



Original Article

Effect of BMI on outcomes of surgical treatment for tibial plateau fractures: A comparative retrospective case series study

Yaşar Mahsut Dinçel^a, Ali Öner^{a,*}, Yavuz Arikan^a, Sever Çağlar^a, Raşit Özcafer^a, Mehmet Akif Güleç^b^a Baltalimanı Bone Diseases Education and Research Hospital, Istanbul, Turkey^b Bağcılar Education and Research Hospital, Istanbul, Turkey

ARTICLE INFO

Article history:

Received 5 May 2017

Received in revised form

29 December 2017

Accepted 26 January 2018

Available online 2 March 2018

Keywords:

Tibial plateau fractures

Risk factor

Body mass index

ABSTRACT

Purpose: Tibia plateau fracture (TPF) treatment aims at achieving a stable, aligned, mobile, painless knee and preventing post-traumatic osteoarthritis. To achieve this goal, surgeons consider criteria such as patients' characteristics, severity, risk of complications, fracture displacement/depression, degree of soft tissue injury. However, body mass index (BMI) is not considered as a risk factor in literature. Our study was conducted to find out any possible correlation between BMI and functional scores or radiological score separately.

Methods: Retrospective analysis of case series between 2011 and 2014 was done on the database of a tertiary hospital in Istanbul. There were 67 TPF patients (54 males, 13 females) in the study. Relationship between BMI and functional knee scores or radiological score was compared statistically. Closed fractures with both high-energy and low-energy injury were included in the study. Patients with open fracture, multi-trauma presence, meniscus and/or ligamentous injury, increased co-morbidity, inadequate records (25 cases in all) were excluded. Surgery type, Schatzker classification, injury side, trauma energy, and gender were considered as possible risk factors. Binary regression analysis was done for possible factors affecting functional knee scores and radiologic score.

Results: Model summary calculations were done as Nagelkerke R^2 test for Knee Society score, Lysholm knee score, and Ahlback and Rydberg radiologic scores, which were 0.648, 0.831, and 0.327 respectively. Homer–Lemeshow test values were 0.976, 0.998, and 0.362, respectively. There is negative correlation between BMI and both knee function scores. There is no correlation between BMI and radiologic score.

Conclusion: An increase in BMI has a negative effect on functional knee scores after surgical treatment of TPFs. Therefore, BMI should be considered as a risk factor for surgical treatment of TPFs.

© 2018 Daping Hospital and the Research Institute of Surgery of the Third Military Medical University.

Production and hosting by Elsevier B.V. This is an open access article under the CC BY-NC-ND license (<http://creativecommons.org/licenses/by-nc-nd/4.0/>).

Introduction

One of the most frequent intra-articular fractures is tibial plateau fracture (TPF), which usually arises due to high energy trauma. However, only 1% of all the fracture cases for whole population, and 8% of fracture cases in the elderly people are TPF.¹ These fractures cover a wide range of injury spectrum, consisting of variable degrees of joint incongruence and/or dislocation. Reconstruction of mechanic axis of lower extremity, ligamentous stability

and joint line; painless and full functional recovery are the purpose of the treatment in TPF.

Surgical treatment of TPF consists of three parts as follows: (1) simple medial and lateral tibial plateau fractures without joint depression can be treated by closed reduction and cannulated cancellous screws (CCS) or single buttress plating or in combination; (2) if joint depression or fracture displacement is obvious, open reduction and joint elevation and support with bone grafting will be necessary; (3) bilateral plateau fractures should be treated with double plating.

The body mass index (BMI) has different impact on different orthopaedic procedures. An increase in BMI leads to higher complication rates.^{2–4} However, there is a gap in literature about effect of BMI on surgical treatment of TPFs, comparing with obese

* Corresponding author.

E-mail address: iletisim@aliooner.com.tr (A. Öner).

Peer review under responsibility of Daping Hospital and the Research Institute of Surgery of the Third Military Medical University.

and normal BMI patients. Our study aims to evaluate presence of any correlation between BMI and functional or radiologic scores separately after surgical treatment.

Methods

After obtaining institutional review board approval, hospital database system was used to conduct a retrospective case-control study of patients who underwent open reduction with internal fixation (ORIF) of TPF from 2011 to 2014. Patient registry was reviewed for general demographics, mechanism of injury, associated injuries, fracture pattern, surgical procedure, and patients were called for last follow-up.

All patients >18 years old received TPF surgical treatment with internal fixation were collected. There were 95 patients in the database system. Closed fractures with both high-energy and low-energy injury were included in the study. Patients with open fracture, multi-trauma presence, meniscus and/or ligamentous injury, increased co-morbidity, inadequate records (25 cases in all) were excluded.

There were 70 patients in the study, 3 patients were lost to follow-up. Sixty-seven fracture patients were available for last functional and radiologic follow-up. Study population included 54 males, 13 females. Mean age at injury was 42.6 years (20–73). Sides of injury were 30 left, 37 right knees. Mean follow-up time is 3.7 years (2–6 years). All patients were grouped according to BMI as slim (<18.5), normal (18.5–25), overweight (25–30), obese class I (30–35), obese class II (35–40), and obese class III (>40). BMI distribution of patients were as 22 normal, 28 overweight, 11 obesity class I, and 5 obesity class II.

All the patients with TPF in the study received operation in 3–10 days after trauma, depends on soft tissue status. Medial and/or lateral proximal tibia anatomic locked plate and 6.5 mm diameter CCS were used, per fracture pattern. CCS were used in 3 of 35 patients in addition to lateral plate. CCS were used in 5 of 15 patients in addition to medial plate. Bilateral plates with double incision were used in 18 patients. Submeniscal arthrotomy was done in all cases for evaluation of meniscus and chondral injury, also physical examination was done for ligamentous injury after fracture fixation. Same side autologous iliac graft was used in all patients. Drain was adapted to all incisions. Long leg splint was applied to all patients after surgery.

At the end of second week, long leg splints and sutures were removed. Among the 67 patients in the study, 60 patients followed the rehabilitation clinic after suture removal, 7 patients who did not participate in hospital rehabilitation program due to personal issues were trained under the guidance of home rehabilitation program. Partial loading was allowed until observed radiological union.

Postoperative follow-up was carried out at 2 weeks, 6 weeks, 3 months, 6 months, 12 months, then annually, and called for last visit.

TPF classification was done according to Schatzker classification.⁵ Lysholm knee score (LKS) and Knee Society knee scoring system (KSS) were applied to both legs of all patients for functional results. Resnick and Niwayama's radiologic criteria (RNR) were used for radiologic results.⁶ Distribution of patients per LKS, KSS, and RNR are given in Table 1.

Knee anteroposterior and lateral view X-rays were studied in emergency room. Indication for surgery in TPF was more than 5 mm step in joint line or condylar widening more than 5 mm in clinic. If there was indication for surgery, computerized tomography of knee will be conducted to define extension, pattern and comminution of fracture, collapse and displacement of joint line.

IBM SPSS v21.0 (IBM Corp. Armonk, NY, USA) software was used for data analysis. Demographic parameters were expressed as mean. Surgery type, Schatzker classification, injury side, trauma

Table 1

Distribution of patients according to LKS and LKS functional and RNR radiologic scores.

Characteristics	Number
Lysholm Knee Score	
Perfect (>90)	34
Good (84–90)	15
Medium (65–83)	10
Bad (<65)	8
Knee Society Knee Score	
Perfect (80–100)	42
Good (70–79)	14
Medium (60–69)	5
Bad (<60)	6
Resnick and Niwayama Radiologic Criteria	
Grade 1	0
Grade 2	38
Grade 3	24
Grade 4	5

energy, and gender were considered as possible risk factors, given in Table 2. Binary regression analysis was done for possible factors affecting functional knee scores KSS, LKS and RNR radiologic score. Hosmer-Lemeshow test was studied for goodness of fit for the models. Nagelkerke R^2 test was performed for model summary control. All calculations were done for 95% confidence interval (CI).

Results

Mean follow-up time was 3.7 years (2–6 years). There was no neurovascular deficit in any of patients. Non-union was not seen and secondary surgery was not needed in any patients. Superficial wound infection was treated with antibiotics in 9 patients, 1 normal BMI, 6 overweight BMI and 2 obese BMI.

Possible risk factors effecting post-surgical functional knee scores and radiological outcome are described as surgery type, fracture type as Schatzker classification, fracture side, trauma energy, gender, and BMI. Binary regression analysis was done for KSS and LKS functional scores, and RNR radiologic outcome according to these variables (Tables 3–5). KSS and LKS for uninjured legs were perfect in all patients. Model summary calculations were done as Nagelkerke R^2 test, which were 0.648, 0.831, and 0.327 respectively

Table 2

Categorical variables' codings for regression analysis.

Items	Frequency	Parameter coding		
		(1)	(2)	(3)
Surgery Type				
Lat/Med with CCS	8	1	0	0
Lateral plate	32	0	1	0
Bilateral plate	17	0	0	1
Medial plate	10	0	0	0
Schatzker Classification				
Type 2	32	1	0	0
Type 4	15	0	1	0
Type 5	9	0	0	1
Type 6	11	0	0	0
Side				
Right	37	1		
Left	30	0		
Trauma Energy				
Low	16	1		
High	51	0		
Gender				
Male	54	1		
Female	13	0		

Lat/Med with CCS: Lateral or medial plate with cannulated cancellous screws.

Table 3
Variables in the equation for KSS.

Independent Variables	B	S.E.	Wald	df	Sig.	Exp(B)	95% CI for EXP(B)	
							Lower	Upper
Age	-.013	0.047	0.080	1	0.777	0.987	0.900	1.082
Gender	1.485	1.626	0.834	1	0.361	4.415	0.182	106.867
Schatzker								
Type 2			1.718	3	0.633			
Type 4	-12.690	21359.788	0.000	1	1.000	0.000	0.000	
Type 5	3.150	2.413	1.704	1	0.192	23.343	0.206	2645.292
Type 6	0.904	2.227	0.165	1	0.685	2.470	0.031	194.382
BMI	-.794	0.322	6.080	1	0.014	0.452	0.240	.850
Trauma								
Energy	1.878	1.570	1.430	1	0.232	6.538	0.301	141.908
Surgery								
Lat/Med with CCS			0.005	3	1.000			
Lateral plate	18.602	12542.056	0.000	1	0.999	119876887.814	0.000	
Bilateral plate	20.919	21359.788	0.000	1	0.999	1216637408.645	0.000	
Medial plate	0.145	2.082	0.005	1	0.944	1.157	0.020	68.453
Fracture								
Side	-1.663	1.343	1.533	1	0.216	0.190	0.014	2.636
Union								
Time	1.204	1.043	1.332	1	0.249	3.333	0.431	25.756
Constant	16.143	9.308	3.008	1	0.083	10253795.982		

Lat/Med with CCS: Lateral or medial plate with cannulated cancellous screws.

Table 4
Variables in the equation for LKS.

Independent Variables	B	S.E.	Wald	df	Sig.	Exp(B)	95% CI for EXP(B)	
							Lower	Upper
Age	-0.102	0.072	1.98	1	0.16	0.903	0.78	1.041
Gender	-0.003	1.911	0	1	1	0.997	0.02	42.222
Schatzker								
Type 2			3.6	3	0.31			
Type 4	21.19	15.228	1.94	1	0.16	1587288951	0	1.4555E+22
Type 5	15.92	10.549	2.28	1	0.13	8224311.45	0.01	7.8465E+15
Type 6	-2.563	2.252	1.3	1	0.26	0.077	0	6.366
BMI	-2.749	1.57	3.07	1	0.08	0.064	0	1.388
Trauma								
Energy	0.648	1.769	0.13	1	0.71	1.911	0.06	61.208
Surgery								
Lat/Med with CC			2.34	3	0.51			
Lateral plate	17.98	11777.63	0	1	1	64401719.7	0	.
Bilateral plate	14.03	9.176	2.34	1	0.13	1233852.04	0.02	7.9824E+13
Medial plate	3.843	3.327	1.33	1	0.25	46.688	0.07	31728.581
Fracture								
Side	2.239	1.585	1.99	1	0.16	9.38	0.42	209.703
Union								
Time	9.143	5.893	2.41	1	0.12	9351.682	0.09	970732966
Constant	28.38	14.298	3.94	1	0.05	2.1142E+12		

Lat/Med with CCS: Lateral or medial plate with cannulated cancellous screws.

(Table 6). Homer-Lemeshow test values were 0.976, 0.998, and 0.362, respectively. Binary regression analysis showed that BMI has negative correlation with both knee scores, however BMI and radiologic outcome has no correlation.

Discussion

Knee is one of the most important joints of the locomotor system, which is prone to injury. Without proper treatment, severe TPF leads to osteoarthritis. The main purposes of TPF treatment are to prevent from step in joint line, instability, angular deformity, and non-union; to provide pain-free full range of motion. Surgical treatment for TPF was studied by many authors and different opinions were expressed. Traction and early continuous passive movement were started and good results were declared by Marwah

et al⁷ and Apley⁸. Closed reduction and brace treatment with earlier mobilization was performed by different authors in literature.^{9–11} We used long leg casting for soft tissue healing until suture removal at 2nd week.

Mean age reported in literature is 55 years, 48 years, and 57 years in studies of Rasmussen,¹² Bowes and Hohl,¹³ and Schatzker,⁵ respectively. Mean age was 42.6 years (20–73 years) in our study, which is slightly younger than that in the literature. The possible reasons could be widespread use of motorcycle by young population, frequently drunk driving, and referral of trauma patients from secondary hospitals to the tertiary hospital.

Majority of heavy works are occupied by men, therefore TPF are more common in men, as stated in literature. TPF in women is increased with age secondary to osteoporosis; only 3 out of 13 female had osteoporosis-related fractures. The rest of the fractures happen

Table 5
Variables in the equation for RNR.

Independent Variables	B	S.E.	Wald	df	Sig.	Exp(B)	95% CI for EXP(B)	
							Lower	Upper
Age	−0.014	0.023	0.405	1	0.524	0.986	0.943	1.031
Gender	0.602	0.800	0.567	1	0.452	1.826	0.381	8.758
Schatzker								
Type 2			1.033	3	0.793			
Type 4	−1.217	2.796	0.190	1	0.663	0.296	0.001	71.001
Type 5	−0.125	1.578	0.006	1	0.937	0.883	0.040	19.471
Type 6	1.229	1.310	0.880	1	0.348	3.418	0.262	44.559
BMI	0.257	0.096	7.124	1	0.008	1.293	1.071	1.561
Trauma								
Energy	0.179	0.702	0.065	1	0.799	1.195	0.302	4.736
Surgery								
Lat/Med with CCS			1.687	3	0.640			
Lateral plate	−0.911	1.739	0.275	1	0.600	0.402	0.013	12.148
Bilateral plate	1.131	1.697	0.444	1	0.505	3.100	0.111	86.307
Medial plate	0.663	1.486	0.199	1	0.656	1.940	0.105	35.715
Fracture								
Side	−0.516	0.623	0.685	1	0.408	0.597	0.176	2.025
Union								
Time	−0.185	0.768	0.058	1	0.810	0.831	0.184	3.747
Constant	−6.431	4.623	1.935	1	0.164	0.002		

Lat/Med with CCS: Lateral or medial plate with cannulated cancellous screws.

Table 6
Hosmer–Lemeshov test for KSS, LKS, and RNR.

Items	−2 Log likelihood	Cox & Snell R Square	Nagelkerke R Square
KSS	25.629 ^a	0.369	0.648
LKS	22.009 ^b	0.579	0.831
RNR	72.921 ^c	0.244	0.327

^a Estimation terminated at iteration number 20 because maximum iterations has been reached. Final solution cannot be found.

^b Estimation terminated at iteration number 20 because maximum iterations has been reached. Final solution cannot be found.

^c Estimation terminated at iteration number 5 because parameter estimates changed by less than 0.001.

to women were high-energy trauma fractures. Osteoporosis-related fractures were less in our series than literature, maybe due to different sociocultural structure.

Distribution of TPF in lateral, medial and bicondylar plateau were 50%–75%, 10%–23%, and 20%–30%, respectively.^{5,12,13} Distribution of TPF in our study was 32 lateral (47%), 15 medial (22%), and 20 (29%) bicondylar plateau fractures which are similar to findings in literature. No correlation was found between age distribution and knee functional scores or radiologic criteria statistically. High and low energy trauma was seen in 51 (76.1%) and 16 (23.9%) TPFs, respectively. There was no correlation between trauma energy and knee functional scores or radiologic criteria statistically. However, prospective controlled studies are necessary to generalize these findings.

We found no relationship between fracture type and functional outcomes statistically. Also, no relationship between BMI and radiologic criteria was found. Fracture type and functional results are not related statistically in the study of Etel et al¹⁴ which is similar to our study. Therefore, functional outcome is more dependent on proper patient selection, good surgical technique, anatomic reduction and sound fixation of fracture, joint stability and postoperative rehabilitation than fracture classification. However, there was a negative correlation between BMI and both KSS and LKS functional scores. Patients with low BMI had better functional outcomes. Brennan et al¹³ stated that increase in BMI in the absence of trauma leads to osteoarthritis of large weight bearing joints. Also, Maheswari et al¹⁵ showed that SF-36 of obese

patients operated for femur or tibia fractures were worse than non-obese patients. In a study of Schatzker type 2 fractures, the group with worse radiologic and clinical outcomes were shown in obese patient group.⁴ These findings are similar to our study.

Obese people are at risk of maintaining their skin integrity due to many pathogenic factors. Also, obesity has serious medical comorbidities and several wound risk factors. Some of these factors are preventable, however others are not. Cellular and molecular alterations, oxidative stress, chronic low-grade inflammation, impaired vascularity, venous insufficiency, and nutrient deficiency are pathogenic factors that impair maintaining skin integrity.¹⁶ Cellular and molecular alterations due to metabolic complications cause chronic inflammation, which leads to impairment of wound healing. Cardiovascular changes in obese people cause reduced oxygenation and nutrient perfusion of wound, also decreased vascularity of hypertrophic subcutaneous adipose tissue leads to decreased oxygenation.¹⁷ Wound edge tension is usually seen in obese patient, which contributes to increased tissue pressure, which decreases microperfusion and oxygenation of tissues, and increases venous insufficiency. Malnourishment causes vitamin and mineral deficiencies, negative nitrogen balance, and low albumin levels, which all cause impaired metabolic cascades and wound healing.

Due to the factors mentioned above, obesity is associated with increased risk of wound dehiscence and superficial wound infection in orthopaedic surgery. Impact of obesity on complications and results in orthopaedic procedures is challenging.^{18,19} It is associated with an increased risk for infection in total hip replacement surgery.²⁰ Postoperative stay at the hospital is prolonged due to tendency to onset wound dehiscence during early postoperative period.²¹ There is not only surgical technique problems, but also rehabilitation problems seen with increased BMI.^{22,23} There were 9 patients with superficial wound infections, treated with antibiotic in our series without additional surgery. However, neither surgical technique problems, nor rehabilitation problems were seen in our series.

This study has a few limitations: retrospective design of the study; non-homogenous distribution due to small number of study population; lack of preoperative magnetic resonance imaging (MRI) evaluation. Due to small number of participants, data analysis for

each Schatzker type could not be done. Therefore, results of our study cannot be generalized for each Schatzker type. Preoperative MRI study could indicate possible cartilage, meniscus and ligament damage which all may lead to worse outcomes, therefore better inclusion - exclusion criteria could be applied to patients. Thus risk factor analysis could be done more accurately.

BMI is a risk factor for functional knee scores in surgical treatment of TPFs. Therefore, patients with increased BMI should be informed before surgical treatment about possible worse outcome. However, prospective, controlled, larger study populations are necessary for evaluation of effect of BMI on each Schatzker type.

Appendix A. Supplementary data

Supplementary data related to this article can be found at <https://doi.org/10.1016/j.cjtee.2017.10.005>.

References

- Hohl M. Part I: fractures of the proximal tibia and fibula. In: *Fractures in Adults*. 3rd ed. Philadelphia: J.B. Lippincott; 1991:1725–1761.
- Abidi NA, Dhawan S, Gruen GS, Vogt MT, Conti SF. Wound-healing risk factors after open reduction and internal fixation of calcaneal fractures. *Foot Ankle Int*. 1998;19:856–861. <https://doi.org/10.1177/107110079801901211>.
- Sitki Çeçen G, Kırdar Kartal Eğitim ve Araştırma Hastanesi L, ve Travmatoloji Kliniği O, Kırdar L. Effect of BMI on the clinical and radiological outcomes of pilon fractures. *Acta Orthop Traumatol Turcica*. 2014;48:570–575. <https://doi.org/10.3944/AOTT.2014.14.0073>.
- Çeçen GS, Gülabi D, Pehlivanoglu G, Elmali N, Teköz A. The impact of obesity on the outcomes of the patients operated on due to Schatzker type I and type II tibial plateau fractures. *Ulus Travma Acil Cerrahi Derg*. 2015;21:209–215.
- Schatzker J. Tibial plateau fractures. In: Browner B, Jupiter J, Levine A, eds. *Skeletal Trauma*. Philadelphia: WB Saunders; 1993:1745–1755.
- Resnick D, Niwayama G. In: Resnick D, Niwayama G, eds. *Diagnosis of Bone and Joint Disorders*. Philadelphia: WB Saunders; 1988.
- Marwah V, Gadegone WM, Magarkar DS. The treatment of fractures of the tibial plateau by skeletal traction and early mobilisation. *Int Orthop*. 1985;9:217–221.
- Apley A. Fractures of the lateral tibial condyle treated by skeletal traction and early immobilization. *J Bone Jt Surg*. 1956;38:699–712.
- Scotland T, Wardlaw D. The use of cast-bracing as treatment for fractures of the tibial plateau. *J Bone Joint Surg Br*. 1981;63B:575–578.
- Duvelius PJ, Connolly JF. Closed reduction of tibial plateau fractures. A comparison of functional and roentgenographic end results. *Clin Orthop Relat Res*. 1988;230:116–126.
- Brown GA, Sprague BL. Cast brace treatment of plateau and bicondylar fractures of the proximal tibia. *Clin Orthop Relat Res*. 1976;119:184–193.
- Rasmussen PS. Tibial condylar fractures. Impairment of knee joint stability as an indication for surgical treatment. *J Bone Joint Surg Am*. 1973;55:1331–1350.
- Bowes DN, Hohl M. Tibial condylar fractures. Evaluation of treatment and outcome. *Clin Orthop Relat Res*. 2011;171:104–108.
- Kayiran E, Orhan Z, Parmaksizoglu A, Erdemir A, Yazici N. Factors affecting the results of surgical treatment of tibial plateau fractures. *Acta Orthop Traumatol Turcica*. 2004;34:34–39.
- Maheshwari R, Mack CD, Kaufman RP, et al. Severity of injury and outcomes among obese trauma patients with fractures of the femur and tibia: a crash injury research and engineering network study. *J Orthop Trauma*. 2009;23:634–639. <https://doi.org/10.1097/BOT.0b013e3181a7f06c>.
- Ballesteros-Pomar MD. Wound risk and prevention in obesity: the role of nutrition. *EWMA J*. 2015;15:71–74.
- Pierpont YN, Dinh TP, Salas RE, et al. Obesity and surgical wound healing: a current review. *ISEN Obes*. 2014. <https://doi.org/10.1155/2014/638936>.
- Compston J, Flahive J, Hosmer D, et al. Relationship of weight, height, and body mass index with fracture risk at different sites in postmenopausal women: the global longitudinal study of osteoporosis in women (GLOW) HHS public access. *J Bone Min Res*. 2014;29:487–493. <https://doi.org/10.1002/jbmr.2051>.
- Karunakar MA, Shah SN, Jerabek S, Surgery J. Body mass index as a predictor of complications after operative treatment of acetabular fractures. *J Bone Jt Surg Am*. 2005;87:1498–1502. <https://doi.org/10.2106/JBJS.D.02258>.
- Everhart JS, Altneu E, Calhoun JH. Medical comorbidities are independent preoperative risk factors for surgical infection after total joint arthroplasty. *Clin Orthop Relat Res*. 2013;471:3112–3119. <https://doi.org/10.1007/s11999-013-2923-9>.
- Graves ML, Porter SE, Fagan BC, et al. Is obesity protective against wound healing complications in pilon Surgery? Soft tissue envelope and pilon fractures in the obese. *Orthopedics*. 2010;33, 555–555.
- Graves ML. Periarticular tibial fracture treatment in the obese population. *Orthop Clin North Am*. 2011;42:37–44. <https://doi.org/10.1016/j.jocl.2010.08.003>.
- Conde J, Scotecce M, López V, et al. Adipokines: novel players in rheumatic diseases. *Discov Med*. 2013;15:73–83.