

## Original Research Article

# A comparative study of tension band wiring and encirclage in treating transverse fractures of patella

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**Received:** 03 March 2017

**Revised:** 21 March 2017

**Accepted:** 22 March 2017

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## ABSTRACT

**Background:** The functional and radiological outcome of the union of transverse fractures of patella treated by tension band wiring (TBW) and encirclage wiring were compared according to WEST's criteria.

**Methods:** During three years, 44 patients with displaced transverse fracture patella were treated randomly either by TBW or encirclage with twenty-two patients in each group. Two patients in each group were lost to follow-up.

**Results:** Results were compared based on the period of union, post-operative complications, early mobilization and recovery to pre-injury level. Fractures united at an average of 13.6 weeks with 8-12 and 10-14 weeks in TBW and the encirclage group, respectively. Results were excellent in 65%, good in 25% and poor in 10% cases in TBW group, as compared to the encirclage group with excellent in 50%, good in 30% and poor in 20% cases. In TBW group, 75% cases had a full range of motion (ROM), 15% had >120° of flexion and 10% had flexion between 90° and 120°, as compared to 50% full ROM, 30% >120° of flexion and 20% between 90° and 120° flexion in the encirclage group. A case of migration of pin and another case of limitation of flexion by 25° were noticed.

**Conclusions:** Patients treated with TBW had better results than the encirclage in the management of transverse fractures of the patella.

**Keywords:** Encirclage, Extensor mechanism, Fracture patella, Tension band wiring

## INTRODUCTION

Patella is the largest sesamoid bone in the body situated in the quadriceps tendon. The main function of the patella is to improve the efficiency of quadriceps muscle by improving the mechanical leverage of the quadriceps muscle. Patellar fractures are common and it constitutes about 1% of all skeletal injuries resulting from either

direct or indirect trauma.<sup>1,2</sup> The subcutaneous location of the patella makes it vulnerable to direct trauma, whereas violent contraction of the quadriceps results in indirect fractures of the patella. These fractures are usually transverse and are associated with tears of medial or lateral retinaculum. Any improper and inadequate treatment would inevitably lead to a great deal of disability which would be most perceptibly felt in a

country like India, where squatting is an important activity in daily life. Controversy exists regarding treatment of patellar fracture since the earliest time. In patellar fractures with displacement less than 3mm, conservative treatment was suggested as the best option.<sup>3,4</sup> Of all surgical management of patellar fractures such as modified tension band wiring (TBW), encirclage wiring, screw fixation, plating, and partial or total patellectomy, encirclage wiring and TBW are popular.

### Biomechanics of patella-femoral joint

The patella is a link in the quadriceps mechanism and it serves two important biomechanical functions (Figure 1). First, it transmits the tensile forces generated by the quadriceps to the patellar ligament. Second, the patella effectively increases the lever arm of the knee extensor mechanism from the axis of knee flexion-extension. This increases the knee extensor moment generated by contraction of the quadriceps.<sup>5</sup>

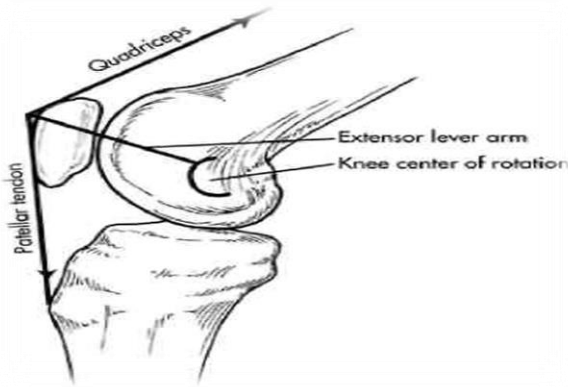


Figure 1: Mechanics around knee joint.

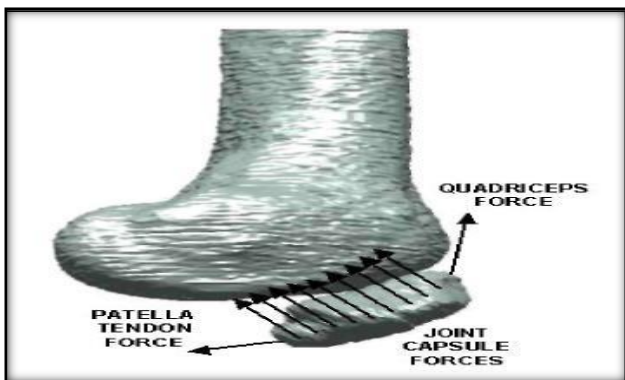


Figure 2: Patello femoral joint reactive force.

The patella transmits most of the loading force of the quadriceps contraction with the knee in extension, however with the knee in flexion; its posterior surface is subjected to a compressive force against the distal femoral condyles, called the patellofemoral joint reactive force, creating a three-point bending configuration in the patella (Figure 2). This bending load results in tension at

the anterior surface of the patella, which is maximum at near 45° of knee flexion and may rise to 6000 Newtons in young trained men.<sup>5</sup> Considering the magnitude of tension, three-point bending stress and compressive forces that occur on the posterior surface of the patella in a loaded flexed knee, the prevalence of patellar fracture is high and have an important effect on the efficacy of various methods of treatment of these fractures.

Both posterior and anterior articular surface of the patella is predominantly convex. Thus the point of contact for the patellofemoral joint range of motion is a transversely linear band. For virtually all activities and angles, the patellofemoral contact stresses exceed those sustained by the tibiofemoral joint. This high contact stress magnifies the importance of maintaining of articular congruity in treating patellar fractures in order to facilitate and maximize stress distribution.

The aim of this study was to analyse the functional and radiological outcome of the transverse fractures of patella treated by TBW and encirclage wiring with an objective to study the mean period of union, the postoperative complication involved, early mobilization outcome, recovery to pre-injury level in both the procedures.

### METHODS

This prospective study was done between September 2012 and August 2015. Forty-four cases of displaced transverse patella fractures were treated with TBW and encirclage (22 in each). Informed written consent was obtained from all patients. The cases were selected based on inclusion criteria; transverse displaced fracture patella who presented within 2 weeks of injury, adults more than 18 years of age, closed fractures, patients who are medically fit for surgery and exclusion criteria; severely comminuted fractures, vertical fractures, old fractures >2 weeks and patients who were not medically fit for the surgery, any associated skin disease. The affected limb was immobilized by an above knee plaster of Paris (POP) posterior slab, while the patient was prepared for surgery.

### Operative procedure

#### Modified tension band wiring

The fracture site was exposed through transverse incision/midline longitudinal incision. Proximal and distal fragments were reduced, restoring a smooth articular surface and was held firmly with patella reduction clamps or towel clips. Two 2mm Kirschner wires (K-wire) were made to pass from inferior to superior pole through each fragment keeping about 5mm deep to the anterior surface of the patella along lines dividing the patella into medial, central, and lateral thirds and as parallel as possible. In some cases, the wires were passed through the fracture site into the proximal fragment in a retrograde manner and after reducing the fracture, the wires were inserted through the distal

fragment. Then an 18-gauge stainless steel wire was passed transversely through the quadriceps tendon attachment, as close to the bone as possible, and deep to the K-wires and then passed over the anterior surface of the patella and then transversely through the patellar tendon attachment on the inferior fragment and deep to the K-wires from lateral to medial side and then back over the anterior patellar surface. Finally, it is tightened at the superolateral end of the patella. The reduction was checked manually and by roentgenography in anteroposterior and lateral view. Upper ends of the two K-wires were embedded into the superior margin of the patella after bending it acutely and protruding ends of the K-wires were cut short inferiorly. Retinacular tears were repaired and the wound was closed over a suction drain.

### Encircelage

After exposure and fracture reduction, a number 18 G stainless steel wire was made to pass transversely at the superolateral border of the patella through the quadriceps tendon using a large gallie needle or large intracath needle. the wire was then passed along the medial border of both fragments midway between the anterior and posterior surfaces of the patella. The wire was made to pass transversely through the patellar tendon from the medial to the lateral side around the distal border of the patella and then proximally along the lateral side of the patella to the superolateral border. After checking the reduction wire ends were tightened with adequate tension. The reduction was confirmed by roentgenograms and palpation of the undersurface of the patella. Then the redundant wire was cut off and the twisted ends were buried into the quadriceps tendon. Retinacular tears were repaired and the wound was closed over a suction drain.

All patients in both groups were advised to do quadriceps strengthening exercises as soon as they were pain-free and weight bearing started from the third post-operative day with help of walker/axillary crutches and long knee brace on. Sutures were removed on 10/12 days and patients were discharged. They were advised to do static quadriceps exercises (isometric exercise) and ankle pump exercises at home regularly.

### Follow-up

They were followed up every 2 weeks for first two months and then monthly once after that. During each follow-up, the patients were examined for both subjective symptoms and objective signs which were recorded. Mobilization of the knee was started at the fourth week in TBW patients, whereas the sixth week in encircelage patients.

Dynamic exercises (isotonic and isokinetic exercises) of the knee were taught in OPD which the patient was asked to continue at home. In PMRC Wax Bath was given and range of motion exercises was taught. In each follow-up the patients were questioned about subjective complaints

like pain, difficulty in walking, squatting, climbing and getting downstairs and ability to perform routine work. The patient's objective assessment was done for extensor lag, the range of knee movement and efficacy of quadriceps power. Assessment of the observations was done statistically and results obtained with the help of SPSS software no. 19.0. In the statistical analysis, chi-square and student T-test were used to find the significance between the two groups. The variables for analysis were based on WEST'S criteria, which is graded as below:

- Excellent- Patients do not have any limitation of activities, No loss of flexion. No extensor lag, no subjective complaints, no quadriceps wasting or subsequent reduction in power.
- Good (1 or >1 criteria)- Moderate limitation of activity, Extensor lag of 5-10 degrees, Minimal wasting of quadriceps and power of Grade 4, Some subjective symptoms, Flexion loss not >30 degrees.
- Poor (1 or >1 criteria)- Marked limitation of activities with significant, Complaints of pain and weakness, marked quadriceps wasting and power <3, extensor lag >10 degrees, flexion loss > 30 degrees.

## RESULTS

In present study 44 cases of displaced transverse fractured patella were treated by modified tension band wiring and encircelage, of which 4 were lost to follow-up (2 in each group). The findings and the end results of present study were analyzed in 40 patients in the following discussion.

**Table 1: Patient profile.**

Variable		TBW	Encircelage
Mean age in years		37±75	39±65
Gender	Male	14 (80%)	15 (75%)
	Female	6 (20%)	5 (25%)
Mode of injury	Direct	9 (45%)	12 (60%)
	Indirect	11(55%)	8 (40%)
Nature of trauma	Road traffic accident	8 (40%)	9 (45%)
	Self-fall	7 (35%)	8 (40%)
	Sports injury	5 (25%)	3 (15)
Hospital stay		11-22 days	11-22 days

In present series the range of age was between 20-60 years, the mean age was 37.65 years and the incidence was high in the age group of 31-40 years. Thirty cases were men and ten were females. Twenty-three fractures were as a result of the indirect mechanism (forceful flexion of the knee against some contracted quadriceps as in fall from height) and seventeen cases were due to direct trauma to the patella due to RTA, accidental fall or sports injury. The average hospital stay in both groups was 11-22 days (Table 1). Herein the findings were analyzed with, tourniquet time, hospital stay, and postoperative immobilization. In our observation, the

mean tourniquet time for the encirclage was 35.1 minutes as compared to 64.8 minutes in TBW. p-value 0.00005 is highly significant (Table 2). As all the cases of patellar fractures in our study were associated with a tear of the extensor retinaculum which was repaired during surgery, all the patients were immobilized in a long knee brace for 4 weeks in TBW and 6 weeks in Encirclage. After which patients were taught knee bending exercises. The mean period of immobilization was less in TBW compared to Encirclage. p value=0.00005 was highly significant (Table 2). The TBW cases were mobilized earlier as per the tension band principle. No intra-operative

complications were encountered; all the fractures were united at an average of 13.6 weeks (Figure 3). There was a single case of migration of pin through the skin after 11 weeks in TBW group, for which the implant was removed and another case of limitation of flexion by 25° was noted. As per the WEST'S criteria, activity, flexion, extension lag, subjective symptoms, and quadriceps power were recorded. In activity, there was a difference at 12 and 16 weeks with a better result in TBW group, but not significant statistically. At the end, the results were same in both groups (Table 3).

**Table 2: Tourniquet time and immobilization period.**

Patient profile	Statistical analysis	TBW	Encirclage	p-value	Statistical inference
Tourniquet time	Mean	64.8	35.1	0.00005	Highly significant
	Standard deviation	5.99	2.511		
Immobilization period	Mean	29.55	43.7	0.00005	Highly significant
	Standard deviation	1.3562	1.2607		

**Table 3: Activity in follow up and analysis.**

Activity no.%	TBW	Encirclage	p-value	Statistical inference
4 weeks				
Limited due to pain	(16) 80	(16) 80	1.00	No difference
Self-care only	(4) 20	(4) 20		
6 weeks				
Limited due to pain	(20) 100	(20) 100	1.00	No difference
12 weeks				
Not limited	(14) 70	(12) 60	0.507	Differentiate but not significant
Limited due to pain	(30) 6	(40) 8		
16 weeks				
Not limited	(15) 75	(12) 60	0.311	Differentiate but not significant
Limited due to pain	(5) 25	(8) 40		
Final				
not limited	100	(20)100		No difference

**Table 4: Flexion in follow up period and analysis.**

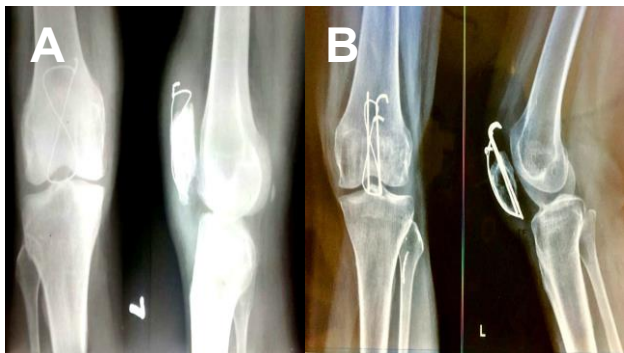
Flexion number (%)	TBW	Encirclage	p-value	Statistical inference
6 weeks				
≤20 DEG	(0) 0	(20) 100	0.0005	Highly significant
>20DEG	(20)100	0		
12 weeks				
Not limited	(3) 15	(9) 45	0.38	Significant
≤70 DEG	(17) 85	(11) 55		
>70DEG				
16 weeks				
≤110 DEG	(5) 25	(10) 50	0.102	Differentiate but not significant
>110DEG	(15) 75	(10) 50		
Final				
≤130 DEG	(5) 25	(10) 50	0.102	Differentiate but not significant
>130 DEG	(15) 75	(10) 50		

**Table 5: Extension lag in follow up period and analysis.**

Ex LAG no.%	TBW	Encirclage	p-value	Statistical inference
4 weeks				
0 degree	(8) 40	(20) 100	0.0005	Highly significant
5 degree	(12) 60	0		
6 weeks				
0 degree	(18) 90	(2) 10	0.38**	Highly significant
5 degree	(1) 5	(12) 60		
10 degree	(1) 5	(6) 30		
16 weeks				
≤110 DEG	(19) 95	(16) 80	0.151**	Differentiate but not significant
>110 DEG	(1) 5	(4) 20		
Final				
≤130 DEG	(19) 95	(16) 80	0.151**	Differentiate but not significant
>130 DEG	(1) 5	(4) 20		

**Table 6: Subjective symptoms in follow up period and analysis.**

Subjective symptoms (no.) %	TBW	Encirclage	p- value	Statistical inference
<b>Subjective symptoms</b>				
No symptoms	(15)75	(13)65	0.745	Different but not significant
Mild pain	(4) 20	(5) 25		
Pain and weakness	(1) 5	(2) 10		

**Figure 3: A) United fracture of patella with encirclage wiring; B) United fracture of patella with tension band wiring.**

Knee flexion in the groups was compared at the end of 6<sup>th</sup>, 12<sup>th</sup>, 16<sup>th</sup> week. At 4<sup>th</sup> week only TBW patients were mobilized. A significant difference was seen at the end of 12 weeks; 85% of cases attained >70 degrees of flexion in the TBW group compared to 55% of cases in the encirclage group (Table 4). Extension lag finally was insignificant statistically, but there was difference in early weeks until 12 weeks. There was significant difference as more cases in encirclage had some lag compared to TBW group. Finally, 4 cases had 5 degrees of extension lag in the encirclage group compared to one case in TBW (Table 5). Subjective symptoms were noted in both groups but were insignificant statistically (Table 6). Quadriceps muscle strength was tested during the follow-up period which was insignificant statistically (Table 7).

**Table 7: Quadriceps power in follow up period and analysis.**

Quads strength no.%	TBW	Encirclage	p-value	Statistical inference
4 weeks				
Power III	(5) 25	(9) 45	0.15	Different but not significant
Power IV	(14) 70	(8) 40		
Power V	(1) 5	(3) 15		
6 weeks				
Power III	(0) 0	(2) 10	0.084	Different but not significant
Power IV	(6) 30	(10) 50		
Power V	(14) 70	(8) 40		
12 weeks				
Power IV	(2) 10	(5) 25	0.212	Differentiate but not significant
Power V	(18) 90	(15) 75		
Final				
Power IV	(2) 10	(5) 25	0.212	Differentiate but not significant
Power V	(18) 90	(15) 75		

After assessing the criteria according to WEST'S scoring, it was found that 65 % cases were excellent; 25% were good and 10 % were poor in TBW group. In encirclage group 50% cases were excellent; 30% were good and 20% were poor. The TBW had better results but



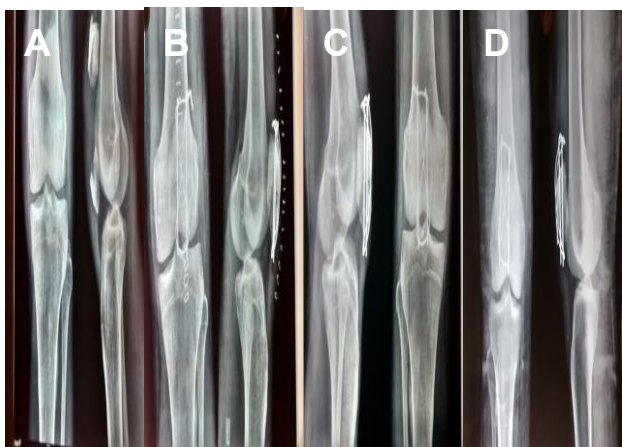
statistically, there was no significant difference at the end. (Table 8). This may be due to low sample size.

**Table 8: Results Obtained by WEST's Scoring.**

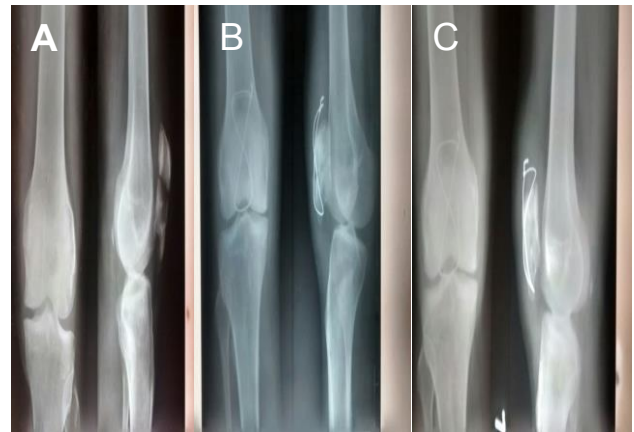
West's scoring (no) %	TBW	Encirclage	p- value	Statistical inference
Excellent	(13) 65	(10) 50	0.563	Different but not significant
Good	(5) 25	(6) 30		
Poor	(1) 10	(4) 20		

**Table 9: X- ray union and Articular surfaces comparison.**

Union	TBW	Encirclage	p-value	Statistical inference
Immediate post OP			0.548	No difference
Not united	100	100		
6 weeks				
United	90	95		
Partial union	10	5		
16 weeks			0.337	Different but not significant
United	100	100		
Articular surfaces Immediate Post OP				
Smooth	50	65		
Rough	50	35		
6 weeks			0.507	Differentiate but not significant
Smooth	60	70		
Rough	40	30		
16 weeks				
Smooth	85	95		
Rough	15	5	0.292	Differentiate but not significant



**Figure 4: TBW A. fracture of patella; B. immediate post op; C. six weeks post op; D. sixteen weeks post op.**



**Figure 5: Encirclage wiring A. fracture of patella; B six weeks post op; C. sixteen weeks post op.**

#### Radiographic union

The period of union in the two procedures was recorded. Three postoperative X-rays were taken in postoperative 1st day, 6th week and 16th week (Figure 4 and 5). Union was defined as callus formation and when no fracture line is seen. Here average period of union was around 6 weeks for both the groups with not much significant difference. Articular surfaces smoothness was similar in both groups with no difference statistically (Table 9).

#### DISCUSSION

In this study, 20 cases were treated with modified tension band wiring and 20 cases were treated with encirclage. In our group, 67.5% (27 cases) were between 21-50 years. In present study, male predominance was noted. Herein, of 40 cases, 30 (75%) cases were male and 25% were female 3:1. Studies have shown high percentage of success in cases treated with tension band wiring.<sup>6</sup> In the TBW group, there were 13 cases (65%) with excellent, 5 cases (25%) with good and only 2 cases (10%) had poor results. The overall results of 20 cases were comparable to most of the series. In encirclage group, 10 (50%) cases had excellent, 6 cases (30%) had well and only 4 cases (20%) had poor results. Early mobilization of joint in TBW group after surgery appears to have greatly helped to gain good range of motions, which is prime requisite for squatting and sitting crossed leg, particularly in Asian sub-continent. From a comparison, it is discernible that the present results are in concordance with the previous results (Table 10). The majority of included patients were satisfied with range of motion gained, corroborating previous studies.<sup>7</sup>

The movements of knee were started after 4 weeks in TBW cases as compared to 6 weeks in encirclage group. Thus, the gain of movements of knee was faster in cases of TBW and at the end of 6 weeks, 70% cases had flexion >90°. The degree of flexion at 12 and 16 weeks was statistically significantly different in both groups, suggesting that TBW had better results. TBW due to

early mobilization principle has better range of motion outcome than Encirclage.<sup>8-12</sup> Five patients (TBW:Encirclage- 1:4) had extensor lag, whereas it was seen in 20% of cases in the another study.<sup>13,14</sup> Herein, normal quadriceps power was observed with 82.3% of patients and 17.7% had grade-IV power of quadriceps in cases treated with TBW and encirclage (2:5) cases. Quadriceps power were statistically insignificant at the end of two years, as compared to studies of Jakobsen et al, Srinivas et al and Edwards et al.<sup>13,15,16</sup> Union was seen in all cases at 8-12 weeks in TBW and 10-14 weeks in Encirclage group, compared to

12-16 weeks of Srinivaslu et al series. In the series of Rudolph and Rosenberg, 84% of cases showed excellent to good results and remaining showed poor results.<sup>17</sup> The overall results of our study were excellent to good in 85% of cases. In cases treated with TBW, excellent to good results were seen in 90% of cases. According to Srinivas et al, 80% of cases treated with TBW shown to have excellent to good results and 20% shown poor results.<sup>13</sup> Two cases, out of ten treated with TBW had the problem of irritation from implant, which was seen in only one case in present study.

**Table 10: Comparison table of previous and our study by WEST'S criteria.<sup>12</sup>**

Author	TBW			Encirclage group		
	Excellent	Good	Poor	Excellent	Good	Poor
Bostman et al <sup>13</sup>	9	3	2	6	6	3
29 cases	31.03	10.3	6.8	20.68	17.2	10.3
Lewack et al <sup>6</sup>	7	5	2	2	5	9
30 cases	23.34	16.66	6	6.67	16.66	30
Present study	13	5	2	10	6	4
40 cases	32.5	12.5	5	25	15	10

Union was seen in all 40 cases, but the union was faster in cases of TBW with the average period of union been 8-12 weeks, whereas it was 10-14 weeks in encirclage group.

## CONCLUSION

Patella is essential for effective function of quadriceps and for proper biomechanics of knee joint so it should be preserved wherever possible. Careful selection of cases and good surgical technique is essential for a good functional outcome in fractures of patella. Place for conservative treatment is only in undisplaced fractures. Operative treatment is essential to carry out repair of the torn expansion of quadriceps and gives good results. Patellectomy leads to quadriceps atrophy, loss of power and extensor lag. Postoperative immobilization and physiotherapy play a vital role. It was concluded that modified TBW was better than encirclage wiring in the treatment of transverse fractures of patella probably because of good stability of implant and easier postoperative rehabilitation. The study should be conducted in larger group and more long-term follow-up is needed.

*Funding: No funding sources*

*Conflict of interest: None declared*

*Ethical approval: The study was approved by the institutional ethics committee*

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**Cite this article as:** Mohapatra S, Das PB, Krishnakumar RV, Rath S, Padhy RN. A comparative study of tension band wiring and encirclage in treating transverse fractures of patella. *Int Surg J* 2017;4:1558-65.