing risk of secondary osteoarthritis in long term [9]. Many authors reported the advantage of early knee joint ROM after surgical treatment of tibial plateau fracture [1]-[3] [7]-[9] [11]-[25]. At postoperative first day, passive motion to 30˚ flexion is suggested and than it can be increased as tolerated. Active and active-assisted range of motion program should be added to the physical therapy afterwards. Via immediate postoperative ROM, 90˚ knee flexion is expected at first week and 120˚ flexion at first month, respectively. It is a fact that weight-bearing time depends on fracture healing and generally partial weight bearing begins at 8 - 12 weeks, full weight bearing is recommended between 12 - 16 weeks after surgery or generally after 16th week [28] [29].

This is a retrospective study and we evaluated the angular measurements and soft tissue pathologies from the hospital records. There may be another reasons for the patient's tolerability of immediate ROM, for example psychological status, painful bruise, etc. But interestingly the rate of soft tissue lesion existence was found by 77% (10/13) in immobilized group and 12% (3/26) in early motion group, respectively. Thus logistic regression analyses were done and soft tissue lesions were found that they affected the initiation of immediate ROM. Additionally these two groups had similar Rasmussen Radiographic scores at the final control.

There is a consensus that treatment of these soft tissue pathologies is needed to obtain a stable knee joint, achieve good functional results, and prevent development of osteoarthritis [9]. However, in this study, the mean follow-up time was 2.7 years (range, 1.2 - 3.6 years), therefore, development of osteoarthritis could not have been monitored.

In this study, we applied grafting to 18 patients (46%), including 7 who received iliac crest autografts and 11 who received allografts. The purpose of grafting depressed fractures is to provide good consolidation [12] [30].

Contracture of the knee is a major complication of surgical treatment for tibial plateau fracture, and early motion has been recommended to prevent contracture [19] [31]. However, reduction loss, implant insufficiency, and soft tissue impairment should also be considered.

Postoperative infection is an important complication occurring in 1% - 8% of all treated cases of tibial plateau fractures [32]. Early stage infection was observed in 2 patients, although these patients responded well to antibiotic treatment. In addition, deep vein thrombosis is the most common complication in cases of tibial plateau fractures [19] [33]. Although symptomatic deep vein thrombosis was observed in 2 patients (including 1 case of pulmonary thromboembolism), both patients were successfully treated. In addition, 1 case of genu varum deformity with a Schatzker type 4 fracture was encountered, and a proximal tibial osteotomy was planned after full healing. Delayed union, nonunion and pseudarthrosis were not observed in the present study. Moore *et al*. reported 3 peroneal nerve injuries in their series of 320 patients [32], peroneal nerve lesion, popliteal artery injury and compartment syndrome were not observed in this study.

5. Conclusion

Although there is no consensus regarding the appropriate diagnostic methods for soft tissue lesions, our results indicate that soft tissue lesions affect patients' ability to initiate immediate knee joint ROM, and this can subsequently affect their clinical outcomes. Therefore, stable fixation of fracture should be attempted in these cases, and meniscus and ligament injuries should be considered as prognostic factors.

Conflict of Interest

The authors claim that there exist no conflicts of interest.

References

[1] Timmers, T.K., van der Ven, D.J., de Vries, L.S. and van Olden, G.D. (2014) Functional Outcome after Tibial Plateau Fracture Osteosynthesis: A Mean Follow-Up of 6 Years. *The Knee*, **21**, 1210-1215.

http://dx.doi.org/10.1016/j.knee.2014.09.011

[2] Russell, N., Tamblyn, P. and Jaarsma, R. (2009) Tibial Plateau Fractures Treated with Plate Fixation: To Lock or Not to Lock. *European Journal of Orthopaedic Surgery & Traumatology*, **19**, 75-82. http://dx.doi.org/10.1007/s00590-008-0372-z

[3] Babis, G.C., Evangelopoulos, D.S., Kontovazenitis, P., Nikolopoulos, K. and Soucacos, P.N. (2011) High Energytibial Plateau Fractures Treated with Hybrid External Fixation. *Journal of Orthopaedic Surgery and Research*, **6**, 35. http://dx.doi.org/10.1186/1749-799X-6-35

[4] Markhardt, B.K., Gross, J.M. and Monu, J.U. (2009) Schatzker Classification of Tibial Plateau Fractures: Use of CT and MR Imaging Improves Assessment. *RadioGraphics*, **29**, 585-597. http://dx.doi.org/10.1148/rg.292085078

[5] Guanche, C.A. and Markman, A.W. (1993) Artroscopic Management of Tibial Plateau Fractures. *Arthroscopy*, **9**, 467-471. http://dx.doi.org/10.1016/S0749-8063(05)80324-X

[6] Vangsness Jr., C.T., Ghaderi, B., Hohl, M. and Moore, T.M. (1994) Arthroscopy of Meniscal Injuries with Tibial Plateau Fractures. *Journal of Bone and Joint Surgery*, **76**, 488-490. http://www.ncbi.nlm.nih.gov/pubmed/8175862

[7] Forman, J.M., Karia, R.J., Davidovitch, R.I. and Egol, K.A. (2013) Tibial Plateau Fractures with and without Meniscus Tear Results of a Standardized Treatment Protocol. *Bulletin of the Hospital for Joint Diseases*, **71**, 144-151. http://www.ncbi.nlm.nih.gov/pubmed/24032616

[8] Agnew, S.G. (1999) Tibial Plateau Fractures. *Operative Techniques in Orthopaedics*, **9**, 197-205. http://dx.doi.org/10.1016/S1048-6666(99)80018-4

[9] Rademakers, M.V., Kerkhoffs, G.M., Sierevelt, I.N., Raaymakers, E.L. and Marti, R.K. (2007) Operative Treatment of 109 Tibial Plateau Fractures: 5- to 27-Year Follow-Up Results. *Journal of Orthopaedic Trauma*, **21**, 5-10. http://dx.doi.org/10.1097/BOT.0b013e31802c5b51

[10] Mitchell, N. and Shepard, N. (1976) The Resurfacing of Adult Rabbit Articular Cartilage by Multiple Perforations through the Subchondral Bone. *Journal of Bone and Joint Surgery*, **58**, 230-233. http://www.ncbi.nlm.nih.gov/pubmed/56336

[11] Manidakis, N., Dosani, A., Dimitriou, R., Stengel, D., Matthews, S. and Giannoudis, P. (2010) Tibialplateau Fractures: Functional Outcome and Incidence of Osteoarthritis in 125 Cases. *International Orthopaedics*, **34**, 565-570. http://dx.doi.org/10.1007/s00264-009-0790-5

[12] Schatzker, J., McBroom, R. and Bruce, D. (1979) The Tibial Plateau Fracture. The Toronto Experience 1968-1975. *Clinical Orthopaedics and Related Research*, **138**, 94-104. http://www.ncbi.nlm.nih.gov/pubmed/445923

[13] Raza, H., Hashmi, P., Abbas, K., Hafeez, K. (2012) Minimally Invasive Plate Osteosynthesis for Tibial Plateau Fractures. *Journal of Orthopaedic Surgery* (*Hong Kong*), **20**, 42-47. http://www.ncbi.nlm.nih.gov/pubmed/22535810

[14] Volpin, G., Dowd, G.S., Stein, H. and Bentley, G. (1990) Degenerative Arthritis after Intraarticular Fractures of the Knee. Long-Term Results. *Journal of Bone and Joint Surgery*, **72**, 634-638. http://www.ncbi.nlm.nih.gov/pubmed/2380219

[15] Rasmussen, P.S. (1973) Tibial Condylar Fractures. Impairment of Knee Joint Stability as an Indication for Surgical Treatment. *Journal of Bone and Joint Surgery*, **55**, 1331-1350. http://www.ncbi.nlm.nih.gov/pubmed/4586086

[16] Burdin, G. (2013) Arthroscopic Management of Tibial Plateau Fractures: Surgical Technique. *Orthopaedics & Traumatology-Surgery & Research*, **99**, S208-S218. http://dx.doi.org/10.1016/j.otsr.2012.11.011

[17] Bennett, W.F. and Browner, B. (1994) Tibial Plateau Fractures: A Study of Associated Soft Tissue Injuries. *Journal of Orthopaedic Trauma*, **8**, 183-188. http://dx.doi.org/10.1097/00005131-199406000-00001

[18] Appley, A.A. (1979) Fractures of the Tibial Plateau. *Clinical Orthopeadics and Related Research*, **10**, 61-74.

[19] Honkonen, S.E. (1994) Indications for Surgical Treatment of Tibial Condyle Fractures. *Clinical Orthopaedics and Related Research*, **302**, 199- 205. http://dx.doi.org/10.1097/00003086-199405000-00031

[20] Watson, J.T. (1994) High-Energy Fractures of the Tibial Plateau. *Orthopedic Clinics of North America*, **25**, 723-752. http://www.ncbi.nlm.nih.gov/pubmed/8090483

[21] Vyrkus, W.W. and Helfet, D.L. (2001) Tibial Plateau Fractures. In: Insall, J.N. and Scott, W.N., Eds., *Surgery of the Knee*, Vol. 2, 3rd Edition, Churchill Livingston, Philadelphia, 1265-1289.

[22] Kohut, M. and Leyvraz, P.F. (1994) Cartilaginous, Meniscal and Ligamentous Lesions in the Prognosis of Tibial Plateau Fractures. *Acta Orthopaedica Belgica*, **60**, 81-88.

[23] Blokker, C.P., Rorabeck, C.H. and Bourne, R.B. (1984) Tibial Plateau Fractures. An Analysis of Treatment in 60 Patients. *Clinical Orthopaedics and Related Research*, **182**, 193-198. http://dx.doi.org/10.1097/00003086-198401000-00025

[24] Hohl, M. (1991) Fractures of the Proximal Tibial and Fibula. In: Rockwood, C.A., Green, D.P. and Bucholz, R.W.,

Eds., *Fracture in Adults*, Chap. 20, Part I, J.P. Lippincott Co., Philadelphia, 1725-1752.

[25] Holt, M.D., Williams, L.A. and Dent, C.M. (1995) MRI in the Management of Tibial Plateau Fractures. *Injury*, **26**, 595-599. http://dx.doi.org/10.1016/0020-1383(95)00109-M

[26] Gardner, M.J., Yacoubian, S., Geller, D., Suk, M., Mintz, D., Potter, H., *et al*. (2005) The Incidence of Soft Tissue Injury in Operative Tibial Plateau Fractures: A Magnetic Resonance Imaging Analysis of 103 Patients. *Journal of Orthopaedic Trauma*, **19**, 79-84. http://dx.doi.org/10.1097/00005131-200502000-00002

[27] Caspari, R.B., Hutton, P.M., Whipple, T.L. and Meyers, J.F. (1985) The Role of Arthroscopy in the Management of Tibial Plateau Fractures. *Arthroscopy*, **1**, 76-82. http://dx.doi.org/10.1016/S0749-8063(85)80035-9

[28] Roberts, J.M. (1968) Fractures of the Condyles of the Tibia. An Anatomical and Clinical End-Result Study of One Hundred Cases. *Journal of Bone and Joint Surgery*, **50**, 1505-1521. http://www.ncbi.nlm.nih.gov/pubmed/5722847

[29] Watson, J.T. and Wiss, D.A. (2001) Fractures of Proximal Tibia and Fibula. In: Rockwood, C., Green, D. and Bucholz, R., Eds., *Fractures in Adults*, 5th Edition, Lippincott Williams-Wilkins Company, Philadelphia, 1801-1806.

[30] Watson, J.T. and Schatzker, J. (1998) Tibial Plateau Fractures. In: Browner, B.D., Levine, A.M., Jupiter, J.B. and Trafton, P.G., Eds., *Skeletal Trauma*, Vol. 2, 2nd Edition, W.B. Saunders, Philadelphia, 2143-2186.

[31] Hohl, M. (1995) Complication of Tibial Plateau Fractures. In: Epps, C.H., Ed., *Complication in Orthopaedic Surgery*, Chap. 20.3, 3rd Edition, J.B. Lippincott Co., Philadelphia, 540-552.

[32] Moore, T.M., Patzakis, M.J. and Harvey, J.P. (1987) Tibial Plateau Fractures: Definition, Demographics, Treatment Rationale, and Long-Term Results of Closed Traction Management or Operative Reduction. *Journal of Orthopaedic Trauma*, **1**, 97-119. http://dx.doi.org/10.1097/00005131-198702010-00001

[33] Kuzgun, U., Özturk, İ. and Ordueri, M. (1991) The Results of Conservative and Surgical Treatment of Tibial Plateau Fractures. *Acta Orthopaedica et Traumatologica Turcica*, **25**, 391-393. http://www.aott.org.tr/article/viewFile/5000008694/5000008484