IOSR Journal of Dental and Medical Sciences (IOSR-JDMS)
e-ISSN: 2279-0853, p-ISSN: 2279-0861.Volume 13, Issue 7 Ver. V (July. 2014), PP 45-52
www.iosrjournals.org

A Prospective analysis of the efficacy of JESS (Joshi's External Stabilizing System) fixator in management of complex tibial plateau fractures.

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Abstract:
Objective: *Complex tibial plateau fractures are caused by variety of mechanisms and have different fracture patterns, may be associated with soft tissue injuries, compartment syndrome, blistrations. Restoration of joint congruity, limb alignment, early range of motion, with a stable knee is difficult at times. We studied efficacy of JESS (Joshi's External Stabilizing System) with or without limited fixations in these complex tibial plateau fractures.*
Material and Methods: *32 patients of complex tibial plateau fractures (Schatzker type V and VI) associated with severe soft tissue injury, crushing , compartment syndrome were studied. All cases were treated by Joshi's External Stabilizing System with or without limited fixation by cannulated cancellous screws. Progress and complaints of the patients were recorded in accordance with Rick/Delamertier and Meason Hohl scoring system. Follow up of patients was at regular interval of 4 weeks for 6 months and thereafter 6 monthly.*
Results: *Out of 32 patients of complex tibial plateau fractures (23 Schatzker Type VI and 9 Type V) with mean age 37.47 (range 20-68) years had right knee injury (n=20) more than left knee (n=12). Mean interval period between injury and the surgery was 6.44 (range 3-16) days. Mean duration of hospital stay was 9.03 (range 5-25) days. Mean range of flexion was 112.19^0 (range 75^0-130^0), Extensor lag of 5^0-10^0 seen in 4 cases. 26 patients have no limitation in activity. Post operative complications like superficial / Pin tract infection in 7, deep infection in 1 and non-union in 1 case were observed. Excellent in 26, good in 4 and satisfactory results in 2 patients were observed in this study.*
Conclusion: *JESS (Joshi's External Stabilizing System) combined with limited fixation is a good alternative technique in management of complex tibial plateau fractures. This technique works on the principle of ligamentotaxis. JESS construct helps to take care of wound and dressings and permits early physiotherapy and range motion exercises.*
Key words: *Complex tibial plateau fractures; ligamentotaxis; jess fixator.*

I. Introduction

Knee is complex weight bearing joint, even small irregularities in articular surface or minimal instability lead to stiffness of knee with below normal range of motion. Treatment of complex condylar fractures of tibia is great challenge to orthopaedic surgeons as they are usually a result of high velocity trauma and associated with considerable soft tissue injuries requiring coverage, compartment syndrome, vascular injuries, ligaments and meniscal tears and eventually knee arthrosis [1], [2].These complex injuries are result of axial loading combined with valgus/varus forces [3]. These injuries severely affect selection of surgical procedure, treatment and poor outcomes occur in terms of infections, wound problems, articular collapse, joint stiffness and mal-alignment of the knee [4]. Casting and traction in these situations produce poor results. Aim of treatment is to restore joint anatomy, preserve knee functions and prevent late degenerative arthritis. Operative procedures are recommended to restore joint congruity, limb alignment and to allow early, stable knee motion. Open reduction and internal fixation of these complex fractures with unilateral or double plating further complicate situation as it devitalizes the tissues, skin and bone fragments.

High infection rates after open reduction and internal fixation on using plates are reported [5], [6]. Newer advancements and designs of internal and external fixation have modified techniques of fracture fixation.

Orthopaedic surgeon has to apply both his scientific analyzing abilities and technical expertise in treating them. Currently such injuries are being managed by variety of surgical techniques and implants varying from less invasive to extensive open reduction and internal / external, minimal fixation with or without arthroscopic assistance. Periarticular cancellous screw and kirschner wire fixation in complex intra-articular fractures help to restore anatomy and attain stable fixation allowing easy wound care, early joint mobilization with minimal soft tissue disruption [7]. We studied efficacy of JESS fixator with or without limited screw fixations based on principle of ligamentotaxis for management of such complex tibial plateau fractures.

II. Material And Methods

The study conducted at UP RIMS&R, Saifai, Etawah between April 2010 – June 2013 and total 32 patients of complex tibial plateau fractures selected and treated by JESS or JESS with limited screw fixation. The study included only Schatzker type V (bicondylar fracture pattern), Schatzker type VI (bi-condylar fracture with metaphyseo-diaphyseal dissociation) which were not associated with neuro vascular deficit, dislocation of knee, ipsi-lateral lower limb injury, any previous fracture / pathology or surgery, any previous history of neuro-muscular weakness (polio etc.).

These injuries were either compound (open) wounds or closed fractures with compartment syndrome or severe swelling, crushing, poor skin condition where other methods of fixations like plate / CC screw fixation or and plaster cast / open reduction and internal fixation at that point could not be not preferred [figure1].

Figure-1

Figure-1:Clinical photograph of patient with complex tibial plateau fracture showing blisterations, poor soft tissue and skin condition, managed with JESS, deferring routine plate osteosynthesis.

In these 32 patients JESS fixation with / without limited internal fixation with CC screw was done as associated soft tissue injuries did not affect the timing of percutaneous fixation.Pre operative immobilization by calcaneal skeletal traction and appropriate antibiotics given regularly for prophylaxis from infections. Antero-Posterior / Lateral view of X-rays, [figure2]

Figure 2

Figure – 2: Anteroposterior and lateral view of radiograph showing complex tibial plateau fracture (Schatzker type VI).

CT and MRI scan were done to assess the extent of associated injuries like ligament and meniscal tears, pattern of tibial plateau fractures, depression and articular comminution. We followed Schatzker staging system for classification for fracture in our study.

Implants:

- Kirschner wires (2mm, 2.5mm, 3mm)
- Connecting rods (3mm, 4mm)
- Z-rods (4mm)
- 4/4 Jess blocks
- 6.5mm cannulated cancellous screw

Technique

Reduction of comminuted fragments was achieved on traction table using principle of ligamentotaxis under image guidance. An articular incongruity >3mm indicated open reduction with limited incision. After achieving acceptable reduction and restoration of anatomy with k-wires of 2-3mm, 6.5mm cannulated cancellous screw were placed in juxtra articular bone to maintain reduction. Screw fixation worked as lag screw in centre of mid portion of condylar fragments perpendicular to fracture line to produce maximum compression. 3 K-wires (2.5mm) were inserted in juxtra articular bone parallel to articular surface at different angles. 3 K-wires (3mm) were placed parallel to each other in distal tibia fragment. Additional K-wires each in proximal and distal fragments were used to maintain mechanical axis and prevent rotation of fragments [figure-3]. Metaphyseo-diaphyseal comminution is spared, ligamentotaxis helps in restoration of anatomy and alignment [figure-4] .

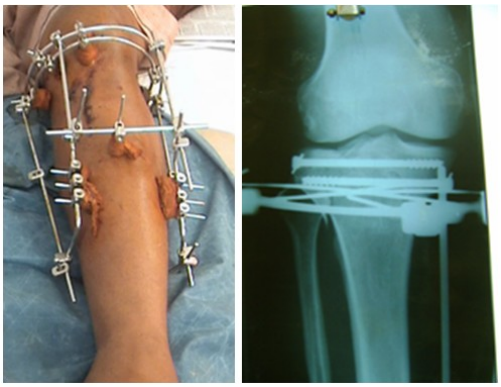

Figure 3: Clinical and radiological photograph showing restoration of mechanical axis , anatomical reduction, compression of condylar fragments with cannulated cancellous screws and stabilization with JESS.

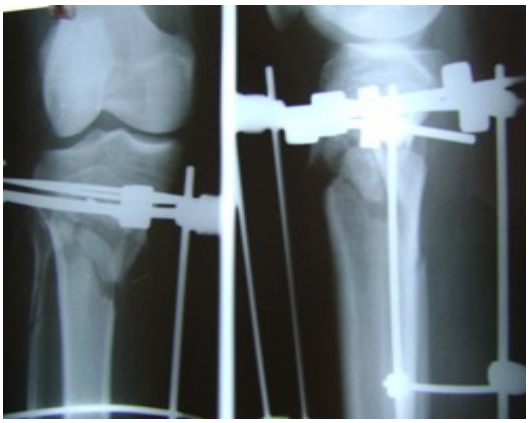

Figure 4: Postoperative antero-posterior and lateral radiograph showing alignment restoration, fracture fixation by fine kirschner wires with spanning area of metaphyseo-diaphyseal comminution through ligamentotaxis.

All these K-wires in proximal and distal fragments are, contacted to each other by JESS blocks and rods to make stable JESS construct.

Regular wound check and pin tract care, dressing done and appropriate antibiotics administered for prophylaxis of infection. Early range of motion exercises promoted as patients tolerance to pain [figure-5] . Partial weight bearing at 12 to 14 weeks and full weight bearing allowed after clinical or radiological union [figure-6] .

Fig.:5(a)

fig.:5(b)

Figure 5(a&b): Clinical photograph showing physiotherapy in early postoperative period.

Figure 6

Figure 6: Clinical photograph showing early weight bearing with JESS frame.

JESS construct removed after clinical or radiological union [figure-7]. PTB brace / support, sticks were given depending upon the requirement of the patients. Patients were followed up at regular interval of 4 weeks for initial 06 months and thereafter 06 monthly after removal of JESS [figure-8]. Progress and patient complains recorded in accordance with **Rick/Delamertier and Mason Hohl** scoring system.

Fig. 7(a)

Fig. 7(b)

Figure 7: Antero-posterior and lateral radiograph showing bony union (a), range of flexion (b) after removal of JESS at 20 weeks.

Fig.8(a)

fig.8(b)

Figure 8: Photograph showing radiological bony consolidation (a), functional range of motion (b) at 36 months follow up.

III. Observations And Result

Out of total 32 patients of complex tibia plateau fracture (Schatzker type V & VI) included were 9 open wounds (6 compound grade II, 3 compound grade III) and 23 closed injury tibial plateau fracture with poor skin condition, severe swelling, blisterations and compartment syndrome in 3 patients, managed with JESS construct alone or JESS construct with limited fixation with cannulated cancellous screws. Maximum patients (n=20) were young adults of 20-40 years age group with mean age 37.47 (range 20-68) years (table-1).

Table 1: Demographic distribution of age, day of presentation to hospital and occupation of patients.

Age			Day of presentation to hospital			Occupation		
Group	**No.**	**%**	**Duration**	**No.**	**%**	**Category**	**No.**	**%**
20-30	11	34.37	0- 1	10	31.25	Labour	7	21.87
31-40	9	28.12	2 – 3	11	34.37	Farmer	7	21.87
41-50	7	21.87	4 – 6	4	12.50	Housewife	1	3.12
51-60	4	12.50	7-10	5	15.62	Student	1	3.12
61-70	1	3.12	>10	2	6.25	Business/Service	16	50.00
Total	**32**	**100.00**	**Total**	**32**	**100**	**Total**	**32**	**100**

Male (n=28) patients greatly outnumbered female (n=4). Right knee injury (n=20) more common than left knee (n=12). Occupation wise service/business class (n=16) 50% sustained high tibial plateau fracture followed by labour and farmer class (n=7) each. This high energy trauma was mainly due to road traffic accidents (n=28) and fall from height (n=4). Type VI Schatzker fracture pattern (n=23) was more observed than Schatzker type V (n=9) [table-2].

Table-2: Demographic distribution of sex, pattern of injury and mode of injury in patients.

Sex			Pattern of Injury									Mode of injury		
Group	**No.**	**%**	**Type**	**No.**	**%**	**Side**	**No.**	**%**	**Type**	**No.**	**%**	**Group**	**No.**	**%**
Male	28	87.50	Simple (closed)	23	71.87	Right	20	62.50	Schatzker V	9	28.12	RTA	28	87.50
Female	4	12.50	Compound (open)	9	28.12	Left	12	37.50	Schatzker VI	23	71.87	Fall from height	4	12.50
Total	32	100	Total	32	100	Total	32	100	Total	32	100	Total	32	100

On statistical analysis of data [table-3], we observed after injury mean time of patient presentation to hospital was 3.50 (range 1- 12) days. Mean interval period between injury and surgery was 6.44 (range 3-16) days. Mean duration of hospital stay was 9.03 (range 5-25) days. The mean interval between surgery and weight bearing was 13.78 (range 12-17) weeks.

Table-3: Statistical analysis of significant variables

Variables	Mean	Range	Mean ± SD	SEM	CI (95%)
Age (years)	37.47	20 – 68	37.47±12.29	2.17	33.04 - 41.90
Day of presentation to hospital (days)	3.50	1 – 12	3.50±3.03	0.54	2.03 - 4.97
Duration between injury and surgery (days)	6.44	3 – 16	6.44±3.41	0.60	5.21 - 7.67
Duration of hospital stay (days)	9.03	5 – 25	9.03±4.10	0.72	7.55 - 10.51
Range of flexion (degrees)	112.19	75 – 130	112.19±14.31	2.53	107.03-117.35
Time of weight bearing (weeks)	13.78	12 – 17	13.78±1.48	0.26	13.25 - 14.31

Abbreviations: SD-Standard Deviation, SEM-Standard Error of Mean, CI-Confidence Interval.

Surgical interventions were delayed mainly due to poor soft tissue condition, impending compartment syndrome and due to delay in presentation to hospital. Fasciotomy in 4 patients and blood transfusion in 6 patients was required. Transfusion of blood was mainly required in open wound cases. Mean follow up of patient was 16 (range 6 – 36) months. Soft tissue coverage was required in 2 cases.

The functional outcomes were recorded in accordance with **Rick/Delamertier and Mason Hohl** scoring system (table-4).

Table - 4: Functional outcomes in accordance to Rick/Delamertier and Mason Hohl scoring system.

Functional Outcomes	Range	Score	n= number of patients	Percentage(%)
Pain	Nil	30	18	56.2
	Occasionally	25	9	28.1
	Over pin tract	20	4	12.5
	During walking	15	1	3.1
Function (Movements)	Movement $\geq 120^0$	30	15	46.9
	$120^0 – 90^0$	25	15	46.9
	$90^0 – 60^0$	20	2	6.2
	$< 60^0$	15	0	0.0
Activity	No Limitation	15	26	81.2
	Limited to walking	10	5	15.6
	Assistance required	05	1	3.1
Infection	Nil	05	24	75.0
	Superficial	03	7	21.9
	Deep	01	1	3.1
Loss of extension	Nil	05	28	87.5
	$<10^0$	03	4	12.5
	$>10^0$	01	0	0.0
Instability	Nil	05	26	81.2
	ACL or MCL or both	03	6	18.8
	2 & PCL	01	0	0.0
Radiological Outcomes				
Collapse of articular surface (Change in varus angle)	$<5^0$	15	25	78.1
	$5 – 10^0$	10	7	21.9
	$>10^0$	05	0	0.0
Varus angle (Residual)	$<10^0$	20	26	81.2
	$10 – 15^0$	15	6	18.8
	$15 – 20^0$	10	0	0.0
	$>20^0$	05	0	0.0
GRADING				
Total Score	Excellent (E)	100 – 125	26	81.2
	Good (G)	90 – 100	4	12.5
	Satisfactory (S)	80 – 90	2	6.2
	Fair (F)	70 – 80	0	0.0
	Poor (P)	< 70	0	0.0

No or occasional pain was observed in 27 patients, 5 had pain over pin tract. Mean range of flexion 112.19^0 (range 75^0-130^0) and extension lag of 5^0-10^0 was observed in 4 cases. No limitation of activity in 26 cases, limited to walking in 5, assistance in activity was required in 1 case. Collapse of articular surface (change in varus angle) $< 5^0$ in 25 cases and 5^0-10^0 in 7 cases were seen. 24 patients had no infection and superficial/pin tract infection in 7 cases, deep infection in 1 and non-union in 1 was observed. The non-union was observed in diaphyseal region requiring bone grafting and fixation. Post operative complications like myositis ossificans, peroneal nerve palsy, pulmonary embolism, deep vein thrombosis were not observed. Excellent results in 26, good in 4 and satisfactory results in 2 patients were observed.

IV. Discussion

Proximal tibia fractures are caused by variety of mechanisms. Treatment of complex tibial plateau fractures and irregularities in articular surfaces or minimal instability following a injury is difficult in terms of restoring function, union and correcting anatomy. These fractures are usually a result of high velocity trauma and are frequently associated with significant articular depression displacements, metaphysio-diaphyseal dissociation [3]. Open wounds or extensive closed soft tissue injury to proximal tibia adds to challenges in adopting surgical procedure. Bracing, casting or tractions have not given optimal results [8]. Unicondylar tibia / lateral condyle fixation or limited C.C. Screw fixations have not been able to provide rigid fixation and resulted in collapse of unsupported tibial plateau condyle producing deformity and instability with loss of functional range of motion later [9]. Spanning fixators restrict the early movements and articular healing [10]. Open reduction and Internal fixation with dual plating techniques have high deep infection rate (80%) in complex bicondylar plateau fracture as large amount of soft tissue stripping is required for plate fixation to achieve rigid fixation [5],[11],[12],[13]. 23% infection rate with dual plating of bicondylar fractures [5],[12]. 87.5% deep infection and 100% complication rate for comminuted or bicondylar plateau fracture [13]. 12% infection rate in ring fixator [6].

High infection rate have been reduced with minimal invasive, indirect reduction and limited surgical techniques for restoration of joint congruity by hybrid or fine wire fixation and spanning of meta- diaphyseal fracture [14],[15],[16],[17],[18]. Management of complex tibial plateau fractures with limited internal fixation and external fixator is satisfactory technique [16]. Concept of spanning area of fracture comminution to achieve indirect fracture reduction and limited internal fixation have decreased infection rates and increased fracture healing. Less invasive technique and procedure provide stable fixation to fracture fragments, restored anatomy and permit early mobilization and help to prevent further soft tissue injury and easy wound care is possible [19]. JESS fixation works on the principle of ligamentotaxis to help achieve and restore articular congruity in both sagittal and coronel planes, metaphysio-diaphyseal alignment, when used with or without cancellous screw [20],[21],[22],[23].

Ligamentotaxis helps in closed anatomical reduction of fracture fragments and limited open reduction and fixation with cancellous screws minimizes further soft tissue damage. Screws placed in lag fashion helps to compress the fractured condyles, support subchondral bone and prevent further articular collapse. JESS combined with cancellous screws has optimal metaphyseal purchase, helps to allow early physiotherapy and weight bearing.

JESS is minimally invasive technique with shorter operating time, requiring no or limited incision. Blood loss is less, hospital stay is shorter. JESS also has lower rates of infection/complications with added advantages of better and easy wound care, good patient compliance at lower cost.

V. Conclusion

JESS (Joshi's External Stabilizing System) construct as an external fixator fulfills the requirement of optimal surgical treatment of these complex high energy tibial plateau fractures combined with limited peri-articular internal fixation with cancellous screws.

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