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A detailed statistical analysis of tibia plateau fractures treated with locking tibia plate: A study of 63 cases

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Abstract
Objectives: To evaluate the results of locking plate system for tibia plateau fractures by detailed stastical analysis.
Materials and Methods: A cohort of 63 tibia plateau fractures, surgically treated, from July 2013 to December 2015, was reviewed with a minimum 6 months up to maximum 2 years. Fractures were classified according the Schatzker classification. The assessment of the functional outcome was done with the use of the modified Rasmussen's clinical and radiological score.
Results: According to modified Rasmussen's scoring system, 40% patients had excellent results, 39% had good results, 11% had fair results and 10% had poor results (Combined clinical & Radiological Results).
Conclusions: The significant analysis was, 1: We found no difference in time for union between open reduction and MIPPO. In our study, time to union was independent of surgical method used & 2: We found no difference in time for union between open and closed fractures.

Keywords: Surgically, Schatzker, Rasmussen's

1. Introduction
Low and high-energy tibial plateau fractures usually result from axial loading in combination with varus/valgus stress forces, present a variety of soft tissue and bony injuries that can produce permanent disabilities and their treatment is often challenged by severe fracture comminution, instability, displacement and extensive soft tissue injuries.
The objectives of surgical management are precise reconstruction of the articular surfaces, stable fragment fixation, normal limb alignment, repair of all concomitant ligamentous and other soft tissue lesions and early mobilization with functional range of knee motion.
The purpose of this study was to evaluate the outcome of lateral locking plates used in tibia plateau fractures in terms of union, complications and functional outcome of patients.

2. Aims and Objectives
This study was taken up with the following aims:
- To study the early (minimum 6 months follow-up) results of tibia plateau fractures fixed with locking tibia plate.
- To apply appropriate stastical test for every aspect of functional outcome following operative procedure.

3. Materials and Methods
This study was carried out at Tertiary Care Hospital from July 2013 to December 2015, inclusive of both. During this period, 86 patients with proximal tibia fractures were identified of which 74 patients were enrolled in the study based on the inclusion and exclusion criteria. With 11 patients being lost to follow-up during the course of study before completing at least 6 months of follow-up, we had 63 patients remaining to study. Three fractures of type IV Schatzker were fixed with medial buttress and hence were not included in the final analysis.
This study was mainly an observational prospective study. However, data for some patients

(n = 31) was collected retrospectively from available medical records. Such patients were followed up prospectively for a minimum of six months post-operative time.

3.1 Inclusion Criteria of our study were

- All the fractures of the tibia plateau with intra articular extension, with recent (<4 weeks) history of trauma.
- Closed fractures, open grade I and open grade II fractures were included.

3.2 Exclusion Criteria of our study were:

- Pathological fractures
- Fractures in children (< 18 years)
- Old neglected fractures
- Pregnant females
- All open grade III fractures
- Crush injuries
- Previously operated Fractures
- Fractures with existing or impending compartment syndrome
- Neurological problems (local or general) which could affect the functional outcome assessment.

3.3 Results, Statistical Analysis and Its Discussion

We analysed our results using,

- Descriptive statistical methods
- Tabulation and graphs
- Mean
- Chi-square test
- Significance of difference between Mean using

Significant p value <0.05

The analysis was done in reference to
(A) Surgical methods *with*
(I)Fracture classification
(II)Additional procedure
(III)Hospital stay

(B) Time of Union *with*
(I)Surgical Method
(II)Fracture type (open/close)
(III)Fracture classification

(C) Knee range of motion *with*
(I)Injury surgery interval
(II)Articular depression
(III)Radiological score

(D) Functional analysis *with*
(I)Pain
(II)Sitting and squatting
(III)Walking ability

(E) Analysis of Results *with*
(I)Age
(II)Types of injury
(III)Classification
(IV)Surgical method
(V)Injury surgery interval
(VI)Comparing clinical and radiological results

(A)Analysis of Surgical methods

(I) Surgical method with Fracture classification:

- Patients in this study were operated by either open reduction or MIPPO.

Table 1

Method	Patients	Percentage (%)
Open reduction and fixation	22	34.92
Closed and MIPPO	41	65.08
Total	63	100

Surgical method

3.4 Selection of MIPPO or Open reduction (Test for difference between two proportions)

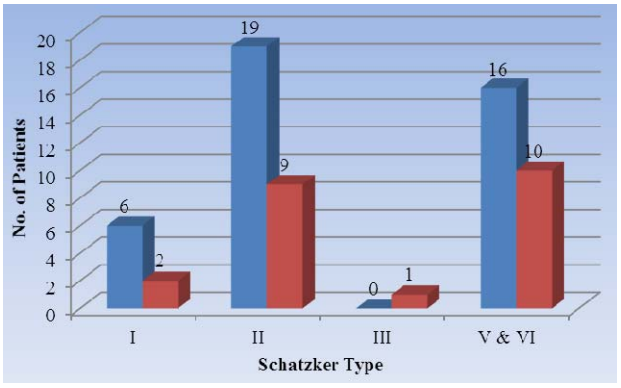
Difference - 30.240%
95% CI - 7.552% to 49.863%
Test Result - 6.701
DF - 1
Significance level P = 0.0096 (<0.05)

3.5 Interpretation: There is significant difference in between selection of method. MIPPO selection was deliberation rather than just due by chance or random selection.

Table 2

Schatzker Type	MIPPO	Open reduction	Total
I	6	2	8
II	19	9	28
III	0	1	1
IV & V	16	10	26
Total	41	22	63

Schatzker type and reduction technique



3.6 Schatzker type and reduction technique

- Both MIPPO and open reduction were done in all varieties of fractures.
- As there is no role of MIPPO in type III fracture, that case was treated by open reduction.
- Not all fracture of tibia plateau can be treated by MIPPO. In our study a significant (35%) group of patients of type II and V & VI required open reduction.

(II) Surgical method with Additional procedure:

- The additional procedures were required in 14 patients.
- The following table shows distribution of patients in MIPPO and open reduction with reference to additional procedures:

Table 3

Schatzker's classification Type	No additional procedure		Additional procedure done		Total
	(MIPPO)	(Open)	(MIPPO)	(Open)	
I	6	2	0	0	8
II	18	9	1	0	28
III	0	1	0	0	1
V & VI	7	6	9	4	26
Total	**31**	**18**	**10**	**4**	**63**

3.7 Additional procedures and reduction technique

- Out of 22 patients treated by open reduction, only 4 required additional procedures but at the same time out of 41 patients treated by MIPPO, 10 required additional procedure.
- As seen from above table, additional procedures (like medial plating, lag screw, revision plating, implant removal etc.) were commonly required in type V & VI varieties of fractures (13 out of 26).

(III) Surgical method with Hospital stay

- Table 2 shows that analysis of surgical method with reference to hospital stay.

Table 4

Method	Mean Hospital Stay(days)	Patients
Open	11.73	22
MIPPO	10.85	41
p value	0.8090	63

Methods and Hospital stay

3.8 Method versus Hospital stay

Difference	=	0.5776
Standard Error	=	2.3751
95% CI of difference	=	-4.2123 to 5.3674
Test statistic t	=	0.243
Two-tailed probability P	=	0.8090 (> 0.05)

3.9 Interpretation: The difference in hospital stay with regards to surgical method was not significant. Hence, we concluded that the type of surgical method used does not affect hospital stay of patients.

(B)Analysis of Time of Union

(I) Time of Union with Surgical method:

- The mean time to union with open reduction was 15.067 (95% CI – 11.64 to18.49) weeks.
- The mean time to union in MIPPO was 11.714(95% CI - 9.965 to13.464) weeks.

Table 5

Method	Mean time of Union(weeks)	Patients
Open	15.067	22
MIPPO	11.714	41
p value	0.3115	**63**

Method with time for union

3.10 Method versus Union

Chi-square test	=	1.024
Degrees of Freedom (DF)	=	1
Two-tailed probability P	=	0.3115 (>0.05)

3.11 Interpretation: We found no difference in time for union between open reduction and MIPPO. In our study, time to union was independent of surgical method used.

(II) Time of Union with Fracture type (open/close):

- Mean time of union for Open fractures – 16.4 (95% CI – 6.07 to 26.08) weeks.
- Mean time of union for Closed fractures –12.42 (95% CI – 10.42 to14.02) weeks.

Table 6

Type of fracture	Mean time of Union(weeks)	Patients
Open	16.4 weeks	7
Close	12.42 weeks	56
p value	0.1179	63

Type of fracture with time for union

3.12 Method versus Union

Difference	=3.9789
Standard Error	=2.4914
95% CI of difference	=-1.0525 to 9.0104
Test statistic t	=1.597
Two-tailed probability P	= 0.11799(>0.05)

3.13 Interpretation: We found no difference in time for union between open and closed fractures.

(III) Time of Union with Fracture Classification

Table 7

Schatzker Type	Mean time of Union(weeks)	No. of Patients
I	11.2	8
II	10	28
III	14	1
V & VI	16.33	26
Total	-	63

3.14 Schatzker type with Union time

- We did not have enough patients in each type to test the significance. However, we found grossly that average time to union was more in type V & VI fractures.

(C)Analysis of Knee range of motion

- The mean range of knee flexion and extension at follow-up is shown in the table below :

Table 8

Follow-up (weeks)	Mean loss of Extension	Mean range of flexion
4	37.67	78.48
8	28.37	88.25
12	18.72	100.58
16	8.83	105.58
20	7.32	109.88
24	7.20	112.79

3.15 Progression of range of motion following surgery

- Three patients developed significant post-operative stiffness.
- Extensor lag persisted in 16 cases.
- 6 patients underwent physiotherapy at their own place under supervision of a qualified physiotherapist.
- None of the patients were readmitted for physiotherapy.

(I) Knee range of motion with Injury Surgery Interval:

- With reference to the time interval between injury and surgery knee range of motion at final follow-up was evaluated.

Table 9

Interval	Patients	Mean loss of extension At final follow-up	Mean maximum Flexion At final follow-up
< 1 week	51	8.57	116.94
> 1 week	12	6.25	106.25
P value	63	0.4030	0.4736

3.16 Injury Surgery interval and Knee range of motion

- **T-test (mean loss of Extension)**

Difference =1.4107
Standard Error =1.6694
95% CI of difference =-1.9607 to 4.7821
Test statistic t =0.845
Two-tailed probability P = 0.4030(>0.05)

- **Welch-test (mean Maximum Flexion)**

Difference =10.6071
Standard Error =14.1046
95% CI of difference =-21.9181 to 43.1324
Test statistic t (d) =0.752
Two-tailed probability P = 0.4736 (>0.05)

3.17 Interpretation: We found no difference between Injury Surgery interval and mean loss of extension or mean maximum flexion at final follow-up.

(II) Knee range of motion with articular depression:

- Articular depression and effect on knee range of motion was also evaluated.

Table 10

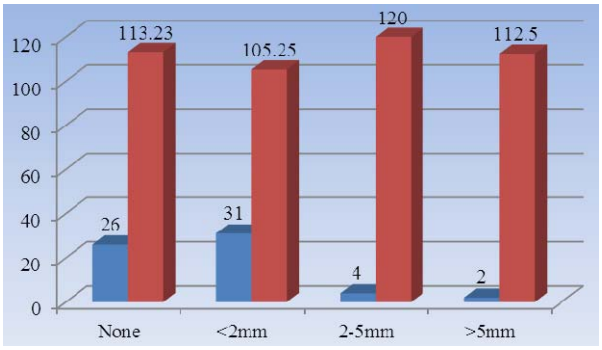
Articular Depression	Patients	Mean knee range of motion
None	26	113.23°
<2mm	31	105.25°
2-5mm	4	120°
>5mm	2	112.5°
Total	**63**	0.966

3.18 Articular depression and Knee range of motion

- **ANOVA test**

F-ratio = 0.0891
Significance level P = 0.966 (>0.05)

- **Interpretation:** We found no difference in particular depression and knee range of movement. In our study articular depression was independent of knee range of movement.



- Patients without articular depression shows mean knee range of motion of 113.23°. While mean knee range of motion of patients having articular depression is 112.58°.

(III) Knee range of motion with Radiological score:

- Evidently better knee range of motion was seen with better radiological score.

Table 11

Results	Patients	Mean knee range of motion
Excellent	31	120°
Good	25	106.31°
Fair	7	91°
Poor	0	0
Total	**63**	

3.19 Rasmussen's Radiological score and Knee range of motion

- All patients having excellent clinical results shows 120° knee range of motion.

(D)Functional Analysis

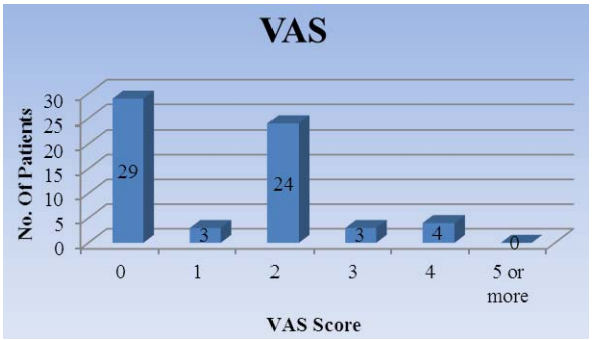
(I) Pain

- VAS score on a scale of 0-10 was used to assess pain at final follow-up.

Table 12

VAS	Patients	Percentage (%)
0	29	46.03
1	3	4.77
2	24	38.09
3	3	4.77
4	4	6.34
5 or more	0	0
Total	63	100

Pain in terms of VAS (Visual Analog Scale)



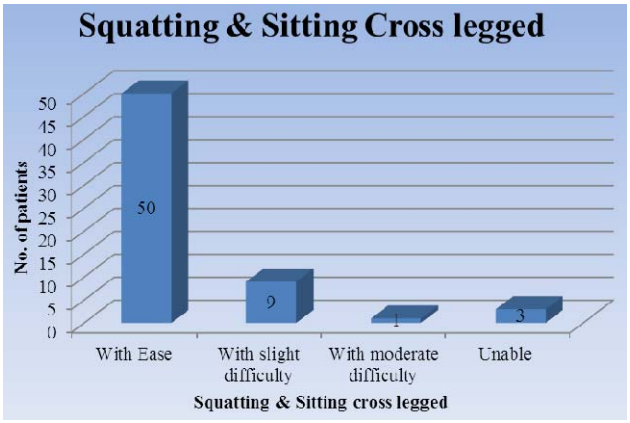
- Mild pain in activity was seen in (VAS <2 or =2) 29 patients.
- Discomfort in ordinary activity was seen in (VAS >2 to <4 or =4) 7 patients.
- Pain limiting routine activity was not found in (VAS 5 or more) any patient.

(II) Sitting and squatting cross legged:

Table 13

Squatting and Sitting cross Legged	Patients	Percentage (%)
With Ease	50	79.37
With slight difficulty	9	14.28
With moderate difficulty	1	1.58
Unable	3	4.77
Total	**63**	**100**

Squatting and Sitting cross Legged



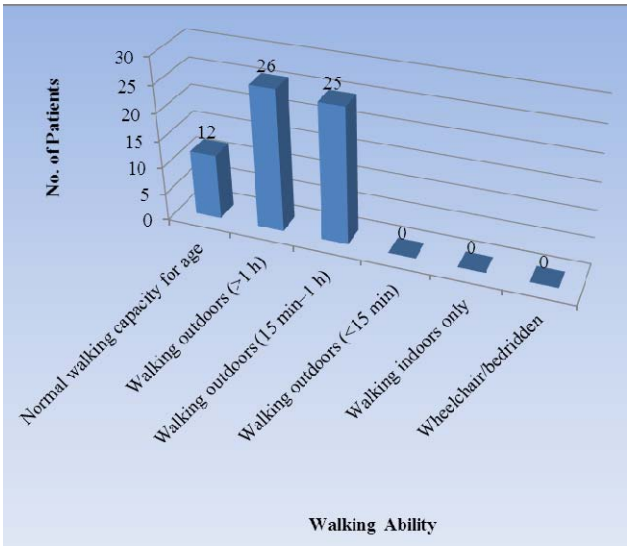
- 50 (79%) patients could squat or sit cross legged without difficulty.
- 9(14%) patients had slight difficulty, while 1 (2%) had moderate difficulty in sitting cross legged and squatting.
- Case no.4 & 6 had comminuted fracture supracondylar femur & post-operatively lack of physiotherapy at home leading to Quadriceps muscle fibrosis hence loosing the ability to squat and sitting cross legged.

(III) Walking ability:

Table 14

Walking ability	Patients	Percentage (%)
Normal walking capacity for age	12	19.05
Walking outdoors (>1 h)	26	41.26
Walking outdoors (15 min–1 h)	25	39.69
Walking outdoors (<15 min)	0	0
Walking indoors only	0	0
Wheelchair/bedridden	0	0
Total	63	100

Walking Ability



- Most of our patients 51 (81 %) were able to walk without support at outdoors.
- Even the poor outcome cases had capacity to walk outdoors, if not independently, but with support of a walking aid.

(E) Analysis of Results:

- Patients were evaluated clinically and radiologically as per the Modified Rasmussen's criteria.
- The results were graded as under :

Table 15

Results	Clinical Results	Radiological Results
Excellent	22(34.93%)	31(49.20%)
Good	28(44.44%)	25(39.68%)
Fair	9(14.28%)	7(11.11%)
Poor	4(6.35%)	0
Total	63	63

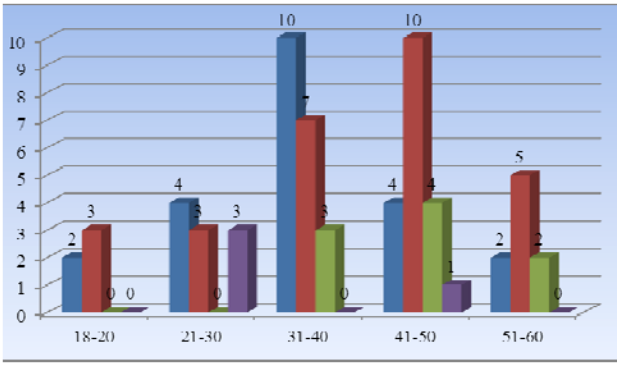
3.20 Results

(I) Results with Age:

Table 16

Age in years	Excellent	Good	Fair	Poor	Patients
18-20	2 (40%)	3(60%)	0	0	5
21-30	4 (40%)	3 (30%)	0	3 (30%)	10
31-40	10 (50%)	7 (35%)	3 (15%)	0	20
41-50	4 (21.05%)	10 (52.63%)	4 (21.05%)	1(5.26%)	19
51-60	2 (22.22 %)	5 (55.56%)	2 (22.22 %)	0	9
Total	22 (34.93%)	28 (44.44%)	9 (14.28%)	4 (6.35%)	63

Age with Results



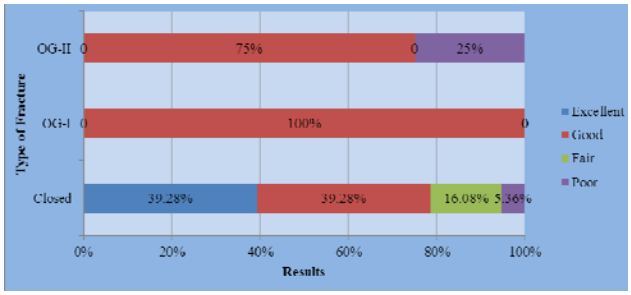
- Out of 20 patients in age group of 31-40, 50% showed excellent results.
- No age group seems to be immune to fair and poor results.
- Factors other than age seem to influence the fractures more in functional outcome.

(II) Results with Type of Injury:

Table 17

Injury	Excellent	Good	Fair	Poor	Patients
Closed	22 (39.28%)	22 (39.28%)	9 (16.08%)	3 (5.36%)	56
OG-I	0	3(100%)	0	0	3
OG-II	0	3(75%)	0	1(25%)	4
Total	**22**	**28**	**9**	**4**	**63**

Type of Injury with Results



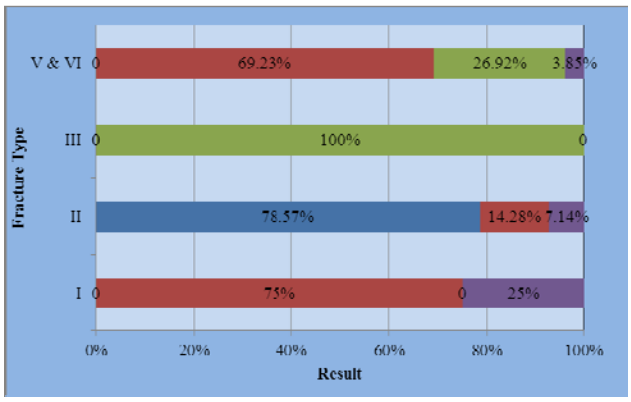
- Although we had more of closed fractures in our sample, even closed fractures showed less than optimum functional results [although less{21%} fair & poor than {79%} good and excellent].
- None of the open fracture gave excellent results.

(III) Results with Classification:

Table 18

Schatzkar's Classification Type	Excellent	Good	Fair	Poor	Patients
I	0	6(75%)	0	2(25%)	8
II	22(78.57%)	4(14.28%)	0	2(7.14%)	28
III	0	0	1(100%)	0	1
V & VI	0	18(69.23%)	7(26.92%)	1(3.85%)	26
Total	22	28	8	5	63

Schatzker Classification of fracture with Results



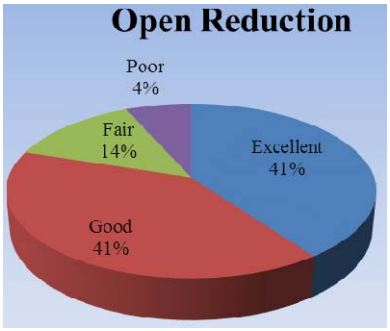
- Type II fracture showed maximum (79%) excellent results.
- Type V & VI fracture showed maximum Fair & Good results.
- None of type V & VI fracture showed excellent results probably due to highly comminuted and depressed fractures.

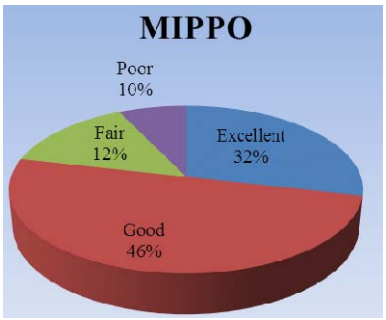
(IV) Results with Surgical method

Table 19

Method	Excellent	Good	Fair	Poor	Patients
Open	9(40.9%)	9(40.9%)	3(13.64%)	1(4.56%)	22
MIPPO	13 (31.70%)	19 (46.35%)	5 (12.19%)	4 (9.76%)	41
Total	22	28	8	5	63

Method with Results

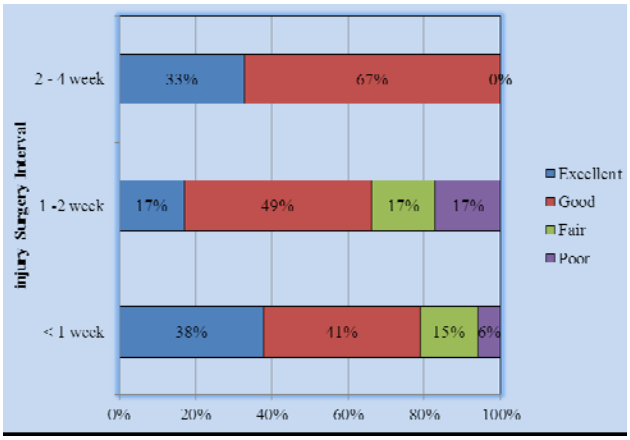




- More excellent, good and fair results are obtained by MIPPO technique probably due to less invasive and less soft tissue damage.

(V) Results with Injury surgery interval

- As seen from previously, knee range of motion was affected by delay in surgery. Similarly, excellent results were seen in cases delayed for as long as 3 weeks.



3.21 Injury Surgery Interval with Results

- Majority of patients were treated in first week of injury out of which 38% had excellent results and 41% had good results.
- Out of 9 patients who were treated within 1 to 2 weeks, 2(16%) had an excellent result, 4 had good, 2 had fair result and 1 had poor results.
- While 4 patients were treated in 2 to 4 weeks duration, out of which 2 had excellent and 2 had good result.

(VI) Comparison of clinical and radiological results

- We tried to correlate functional score and radiological scores and decipher whether they are interdependent or otherwise. We performed the Chi-square test and measured probability.

Table 20

Results according to Rasmussen's Scoring system					
Clinical / Radio-logical	Excellent	Good	Fair	Poor	Total
Excellent	22	9	0	0	31
Good	0	19	4	2	25
Fair	0	0	4	3	7
Poor	0	0	0	0	0
Total	22	28	8	5	63

Chi-square test for comparison of clinical and radiological results

4. Result

Chi-square - 43.096
Degree of Freedom - 6
Significance level P - < 0.0001 (0.00007677)
Contingency coefficient - 0.708

4.1 Interpretation: The clinical and radiological result difference seen in our study is highly significant ($p < 0.0001$), not just due to chance. So, clinical and radiological results may vary in patients treated for tibia plateau fractures.

4.2 Summary & Conclusion of Results and Analysis

- A sample size of 63 (51 male, 12 female) patients was selected to evaluate fractures of Tibial plateau treated by locking plate using either open reduction (22) or MIPPO (41).
- Majority (54) of the patients were in the age group 31-40 years (Range 18-60 years).
- The predominant cause of trauma was a road traffic accident (76%).
- We had seven cases of open fractures (OG I & II).
- Schatzker classification of fractures showed 8 of type I, 28 of type II, 1 of type III, 3 of type IV and 26 of combined type V & VI.
- 15 patients had associated injuries sustained during trauma which could have directly or indirectly influenced the functional outcome of the patients.
- Preference to MIPPPO was given in deciding the surgical method of fixation which was proved by statistical test. 41 patients underwent MIPPO and 22 underwent open reduction for fracture fixation.
- Most (51) patients were operated within first week of trauma. Average time period from injury to surgery was 4.0 days. The duration of hospital stay was not affected by type of surgical method used.
- 50 fractures united between 16-24 weeks. Average time of union was 12.88 weeks. Open fractures did not obviously show any abnormal delay in union time. Union time appeared independent of the type of surgical procedure.
- We had achieved <5 mm articular step-off in all except one patient, who had reasonably good result at 6 months follow-up. However, 4 patients developed articular depression of >5 mm during follow-up. Articular depression was not significant enough in any patient so as to affect knee range of motion.
- The mean loss of extension was 7.2° and mean flexion was 112.8°. 73% (n=32) had full range of movement at knee joint. 3 patients developed knee stiffness.
- Almost 40% of patients showed progression to Grade I Osteo-arthritis at 6 months of follow-up.
- 45 patients started weight bearing at 8 months of follow-up and 12 patients at 12 weeks. 6 patients required prolonged immobilization.
- Complications were seen in 15 patients. Three patients had joint stiffness but were able to ambulate independently. Implant removal was done in 3 cases. Two patients encountered implant failure due to progressive varus. Infection was not a significant burden in the weightage of complications.
- Rasmussen's criteria showed 22 excellent and 28 Good and 8 fair functional scores. Only 5 patients scored poor on functional outcome. Average functional score was 25.76 and average radiological score was 8.24.
- Excellent results were more commonly seen in closed fractures, type II Schatzker's and fractures treated by MIPPO. By statistical analysis we also concluded that clinical and radiological results may vary in patients treated for tibia plateau fractures.

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