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Evaluation of Internal Fixation of Patellar Fractures Using Cannulated Screws with Tension Band versus Modified Tension Band Wiring

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Abstract:

The goal of this study is to evaluate both functional and radiological outcomes in patellar fractures management with both techniques; cannulated screws with tension band and modified tension band wiring. 30 patients, with displaced or mildly comminuted and partial articular patellar fractures, were randomly grouped into two groups, 15 in each group. Group 1: fixed by cannulated screws with tension band and group 2: fixed by modified tension band wiring. By comparison between types of fixation, regarding post-operative complication (loss of knee motion, loss of reduction, delayed or non-union and pain during movement) there was no statistically significant difference between types of fixation, but there was statistically significant increase hardware removal and infection in K-wires method. Cannulated screws with tension band has a better radiological outcomes and better curative effects on patella fracture with low incidence of complications. Modified tension band wiring technique despite being the traditional and most widely accepted method of transverse patella fracture fixation; it has certain distinct disadvantages.

Keywords: Patellar fractures, cannulated screws with tension band, cannulated screws with cerclage, modified tension band wiring.

1. Introduction:

The patella is the largest sesamoid bone, roughly triangular in shape. Patellar fractures are mostly seen in the age group of 20-50 years, account for 1% of all skeletal injuries, male to female 2:1. Mechanism of injury: Either by direct impact injury: This occurs from fall or dashboard injury, causes failure in compression, or indirect eccentric contraction: which occurs from rapid knee flexion against contracted quads muscle, causes failure in tension [1].

Patellar fractures may be displaced or undisplaced. Undisplaced fractures are usually managed by immobilizing the limb in a cylindrical cast. Classifications of patellar fractures according to the AO/ASIF: Extra

Articular: 34-A1 (Avulsion), 34-A2 (Isolated Body). Partial Articular: 34-B1 (Vertical, Lateral), 34-B2 (Vertical, Medial). Complete Articular: 34-C1 (Transverse), 34-C2 (Transverse plus second fragment) and 34-C3 (Complex) [2].

The surgical management of patellar fractures has evolved over the years necessitated by the need for stable fixation to allow early mobilization and aggressive rehabilitation to preserve the range of knee motion in the young physically active age group; from simple cerclage wiring to tension band wiring (TBW) in 1950s which was further modified to increase its strength by adding Kirschner wires (K-wires) to the construct, cancellous screws have also been used in the management of patellar fractures with high failure rates compared to modified tension band wiring. The surgical management of patellar fractures is constantly evolving, with the latest additions being cable pin system, mini-screw fragment fixation system and fixed angle plate fixation for various patellar fracture configurations [3].

Combining interfragmentary screw fixation with the tension band principle appears to reduce failure rate and provide improved stability over the modified tension band or screws alone for patella fractures by reducing fracture separation by providing compression throughout the range of motion and by resisting the tensile loading during terminal extension. Cannulated screws allow for simple, reliable addition of a tension band to screw fixation. The construct has been proved to be mechanically stronger than modified tension band in various biomechanical studies [4].

The knee mobility and function evaluated by Bostman's scoring postoperatively. Fracture healing, fixed position and the length of patellar length also were investigated by radiographic examination. All patients assessed at follow-up at the 12th postoperative week achieved radiological union. At the 12th postoperative month, knee flexion range of motion (ROM) was 132° ± 4.5°, knee extension ROM was 0.6° ± 1.8°, and the mean Bostman's score was 28.2 ± 0.8 points. There were also no statistical difference in the length of the patella between 12 weeks and 12 months and no significant complications were observed during the whole follow-up period. Cannulated screws combined with figure of eight wire demonstrated excellent results and could be a recommended surgical method for patellar fractures [5].

2. Patients and Methods:

This was a randomized comparative study performed in Beni-Suef university hospital within six months from January 2020 involving 30 patients, verbal consents were obtained.

Inclusion criteria:

1. Patients with displaced or mildly comminuted patellar fractures (34-C1, 34-C2).

2. Patients with partial articular fracture (34-B1, 34-B2).

Exclusion criteria:

1. Pathological fractures.
2. Comminuted fractures or three-part fractures.
3. Severe soft tissue injury.
4. Patients unfit for surgery.

All patients were subjected to:

A. Preoperative:

Preoperative history and clinical examination: A detailed history was taken, including patient's complaint, time and mode of trauma, pain, and swelling or associated injuries, time passed after present fracture and history of any other associated injuries or underlying medical disease. Clinical examination aimed to measure the pre-operative range of motion for both sides, while post-operative range was reported for the affected side at end of follow up period. The soft tissue condition was classified according to Tscherne classification [6].

Inspection: Inspection of the soft tissue: skin integrity, swelling, abrasions, skin bullae, contusions, ecchymosis, palpable patellar defect, significant hem-arthrosis and any open wound was addressed according to its extent and size.

Neurovascular examination: This included assessment of the popliteal, posterior tibial and dorsalis pedis pulsations. Movements of ankle and toes were assessed together with sensation around the foot.

Motion: Patient unable to perform straight leg raise indicates failure of extensor mechanism .

Radiological evaluation: Plain X- ray: each patient had the standard X-ray: AP and lateral views of the knee. Each view was assessed for: morphology of the fracture, the degree of the bone comminution, the degree of bone fragments displacement, the degree of depression of articular bone fragments. The fractures were classified according to AO classification.

Preoperative investigation: Laboratory investigations, ECG and chest X-ray were done for patients older than 40 years or when indicated.

Preoperative preparations: All patients were admitted with an elevated limb and in the inpatient ward received medical treatment and the duration between injury and operation was recorded for each patient.

B. Operative:

Timing of surgery: Each patient underwent the scheduled surgical procedure according to general condition and local skin condition, but all of them were done within the first week from the injury.

Surgical technique and implants: With the patient supine, under tourniquet control; an anterior longitudinal midline incision 6 to 10 cm in length over the knee is performed in both groups.

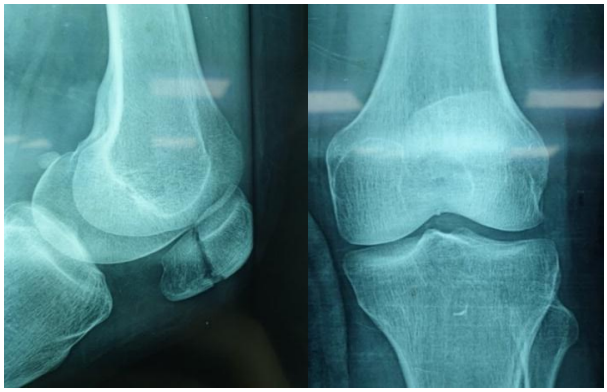


Fig. (1): pre-operative x-rays showing simple transverse patellar fracture.

In case of cannulated screws method:

The entire flap is sectioned until the fragments and peripatellar tissue are fully exposed. The retinacular tears are identified and the knee joint is inspected for cartilage damage (osteochondral fractures). Any bone chips and hematoma are removed, and the articular cavity is rinsed with sterilized saline. The distal and posterior fragments are reduced and temporarily fixed with 2 large towel clamps.

Two parallel guide wires are passed and their position checked together with anatomical reduction of articular surface under image intensification. The 2 parallel K-wires were drilled from the superior to the inferior pole of the patella, with a 2 cm space between the 2 wires and a distance of 10mm from the articular surface. Articular congruity is assessed by digital palpation through the retinacular tear and confirmed on fluoroscopy.

After confirming the screw size, the screws are passed over the guide wires in antegrade or retrograde direction after drilling the fracture fragments. The guide wires are removed and an 18G stainless steel wire is passed through the cannulated screws and crossed over the anterior aspect of the patella. The wire ends are tightened with the knee in full extension. The articular surface is evaluated by palpating the articular surface through the retinacular defect and by fluoroscopy.

Stability of the final construct is tested by taking the knee through the range of motion. Finally, the soft tissues are repaired including the synovium, capsule and extensor mechanism, the wound is then closed in layers.

Fig. (2): 3 months follow up x-rays showing union of patella fixed by cannulated screws.

In case of modified tension band wiring technique:

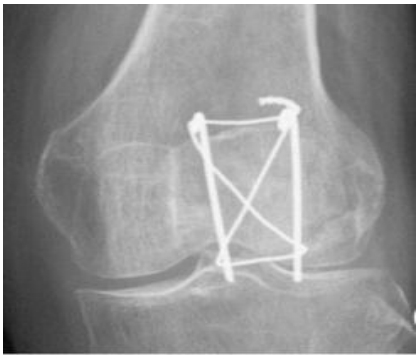
Avoid extensive soft tissue dissection to preserve blood supply and viability of skin flaps. After exposure of the fracture margins,

remove devitalized fragments and loose bodies, retain as much of patella as possible, the fracture is then reduced and provisional fixation is undertaken with appropriate reduction forceps.

Longitudinal K-wires are then driven across the fracture site. Two K-wires are used. All K-wires are placed parallel to each other and perpendicular to the fracture line. The 2 parallel K-wires (2.0mm in diameter) were drilled from the superior to the inferior pole of the patella, with a 2 cm space between the 2 wires and a distance of 10mm from the articular surface. Care is taken to ensure that the wires do not penetrate the articular surface. When advancing the wires, they are driven to the opposite pole of the patella and then pulled back approximately 1 cm. This facilitates later impaction of the wires once they have been bent. It may be prudent at this point to use the image intensifier to verify the reduction and wire placement.

Once the K-wires have been placed a Figure of eight wire is passed. The transverse limbs of the Figure-eight wire should be as close as possible to the respective pole of the patella with a 2 cm space between the wires and a distance of 10mm from the joint surface. Two twists are made in the Figure-eight wire, one on each vertical limb, to prevent asymmetric tightening. The twists are pulled to tighten the wires and then turned to take up the slack, as the pull is released, to remove any slack in the wires. Both twists are made simultaneously or alternate small adjustments are made in each until the appropriate tension is generated in the Figure of eight. The longitudinal K wires are then bent 180 degrees as close as possible to their entry points into the patella. The excess wire is then cut leaving 2 to 4 mm of a hook. The bend in each wire is then turned such that the hook is directed posteriorly. This will ensure that the Figure of eight wire will be captured. The tendon at the point of entry of the longitudinal wire should be split for several millimeters and with the tendon retracted the bent wire is advanced with a punch until it is flushed with the bone.

Ensuring that there is no tendon captured by the bend in the wire and engaging the bone with the bend reduces the risk of wire back out. The same procedure is carried out with all K-wires. The final position is verified clinically and radiologically. The non-bent ends of the wires should not protrude beyond the bone and must not penetrate the articular surface. Final stability of the construct is tested by taking the knee through the range of motion. The usually present retinacular rents, medially and laterally, are repaired and then the wound is closed in layers.



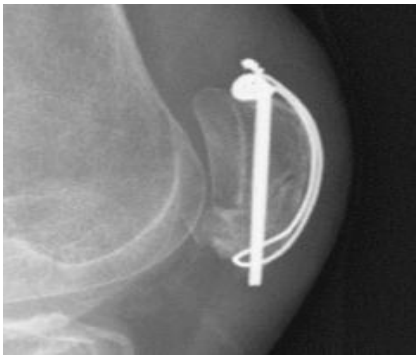


Fig (3): 3 months follow up x-rays showing union of patella fixed by modified tension band wiring.

C. Postoperative Management:

Postoperative radiology: AP and lateral views X-rays were taken in the 1st postoperative day. Postoperative medications including: analgesics, anti-inflammatory, anti-edematous and anti-biotics.

For both methods of fixation none of the patients required knee immobilization postoperatively. Static quadriceps exercises, straight-leg raising, and progressive knee joint flexion were started as early as postoperative day 1. Partial-weight-bearing exercises with the help of crutches were allowed for 6 weeks postoperatively, and then the patient was permitted full weight bearing. The tension band wire is removed only in patients with significant hardware related symptoms and not generally for at least 6 months from the date of surgery.

D. Follow up:

Radiological evaluation by standard knee x-rays; AP and lateral views to assess fracture reduction.

Early follow up: Both active and passive knee motion exercises begin 1 day after the surgery, with knee flexion less than 90°. At this time, isometric exercises involving the quadriceps are initiated. On postoperative day 2 or 3, partial or full weight-bearing exercises are started with physiotherapy comprising of passive ROM under the protection of a hinge brace if needed and the patient is discharged.

Late follow up: Static quadriceps and hamstring settings are taught and weight bearing using crutches allowed as tolerated, walking exercises involving the use of crutches also begin and last for a period of 4 weeks. Beginning in the fourth postoperative week, normal daily activities for the participants are permitted. Gradually the ROM is increased up to 90 degrees by the second week and increased as tolerated by the patient.

The patients are followed up at two weeks, six weeks and three months. Both clinical and radiological assessments are done for fracture healing and functional recovery. Patients are evaluated using the Bostman's scoring. Bostman's score evaluates patients during follow up by giving the patient points according to: range of motion (ROM), pain, work, atrophy, giving way, walking and stair-climbing. The result is ***excellent*** if the patient scored 30 - 28, ***good*** if scored 27 - 20 and ***unsatisfactory (poor)*** if the total score is less than 20.

Fig. (4): Clinical pictures showing range of motion at 3 months follow up.

Statistical methodology

Data were collected, coded, revised and entered to the Statistical Package for Social Science (IBM SPSS) version 20. The data were presented as number and percentages for the qualitative data, mean, standard deviations and ranges for the quantitative data with parametric distribution and median with inter quartile range (IQR) for the quantitative data with non-parametric distribution. Chi square will be used to detect the difference between both groups regarding categorical variables. Independent t-test will be used to detect the difference between groups regarding the scale variables. Paired t-test will be used to follow up the changes in scale variables.

The confidence interval was set to 95% and the margin of error accepted was set to 5%. P value < 0.05: Significant

3. Results:

The current study was conducted at Beni-Suef university hospital within six months from January 2020. A total of 30 patients were randomly grouped into two groups, 15 in each group.

Table (1): Demographic data regarding sex, age, occupation and smoking

		No	%
Sex	Male	22	73.3%
	Female	8	26.7%
Age	Mean± SD	32.83	9.84
	Range	19	60
Occupation	Worker	6	20.0%

	Driver	15	50.0%
	Employer	1	3.3%
	Housewife	8	26.7%
Smoking	No	11	36.7%
	Yes	19	63.3%

Table (2): Comparison between types of fixation among bostman's score

		K-wires		Screws		Chi square test	
		No	**%**	**No**	**%**	**X^2**	**P value**
Bostman's score	Excellent	6	40.0%	12	80.0%	5.000	0.082
	Good	6	40.0%	2	13.3%		
	Poor	3	20.0%	1	6.7%		

P-value > 0.05 (Non-significant)

Table (2) show no significant difference between both groups as regards the Bostman's score.

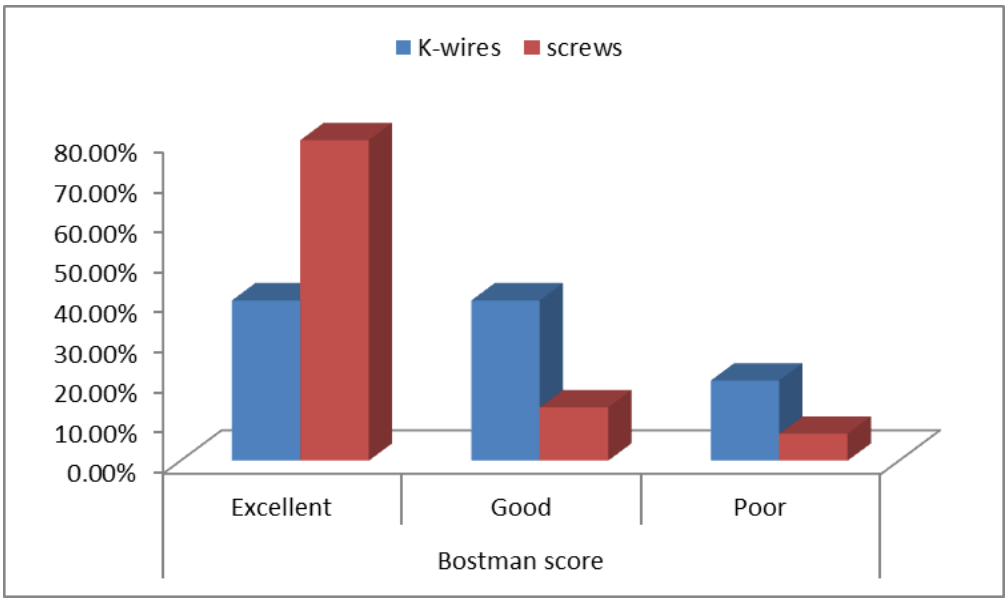


Fig. (5): Types of fixation among Bostman's score.

Table (3): Comparison between types of fixation among post-operative complications

	K-wires		Screws		Chi square test	
	No	**%**	**No**	**%**	**X^2**	**P value**
Loss of reduction	4	26.7%	1	6.7%	2.160	0.142
Delayed or non-union	5	33.3%	1	6.7%	3.333	0.068
Pain during movement	7	46.7%	3	20.0%	2.400	0.121
Hardware removal	7	46.7%	2	13.3%	3.968	0.046*
Loss of knee motion	4	26.7%	1	6.7%	2.160	0.142
Infection	6	40.0%	1	6.7%	4.658	0.031*

P-value > 0.05 (Non-significant) as regards loss of knee motion, loss of reduction, delayed or non-union and pain during movement.

*P-value < 0.05 (Significant) as regards hardware removal and infection.

Table (3) show no significant difference between both groups as regards loss of knee motion, loss of reduction, delayed or non-union and pain during movement, but there is significant difference between both groups as regards hardware removal and infection.

4. Discussion:

Selecting the appropriate and effective method and materials for treating patellar fractures is a tough challenge for orthopedists. Surgical is a common method for the treatment of displaced patella fracture, of which tension band fixation is the current treatment standard. However, due to the complexity of patella fracture, there is no consistent conclusion on the best clinical treatment scheme at present [7].

Screws have recently been used for internal fixation of transverse patella fractures, which show better biomechanical stabilization than K-wires by resisting tensile loading throughout knee flexion [8]. Cannulated screw tension band is an improved technique based on the Kirschner wire tension band. Theoretically, the cannulated screw tension band has the advantages of stable fixation and implant protection [9].

The main goal of this study was to evaluate both functional and radiological outcomes of both techniques; cannulated screws with tension band and modified tension band wiring.

In our study 22 patients (73.3%) were males and 8 (26.7%) were females. Mean of age was 32.83 with range from 19 to 55 years. By

comparing our study with other studies; in the study of Liu et al. [10] there were 71 patients in the tension band with a cannulated screw (TBWCS) group, including 33 male and 38 female patients, with an age of (57:23 ± 8:67) years, and 75 patients in the tension band with Kirschner wire (TBWKW) group, including 31 male and 44 female patients, with an age of (60:74 ± 14:82) years. There was no statistical difference in gender ratio and age between the two groups. In the study Tan et al. [11] the patients were divided into MKTB and CSTB groups according to the surgical technique. The MKTB group comprised 29 patients: 22 men and 7 women. Mean age was 37.12±10.35 years (range 18–54 years). The CSTB group comprised 26 patients: 19 men and 7 women. Mean age was 35.96±10.75 years (range 18–54 years). In the study of Lin et al. [12] Sixty-three patients with transverse patellar fractures displaced less than 8 mm were included in this prospective, randomized, controlled trial, with 52 patients in the final data analysis. Thirty-two patients were operatively treated by with either two or three cannulated screws. Thirty-one patients were operatively treated by conventional open reduction using the modified tension band technique. There were no statistically significant differences between the two groups, including age, side, gender, fracture classification, mechanism, fracture displacement, and operative time to injury. The average age of the 52 patients was 51.7 years old (range, 22–76 years old).

In our study 5 patients (16.7%) had loss of knee motion, four of them were treated by K-wires, 5 patients (16.7%) had loss of reduction or implant failure, four of them were treated by K-wires, 6 patients (20%) had delayed or non-union, five of them were treated by K-wires, 10 patients (33.3%) had pain during movement, seven of them were treated by K-wires. By comparison between types of fixation among post-operative complication (loss of knee motion, loss of reduction, delayed or non-union and pain during movement) there was no statistically significant difference between (loss of knee motion, loss of reduction, delayed or non-union and pain during movement) among types of fixation, which is in agreement with the study of Liu et al. [10] which reported there was no significant difference in the incidence of knee joint movement limitation, traumatic arthritis, bursitis, displaced internal fixation, reduction loss, and delayed fracture healing between the two groups, but the total incidence of complications in the TBWCS group was lower than that in the TBWKW group.

In our study 9 patients (30%) had hardware removal (Table 3) seven of them were treated by K-wires and 7 patients (23.3%) had infection, six of them were treated by K-wires. By comparison between types of fixation among post-operative complication (hardware removal and infection) there was statistically significant increase

hardware removal in K-wires type and there was statistically significant increase infection in K-wires type. This was in agreement with the study done by Liu et al. [10] which reported the infective rate of patients in the TBWCS group was significantly lower than that in the TBWKW group. This was also in agreement with lazaro et al. [13] which reported a rate of 37% hardware removal due to prominent and symptomatic implants as a result of breakage, infection or continuous soft tissue irritation.

By Comparison between types of fixation among Bostman's score; in K-wire technique the score of 6 patients was excellent, in screw technique 12 patients was excellent, in K-wire technique 6 patients was good, in screw technique 2 patients was good, in K-wire technique 3 patients was poor (unsatisfactory), in screw technique 1 patient was poor. In the study of Liu et al. [10] at 1, 3, 6, and 12 months after the operation, the Bostman's score of the two groups of patients gradually increased with the time ($P < 0:05$), while the Bostman's score of the TBWCS group was higher than that of the TBWKW group. In the study Tan et al. [11] at the follow-up evaluation before removing implant in the MKTB group, according to the Bostman's grading system; 17 patients (59%) had an excellent result, 9 (31%) had a good result and 3 (10%) had a poor result. In the CSTB group; 22 (85%) patients had an excellent result and 4 (15%) had a good result. A significant difference was found in the rate of excellent outcomes between the 2 groups.

In a biomechanical analysis on the treatment of patella fracture with wire tension band by Lee et al. [14] a cannulated screw tension band has higher load-carrying capacity and rigidity and can absorb higher energy. However, Chengxue et al. [15] showed that there was no significant difference between cannulated screw and Kirschner wire tension band in improving Iowa knee joint score of patella fracture patients. Lin et al. [12] also found that after 12 months of treatment, there was no significant difference between cannulated screws and Kirschner wire higher energy. However, Chengxue et al. [15] showed that there was no significant difference between cannulated screw and Kirschner wire tension band in improving Iowa knee joint score of patella fracture patients. Lin et al. [12] also found that after 12 months of treatment, there was no significant difference between cannulated screws and Kirschner wire tension band in improvement of VAS score, knee joint mobility, flexion, and extension of patella fracture patients. Hoshino et al. [16] also reported that the failure rate of patella fracture fixation with a cannulated screw tension band was higher than that with the Kirschner wire tension band. Tension band in improvement of VAS score, knee joint mobility, flexion, and extension of patella fracture patients. Hoshino et al. [16] also reported that the failure rate of patella fracture fixation with a cannulated

screw tension band was higher than that with the Kirschner wire tension band. Tan et al. [11] also reported in the study that the cannulated screw tension band had a better curative effect in the treatment of patella fracture compared with the Kirschner wire tension band, and it reduced the occurrence of pain caused by implants and implant loosening, which is in agreement with our study (table 3)

However, some problems need to be paid attention to when using cannulated screws tension band to treat patella fracture. Patello-femoral articular surface congruity must be assessed by digital palpation and by fluoroscopy. The cannulated screws placed in the operation needs to be of appropriate size and can be completely embedded into bone. The head and tail of the screws must not penetrate through the upper and lower ends of the patella, thus ensuring the action of the tension band of steel wire and reducing the friction loss between the screw and steel wire, steel wire and patella.

The infected cases were treated by repeated dressing and antibiotic, the cases with implant failure and loss of reduction were reoperated for revision, the cases with cerclage and wire protrusion were treated operatively for irrigation, debridement and hardware removal. Our study had a number of limitations; the small number of cases, relative short time of follow-up and the two methods of fixations were not compared to other methods.

5. Conclusion and Recommendations:

Cannulated screws with tension band has a better functional and radiological outcomes and better curative effects on patella fracture, low incidence of complications, early start of postoperative functional exercise, and higher quality of life. From a biomechanical point of view; screw tension band has higher load-carrying capacity, rigidity and can absorb higher energy.

Modified tension band wiring technique despite being the traditional and most widely accepted method of transverse patella fracture fixation; this technique has certain distinct disadvantages, it showed significant increase in hardware removal and infection when compared to cannulated screws.

A future study with a large sample size and long term follow-up would provide a better evaluation of the studied fracture and treatment methods. The two methods of fixation (TBW and CSTB) should be compared to other methods of patella fracture fixation.

6. References:

1. Palmu, S., Kallio, P.E., Donell, S.T., Helenius, I., and Nietosvaara, Y. Acute patellar dislocation in children and adolescents: a randomized clinical trial. JBJS,2008. 90(3): p. 463-470.
2. Gwinner, C., Märdian, S., Schwabe, P., Schaser, K.-D., Krapohl, B.D., and Jung, T.M. Current concepts review: Fractures of

the patella. GMS Interdisciplinary plastic and reconstructive surgery DGPW,2016. 5.

3. Mao, N., Liu, D., Ni, H., Tang, H., and Zhang, Q. Comparison of the cable pin system with conventional open surgery for transverse patella fractures. Clinical Orthopaedics and Related Research®,2013. 471(7): p. 2361-2366.
4. Malik, M. and Halwai, M.A. Open reduction and internal fixation of patellar fractures with tension band wiring through cannulated screws. The journal of knee surgery,2014. 27(05): p. 377-382.
5. Chang, C.-W., Chen, Y.-N., Li, C.-T., Chung, Y.-H., Chang, C.-H., and Peng, Y.-T. Role of screw proximity in the fixation of transverse patellar fractures with screws and a wire. Journal of Orthopaedic Surgery,2018. 26(3).
6. Tscherne, H. and Oestern, H. A new classification of soft-tissue damage in open and closed fractures (author's transl). Unfallheilkunde,1982. 85(3): p. 111-115.
7. Matthews, B., Hazratwala, K., and Barroso-Rosa, S. Comminuted patella fracture in elderly patients: a systematic review and case report. Geriatric orthopaedic surgery & rehabilitation,2017. 8(3): p. 135-144.
8. Melvin, S.J. and Mehta, S. Patellar fractures in adults. JAAOS-Journal of the American Academy of Orthopaedic Surgeons,2011. 19(4): p. 198-207.
9. Alluri, R.K., Hill, J.R., Navo, P., Ghiassi, A., Stevanovic, M., and Mostofi, A. Washer and post augmentation of 90/90 wiring for proximal interphalangeal joint arthrodesis: a biomechanical study. The Journal of hand surgery,2018. 43(12): p. 1137. e1-1137. e10.
10. Liu, C., Ren, H., Wan, C., and Ma, J. Comparison of the Therapeutic Effects of Tension Band with Cannulated Screw and Tension Band with Kirschner Wire on Patella Fracture. Computational and Mathematical Methods in Medicine,2020.
11. Tan, H., Dai, P., and Yuan, Y. Clinical results of treatment using a modified K-wire tension band versus a cannulated screw tension band in transverse patella fractures: a strobe compliant retrospective observational study. Medicine,2016. 95(40).
12. Lin, T., Liu, J., Xiao, B., Fu, D., and Yang, S. Comparison of the outcomes of cannulated screws vs. modified tension band wiring fixation techniques in the management of mildly displaced patellar fractures. BMC musculoskeletal disorders,2015. 16(1): p. 1-10.
13. Lazaro, L.E., Wellman, D.S., Sauro, G., Pardee, N.C., Berkes, M.B., Little, M.T., Nguyen, J.T., Helfet, D.L., and Lorich, D.G. Outcomes after operative fixation of complete articular patellar fractures: assessment of functional impairment. JBJS,2013. 95(14): p. e96.
14. Lee, K.-H., Lee, Y., Lee, Y.H., Cho, B.W., Kim, M.B., and Baek, G.H. Biomechanical comparison of three tension band wiring techniques for transverse fracture of patella:

Kirschner wires, cannulated screws, and ring pins. Journal of Orthopaedic Surgery,2019. 27(3).

15. Chengxue, W., Baochang, Q., Xiangfeng, H., Yulong, H., Haipeng, Z., Tiecheng, Y., and Lei, T. A retrospective comparison of the modified tension band technique and the parallel titanium cannulated lag screw technique in transverse patella fracture. Chinese Journal of Traumatology,2014. 17(4): p. 208-213.
16. Hoshino, C.M., Tran, W., Tiberi III, J.V., Black, M.H., Li, B.H., Gold, S.M., and Navarro, R.A. Complications following tension-band fixation of patellar fractures with cannulated screws compared with Kirschner wires. JBJS,2013. 95(7): p. 653-659.