RESEARCH ARTICLE

Conservative Management of Varus/Valgus Stable Tibial Plateau Fractures in Osteoporotic Bone – Preliminary Results and Considerations

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Abstract

Objectives: While operative fixation is the current recommendation for treating significantly displaced tibial plateau fractures (DTPFs) in elderly patients, our research suggests that non-operative management may also be a viable option as the primary treatment for these individuals. Our study aimed to evaluate the clinical outcomes of patients with complex DTPFs who received non-operative management as their primary management.

Methods: Our study involved a retrospective analysis of non-operatively treated DTPFs during the period of 2019 to 2020. We included all patients for the evaluation of fracture healing and range of motion (ROM). Additionally, we conducted functional outcome assessments on all patients, utilizing the Oxford Knee Score (OKS) both before their injury and at the 10-month mark after their injury.

Results: The study included 10 patients, comprising two males and eight females, with a mean age of 62.9 years (range: 46-74). Among them, four patients had Schatzker Type III DTPFs, two had Type V, and four had Type VI. Non-operative management was administered using hinged-knee braces, and patients progressed to weight-bearing gradually, with a minimum follow-up period of 10 months. The average time to bone union was 4.3 months (range: 2-7). The mean Oxford Knee Score (OKS) after the injury was 38.8 (range: 23-45), with an average reduction of 16.9% ($p = 0.003$). The average fracture depression was 11.41 mm (range: 4.2-29), and the average fracture split was 14.03 mm (range: 5.5-44).

Conclusion: Based on our study, it appears that elderly patients with significantly displaced tibial plateau fractures (DTPFs) can be treated non-operatively as their primary management, despite the current consensus suggesting otherwise.

Level of evidence: IV

Keywords: Elderly, Non-operative management Orthopaedic Surgery, Tibial plateau fractures

Introduction

DTPFs represent 8% of fractures in the elderly and are typically due to direct trauma or axial loading on the knee in valgus or varus.[1] With an increasing life expectancy worldwide, the rates of fragility fractures are rising.[2] The best treatment modality for DTPFs in the elderly remains controversial, however it has been shown that varus/valgus stable fractures with no associated injuries can be safely managed nonoperatively. The knee is a major weight-bearing joint so effective management of these fractures can restore mobility and minimise any reduction in quality of life.[2]

Young patients often present with high-energy fractures

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that require operative management to establish articular surface congruity and minimise risk of arthritis, whereas arthritis.[3] the low energy mechanism of injury seen in the elderly is usually due to age-related changes in the bone architecture. DTPFs in the elderly are further complicated by patient comorbidities, pre-existing osteoarthritis (OA), significant comminution at the fracture site with very few fixation amenable fragments as well as lower levels of preinjury functional and ambulatory status.[4]

The aim of this study was to assess the clinical and functional outcomes of complex DTPFs in patients who were initially planned for total knee replacement (TKR) around 6-8 weeks after the injury to allow for the fracture(s) to unite and permit the insertion of a stemmed tibia or normal tibial component without the need for any augments. However, these patients were treated non-operatively with serendipitous results.

elderly patients are more likely to present with low-energy, fragility fractures, many of whom have pre-existing

Materials and Methods

At a major trauma center, a review of the surgical database was conducted to identify all older adult patients with complex DTPFs who were treated between 2019 and 2020. Out of these patients, 10 were managed non-operatively as their primary form of treatment. The classifications systems used to classify the type of DTPFs included Schatzker, Hohl and Moore and AO/OTA. [5, 6] the fracture characteristics, clinical outcomes, and complications of all 10 patients were evaluated by reviewing their medical records. The patients' demographics and clinical details, as well as information on the fractures, are presented in [Table 1].

Table 1: Demographic data

Patient	Sex/Age/Side	Mechanism of Injury	Schatzker/ Hohl/ AO Classification	Associated Lesions	Complications
1	F/73/R	Falling tree branch landed onto knees	VI/II/41C1	Proximal fibula fracture	Varus and recurvatum malalignment with incongruent medial surface and some post-traumatic osteoarthritic changes
2	F/70/L	Kicked by a horse	III/IV/41B3		Slight valgus deformity
3	F/72/L	Tripped down stairs onto hard flooring	VI/II/41C1	Proximal fibula fracture	5° fixed flexion deformity
4	F/65/L	Tripped over dog onto concrete	III/IV/41B3		10° flexion deformity and valgus deformity of 5-10°
5	F/64/L	Collision with a cyclist	III/IV/41B3		Genu Valgum
6	F/56/R	Missed step, landed on knee	V/I/41B3		
7	F/46/L	Knee gave way whilst walking	III/IV/41B3	Avulsion of PCL	
8	M/55/R	Landed on concrete floor	V/IV/41B3	Proximal fibula fracture	
9	M/54/L	Motorcycle collision	VI/II/41C2	Open proximal fibula, Patella, Clavicle, Rib and Scapula fractureLiver laceration	Apex posterior deformity and slight varus deformity
10	F/74/R	Pedestrian hit by a car	VI/II/41C1	Spinal Fracture	

All patients were capable of independent ambulation and performing their daily activities before sustaining the injury. Of the 10 DTPFs, 9 were closed and 1 was open. All of them were varus/valgus stable with no associated neurovascular injury. Radiographs taken on the day of injury are shown in [Figures 1-10].

Possible predictive variables and clinical outcomes were analyzed for associations, and IBM SPSS Statistics was used for statistical analysis. The variables included the three different classifications of DTPFs, and a one-way ANOVA was conducted to compare the reduction in OKS at 4- and 10-months post-injury to pre-injury. An independent t-test was used to compare the reduction in OKS at 10 months post-injury to pre-injury. Statistical significance was set at

p < 0.05 in all cases

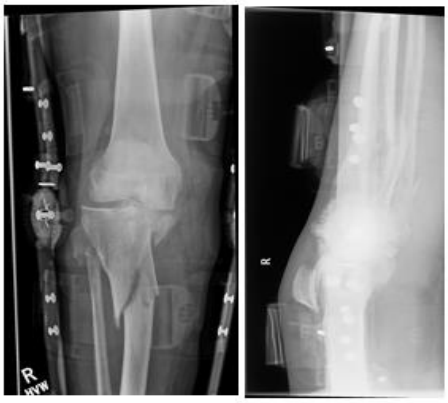

Fig 1. Radiographs on the day of the injury for Patient 1

Fig 2. Radiographs on the day of the injury for Patient 2

Fig 3. Radiographs on the day of the injury for Patient 3

Fig 4. Radiographs on the day of the injury for Patient 4

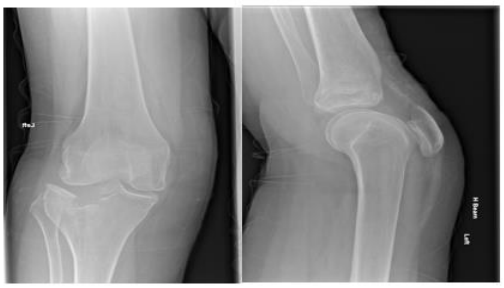

Fig 5. Radiographs on the day of the injury for Patient 5

Fig 6. Radiographs on the day of the injury for Patient 6

Fig 7. Radiographs on the day of the injury for Patient 7

Fig 8. Radiographs on the day of the injury for Patient 8

Fig 9. Radiographs on the day of the injury for Patient 9

Fig 10. Radiographs on the day of the injury for Patient 10

Treatment

After the injury, CT imaging was used to review the fractures and determine the appropriate management strategy. The consultant decided that fixation would not provide significant benefits due to fracture comminution and bone condition, so non-operative management was chosen for six to eight weeks to allow swelling to subside and for partial bone healing before performing a TKR. It was discovered that patients showed good functional recovery while awaiting their operations, so operative management was delayed. Patients with varus/valgus instability of the knee joint received a TKR, while others continued with conservative treatment. During the recovery period, patients had access to physiotherapy and were regularly monitored for pain, mobility, clinical and radiographic stability at follow-up appointments every four to six weeks. All patients had a minimum clinic follow-up of 10 months and were discussed in the knee multi-disciplinary team meetings.

Initially, all patients were treated in an above-knee back slab or cricket-pad splint, which was then replaced with a hinged knee brace as soon as possible. The brace was locked in 10 degrees of flexion, and patients were advised to gradually progress from non-weightbearing or toe-touch weightbearing for six weeks before gradually fully weight-bearing as tolerated. Venous thromboembolism risk was assessed at every clinic appointment and prescribed accordingly.

Functional outcome assessment was performed in all patients using the OKS system 10 months post-injury and retrospectively recorded for pre-injury. The OKS is a patient-reported outcomes measure (PROM) evolution tool that is validated for use by the National Joint Registry, UK. [7] To assess pain, knee function, and gait, subjective evaluations were conducted. [8] Radiological outcomes were evaluated through X-rays in AP-Lat views to look for fracture alignment and bone union time. To obtain unbiased functional outcomes, the OKS was verified by two reviewers.

Results

All 10 patients achieved bony union, with an average union time of 4.3 months (range: 2-7 months). The patients were followed up for an average of 18.7 months (range: 10-34 months). On average, patients reached partial weight bearing (PWB) at 8.3 weeks (range: 4-24 weeks) and full weight bearing (FWB) at 5 months (range: 2-9 months). The fractures had an average depression of 11.41 mm (range: 4.2-29 mm), an average split of 14.03 mm (range: 5.5-44 mm), and an average lateral translation of 8.41 mm (range: 3.8-14 mm). At 10 months post-injury, the average range of motion (ROM) from extension to flexion of the knee joint was 6.1-99° [Table 2]. [Table 1] summarizes the main complications and associated lesions observed, while [Figures 11-20] show radiographs taken 10 months after the initial injury [Figures 11-20].

The mean OKS before injury was 46.7 (Range: 43-48), whilst the mean OKS 10 months after injury was 38.8 (Range: 23-45). This reduction of 16.9% is statistically significant ($p = 0.003$). When comparing the reduction in OKS at 4- and 10-months post injury for the different Schatzker classifications, none had a statistically significant reduction, however it can be seen from [Table 3] that the OKS were improving in Schaetzker Type V and VI DTFs, whilst the OKS in Type III DTFs were getting worse [Table 3].

When analysing associations between the three different DTPFs classifications and clinical outcomes, there were none that were statistically significant [Table 4, 5 and 6]. However, follow up time increased as the Schatzker classification increased, whilst time to partial weight

bearing and full weight bearing increased as the Hohl and Moore classification increased.

Table 2. Clinical and Functional Outcomes

Patient	Bone Union Time (months)	Time to PWB (weeks)	Time to FWB (months)	ROM (extension-flexion) 10 months after injury	Depression (mm)	Split (mm)	Lateral Translation (mm)	OKS before injury	OKS 10 months after injury
1	5	6	5	20-50°	4.2	8	7.4	45	23
2	3	9	3	10-100°	8	5.5	11	48	44
3	3	7	4	5-105°	4.2	8	8	48	45
4	3	4	3	10-110°	12	6.8	4	48	44
5	2	4	6	0-110°	14	15	3.8	47	42
6	6	6	2	5-90°	8	12	7.3	47	40
7	5	5	9	5-100°	5.7	13	13	46	29
8	6	24	9	0-130°	16	16	7.6	43	41
9	7	12	4	0-100°	29	44	14	48	41
10	3	6	5	5-95°	13	12	8	47	39

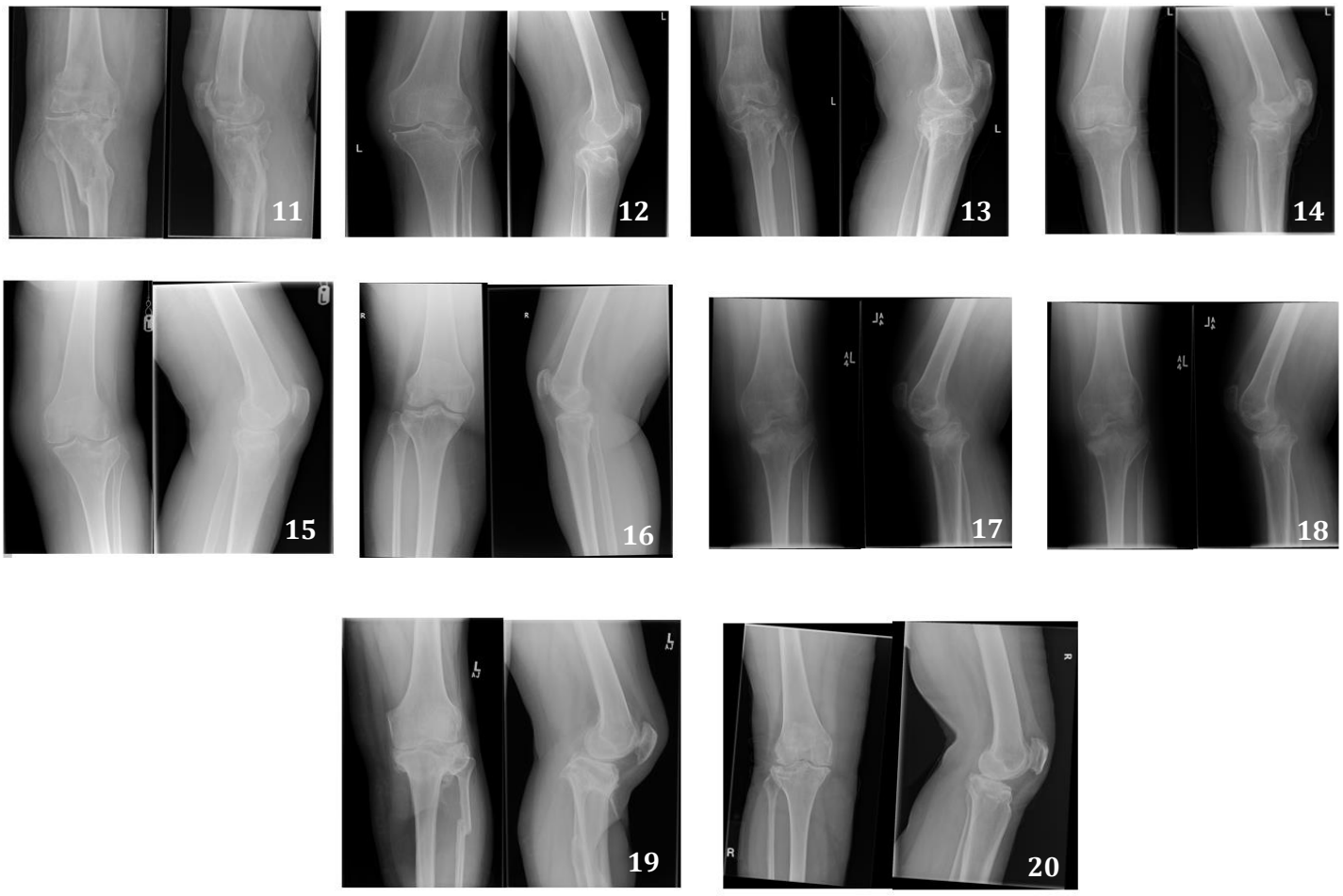

Fig 11. Radiographs at 10 months following the injury for Patient 1
Fig 12. Radiographs at 10 months following the injury for Patient 2
Fig 13. Radiographs at 10 months following the injury for Patient 3
Fig 14. Radiographs at 10 months following the injury for Patient 4
Fig 15. Radiographs at 10 months following the injury for Patient 5
Fig 16. Radiographs at 10 months following the injury for Patient 6
Fig 17. Radiographs at 10 months following the injury for Patient 7
Fig 18. Radiographs at 10 months following the injury for Patient 8
Fig 19. Radiographs at 10 months following the injury for Patient 9
Fig 20. Radiographs at 10 months following the injury for Patient 10

Table 3: Comparison of OKS before injury, at 4 months and 10 months post injury

Schatzker Classification	OKS before injury	OKS 4 months after injury	OKS 10 months after injury	*p*
III (n =4)	47.25	42.75	39.75	0.095
V (n = 2)	45	36.5	40.5	0.059
VI (n = 4)	47	35.5	37	0.115

Table 4: Comparison of clinical outcomes between different Schatzker classifications

	Schatzker Classification			
	III (n = 4)	V (n = 2)	VI (n = 4)	*p*
Follow up time (months)	13.75	16.5	26.7	0.292
Bone union time (months)	3.25	6	4.5	0.171
Time to PWB (weeks)	5.5	15	7.75	0.193
Time to FWB (months)	5.25	5.5	4.5	0.887
OKS 10 months after injury	39.75	40.5	37	0.269

Table 5: Comparison of clinical outcomes between different Hohl and Moore classifications

	Hohl and Moore Classification			
	I (n = 1)	II (n = 4)	IV (n = 5)	*p*
Follow up time (months)	10	26.7	15.6	0.269
Bone union time (months)	6	4.5	3.8	0.778
Time to PWB (weeks)	6	7.75	9.2	0.891
Time to FWB (months)	2	4.5	6	0.304
OKS 10 months after injury	40	37	40	0.423

Table 6: Comparison of clinical outcomes between different AO/OTA classifications

	AO/OTA Classification			
	41B3 (n = 6)	41C1 (n = 3)	41C2 (n = 1)	*p*
Follow up time (months)	14.67	28	24	0.291
Bone union time (months)	4.167	3.667	7	0.116
Time to PWB (weeks)	8.67	6.3	12	0.747
Time to FWB (months)	5.3	4.67	4	0.872
OKS 10 months after injury	40	35.67	41	0.150

Discussion

There is, to date, no published literature on the clinical outcomes of non-operative management of complex DTPFs that the authors are aware of. For this reason, our study is relevant and important, especially if we consider the huge socioeconomic impact that these injuries have on the elderly.

DTPFs are complex and associated with high complication rates, so caution must be taken regarding decisions about fracture management, especially in the elderly.[9-11] although open reduction internal fixation (ORIF) has been the mainstay of treatment for DTPFs in the elderly, if a TKR is needed in the future, it has been associated with both early and late complications. A study by Scott et al 12 showed that wound infection rates after a TKR was higher in the group which previously had an ORIF (n = 4/24) compared to the group which were initially treated conservatively (n = 0/7).

Recently there has been a role for non-operative management. Non-operative management is typically considered in laterally stable fractures as well as in patients with multiple morbidities that preclude any surgical intervention. We define "unstable fracture" as a varus/valgus unstable knee joint which is always reported by patients as soon as they start weight bearing. Non-operative treatment should aim to prevent permanent knee stiffness, by allowing for increased early ROM. Scharzker *et al's* [13] seminal paper shows that non-operative treatment in displaced, unstable DTPFs is associated with poor outcomes. Employing non-operative techniques has comparable outcomes to operative treatment in patients who are deemed eligible, however patients with pre-existing osteoporosis or osteoarthritis may require alternative treatments.[14]

There exists a multitude of non-surgical interventions that can be utilized for treating DTPFs in elderly patients. Hinged knee braces offer protection during weight bearing while allowing for a tolerable range of motion. In cases where patients are non-compliant, a cast with slight knee flexion may be utilized, though frequent skin examinations are necessary. While joint protection is crucial, early mobilization is also important.

To facilitate this, continuous passive motion machines are employed. Physical therapy is utilized to transition patients from passive assistance to active assistance and eventually to an active range of motion. [15]

Moreover, some studies have shown better functional results with non-operative management compared to surgery. Jensen et al [16] showed that early knee movement and traction produced significantly greater proportions of excellent or good clinical outcomes than with surgery. Additionally, the surgical group had significantly higher post-operative arthritis (POA) occurrence. However, the surgical group had a greater proportion of complicated fractures, so non-randomisation may be problematic for drawing conclusions from this paper. Additionally, mean hospital stay was significantly shorter for the surgical group (1 week versus 6 weeks for traction, p > 0.0001). This study by Jensen et al emphasises the conclusion that non-surgical management is an effective intervention, but should be reserved for varus/valgus stable DTPFs, or where surgery is undesirable. The greater complication rates described in the literature for elderly patients following surgery may lead to a greater likelihood of considering non-operative management. Further to this, Pean et al [17] showed different outcomes for use of bracing (with free ROM), depending on the indication for non-surgical care. Minimally displaced fractures had significantly better outcomes than those that

were surgically precluded; no significant difference in ROM was found. This study by Pean et al reported a 59% (n = 37) good or excellent evaluation of the knee using non-operative management. These findings support earlier conclusions that favour non-operative treatment of (varus/ valgus-) stable knees, irrespective of roentgenographic appearance.[18]

In our study, all patients presented with complex DTPF patterns and were discharged home to allow for fracture healing and swelling reduction before being considered for a TKR. Despite the plan for surgical intervention, non-operative management resulted in serendipitous improvements in function, with an average drop of 16.9% in OKS at 10 months. Williams et al examined over 1000 patients who underwent primary TKR for arthritis and found that their average OKS was 34.3 at one year post-operatively. [19] In contrast, the patients in our cohort reported an average OKS of 38.8 at 10 months post-injury, indicating that the decrease in function associated with the fracture was similar to what would have been expected if they had undergone a TKR.

However, we acknowledge that this treatment approach is suitable only for patients with stable osteoporotic fractures and adequate social care arrangements, and we recommend multidisciplinary team management with patient involvement at every stage. Long periods of non-weightbearing can be challenging for some patients, and we suggest close monitoring and considering the option of a TKR at each follow-up visit.

Our study has some limitations due to its retrospective nature, including a small sample size and a single centre study. Although the pre-injury OKS scores were collected retrospectively and may not accurately reflect the patients' exact scores at the time, they do demonstrate good pre-injury knee function in all patients.

Conclusion

To conclude, our study indicates that non-operative management can be a viable primary treatment option for elderly patients with varus/valgus stable DTPFs despite the current consensus.

This approach may prevent complications associated with ORIF, particularly in elderly patients, and potentially eliminate the need for surgery altogether.

Looking ahead, we intend to assess the long-term efficacy of non-operative management for complex DTPFs and its potential to delay or eliminate the need for TKR in the future.

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