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Metallic Implants for Patellar Fracture Fixation: A Systematic Review

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ABSTRACT

Background: Although tension band wiring is the traditional method to fix the transverse patellar fracture, there are many published studies regarding the use of other metallic implants to fix the patellar fracture. This study aims to find out the good choice of fixation by performing a systematic review of the literature to compare clinical and radiological outcomes of the studies that use metallic implants to fix transverse patellar fractures.

Methods: The following keywords (patella cerclage, patella wire, patella plate, patella fixation, tension band) were used to perform a systematic search of literature until 2021. All abstracts were reviewed, and the selection of these abstracts was then performed based on the inclusion and/or exclusion criteria.

Results: A total of 19 studies involving 1264 patients were included (623 males and 641 females). The tension band with K wires method was the most used method in the studies followed by tension with cannulated screws, plates, and lag interfragmentary screws respectively. 95.4 % of patients had a complete union. TBCS had lower postoperative complications, less hardware failure, and short healing time, but no significant difference between TBCS and TBKW regarding the range of motion and operative time.

Conclusion: TBCS technique had a low risk of hardware failure and complication in comparison to the TBKW technique while no superior method regarding ROM and operative time. On the other hand, plate osteosynthesis and isolated interfragmentary screws may provide other choices for the fixation of transverse patella fractures but it needs more trials and studies to be confirmed to be effective.

Keywords: patella cerclage, patella wire, patella plate, patella fixation, tension band.

INTRODUCTION

The patella is a crucial component of the extensor mechanism of the knee, with one of the thickest articular cartilages in the human body. Its primary function is to increase the moment arm of the extensor mechanism of the quadriceps by 30%. Fractures of the Patella account for about 1% of skeletal injuries. Patellar fractures are classified descriptively as transverse, vertical, comminuted, marginal, or osteochondral. Patellar fractures may be displaced (step-off >2 to 3 mm and fracture gap >1 to 4 mm) or non-displaced [(1)].

Most non-displaced fractures are managed conservatively. Surgical management is indicated when the extensor mechanism of the knee is disrupted or the articular congruity is affected [(2)]. Because of the high tensile and compressive forces subjected to the patella, adequate and rigid fixation and anatomical reduction by implants are mandatory [(3)].

Surgical approaches are variable and could be longitudinal, transverse, or minimally invasive. A longitudinal midline incision is the most preferred approach for good exposure for the patella allowing good confirmation of reduction. In contrast, the transverse approach provides reasonable exposure for patella and extensor mechanism ligaments and good cosmetic results [(4,5)]. Zhou describes a percutaneous technique providing good rigid fixation small incisions [(6)]. Another minimally invasive technique using arthroscopy was reported for a good vision of the articular surface [(7, 8)].

Implants are numerous and can be divided into two main categories metallic and non-metallic. Metallic implants include tension band wiring, tension band on cannulated screws, interfragmentary screw fixation, and cerclage [(9), (10)]. Non-metallic implants include suture materials and bio-absorbable cannulated screws [(11)]. Combined techniques and plate osteosynthesis were also described [(12, 13)].

This systematic review aimed to provide a piece of evidence about the best metallic implant to fix simple transverse patellar fractures. We have analyzed and compared the clinical, radiological, and functional outcomes and complications of patients treated with different techniques of fixations using metallic implants.

MATERIALS AND METHODS

This systematic review was conducted according to the guidelines presented in the PRISMA Statement (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) (figure 1) [(14)]. An initial search in the following databases: Google Scholar, EKB (web of science, Elsevier), and PubMed. The following Mesh entries were used for research articles patella

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cerclage, patella wire, patella plate, patella fixation, and tension band. The research was restricted to studies of acute, simple, closed patella fractures treated by surgical fixation by any metallic implant. All cadaveric, biomechanics, histological, technical notes, case reports, Non-English language, open patellar fracture, and associated with other fracture studies were excluded. Studies using non-metallic or hybrid implants (metallic and non-metallic) were also excluded.

After initial research, duplicate studies were removed, and eligible full-text studies were processed for data extraction and analysis. Full texts were reviewed, and data were extracted, including the following: author name, type of fracture, year of publication, study type, number of patients, method of fixation, surgical technique details, and duration of follow-up. Studies outcomes were reviewed for clinical and radiological parameters: fracture reduction, union time, knee function, infection, hardware problems, and complication.

The quality and bias of the included studies were assessed using The Methodological Index for Nonrandomized Studies (MINORS) checklist (figure2) [15]. Data were collected in an Excel master sheet, coded, entered, and analyzed using EPI-INFO medical statistical package and computer medical software SPSS version 23 (Chicago, Inc. USA). After pooling the collected data from the desired search studies, the relative risk of each of the intended outcome measures of interest was calculated, and a comparison between the literature was estimated.

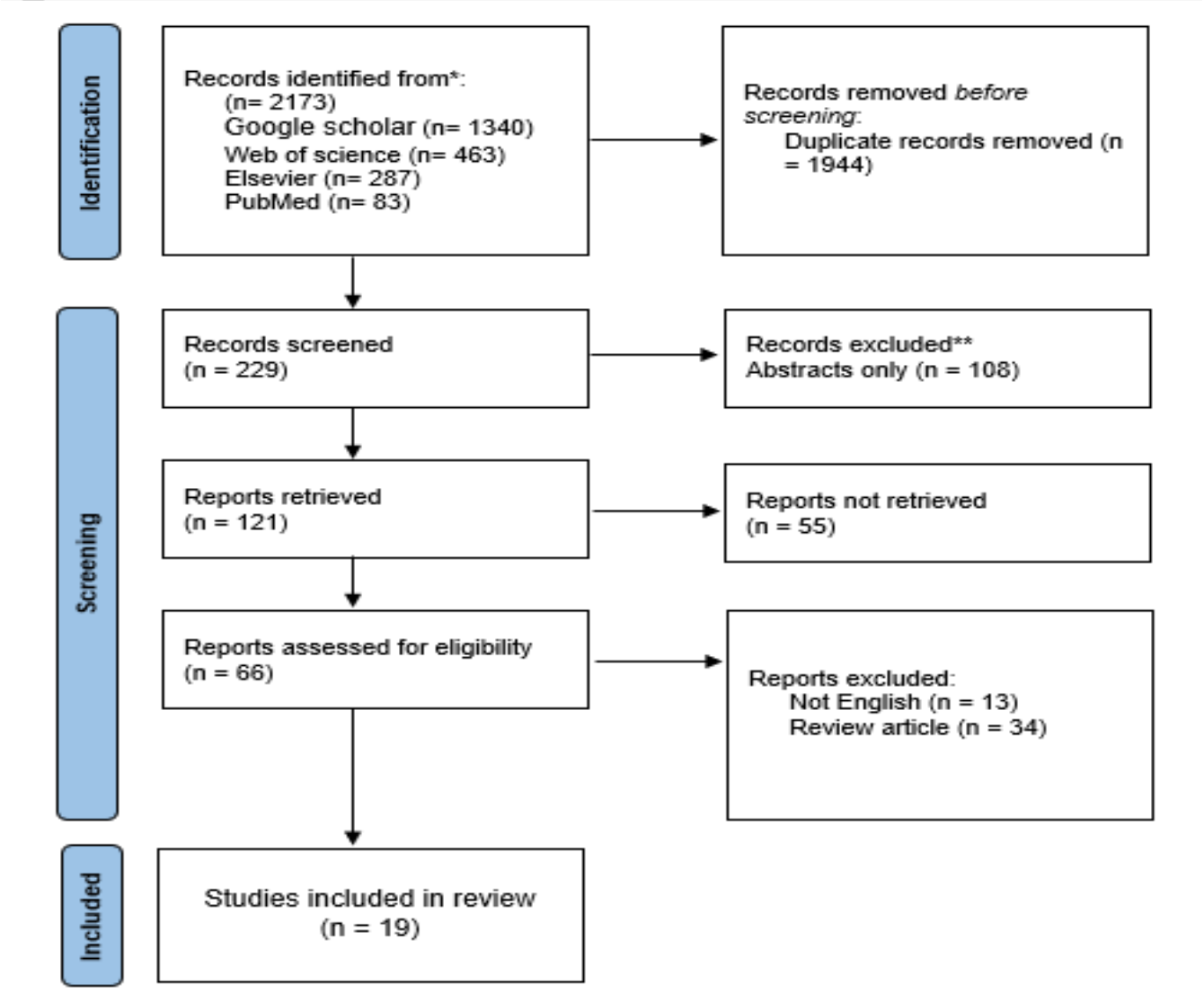

Figure 1: PRISMA flow diagram of the literature search

Surgical techniques

The surgical techniques varied between studies. The most frequently used method was the tension band with K wires. Placement of two parallel wires perpendicular to the fracture line after reduction. Stainless steel wire or titanium cable passed behind K wires to form a vertical figure of eight; then the cable tensioned and tightened slowly using a clamp or twister and embedded into deep tissues [(16)].

The tension band cannulated screws technique uses two longitudinal parallel guide wires to pass through the patella perpendicular to fracture, and the patella was drilled over guide wires using a cannulated drill bit. 4 or 4.5 mm cannulated partially threaded steel or titanium screws of measured length placed over guidewires directed downwards then guidewires removed. Steel wire was inserted through cannulated screws in the figure of eight, twisted slowly and gently, and embedded into deep tissues [(17)].

Interfragmentary cannulated screws were inserted over guidewires percutaneously. Screws were cannulated partially threaded 4.0 mm titanium [(18)]. A new technique using small types of plates, using an open approach but with different shapes and materials (X-plate, claw, adjustable patella grapple), was also studied [(19)(13)(20)].

Patient-reported outcome measures

We statistically analyzed clinical and radiological outcomes for subgroups TBCS and TBKW. Outcomes statistically analyzed were operative time, healing (union) time, post-operative ROM, hardware failure, and complications. Unfortunately, we could not analyze knee function by scores (Bostman score and Lysholm score) because of the lack of comparable data between selected studies.

Study ID	A clearly stated aim	Inclusion of consecutive patients	Prospective collection of data	Appropriate endpoints	Unbiased assessment of study endpoint	Appropriate follow-up period	Loss to follow-up less than 5%	Prospective calculation of study size	Total
Tian Y. et al. [1]	2	1	0	2	1	2	2	0	10
Mao et al. [2]	2	2	0	2	2	2	2	0	12
Rathi et al. [3]	2	2	0	2	1	2	2	0	11
Cho et al. [4]	2	2	0	2	2	2	2	0	12
Kim et al. [5]	2	2	0	2	1	2	2	0	11
Malik [6]	2	2	0	2	1	2	2	0	11
Wang et al. [7]	2	2	1	2	2	2	2	0	13
Yan et al. [8]	2	2	1	2	2	2	2	0	13
Hao et al. [9]	2	2	0	2	2	2	2	0	12
Lin et al. [10]	2	1	0	2	1	2	2	0	10
Tian et al. [11]	2	2	0	2	2	2	2	0	12
Tan et al. [12]	2	2	0	2	1	2	2	0	11
Hsu et al. [13]	2	2	0	2	2	2	2	0	12
Yang et al. [14]	2	2	0	2	1	2	2	0	11
Meng et al. [15]	2	2	0	2	1	2	2	0	11
Liu et al. [16]	2	2	1	2	2	2	2	0	13
Vicenti et al. [17]	2	2	1	2	2	2	2	0	13
Hançerli et al. [18]	2	2	0	2	2	2	2	0	12
Huang et al. [19]	2	1	0	2	1	2	2	0	10

Table 1: **Literature appraisal using the MINORS assessment tool.**

RESULTS

The initial search resulted in 2173 articles from three databases: 1340 articles from Google Scholar, 750 from EKB (web of science= 463, Elsevier= 287), and 83 articles from PubMed. Of these 2173 articles, 19 studies were included in this meta-analysis. The PRISMA flow diagram demonstrates the number of studies identified, screened, included, and excluded and the reasons for exclusion [14]. The Methodological Index for Nonrandomized Studies (MINORS) checklist was used to evaluate the quality of all included studies[15]. The mean MINORS score was 11.58 (range 10 to 13).

This study analyzed metallic implants (k-wire tension band-cannulated screws tension band isolated interfragmentary cannulated screws-plates-cerclage). TBKW and TBCS have been heavily reported in the literature with plentiful data and results, so we did a meta-analysis for these two groups; we investigated operative time, ROM, healing time hardware failure, and complications. This meta-analysis included 10 retrospective studies,8 prospective studies, and only one randomized controlled trial. Other metallic implants had insufficient data for a meta-analysis.

Demographic data

The pooled number of patients treated with metallic implants for patellar fracture fixation and included in this systematic review was 1264 (623 males and 641female). The mean age at surgery was 50.89 ± 8.58 (23 and 77 years). They were followed up for a mean of 20.58 ± 7.52. the fracture type in all patients was closed simple transverse. Fall from height was the most common cause of patellar fracture, followed by traffic accidents, sports injuries, and others.

Post-operative Outcomes

Operative Time: The operative time between TBCS and TBKW was not significantly different. (OR = 1.93, 95% CI: (-1.88, 5.73)), with high heterogeneity (p=0.32) figure 2.

The shortest operative time (mean 46.39±3.83 minutes)was related to the TBCS group in the **Tian** study[16]. The longest time (mean 62±3.52 minutes)was also related to the TBCS group in the **Tan** study [21].

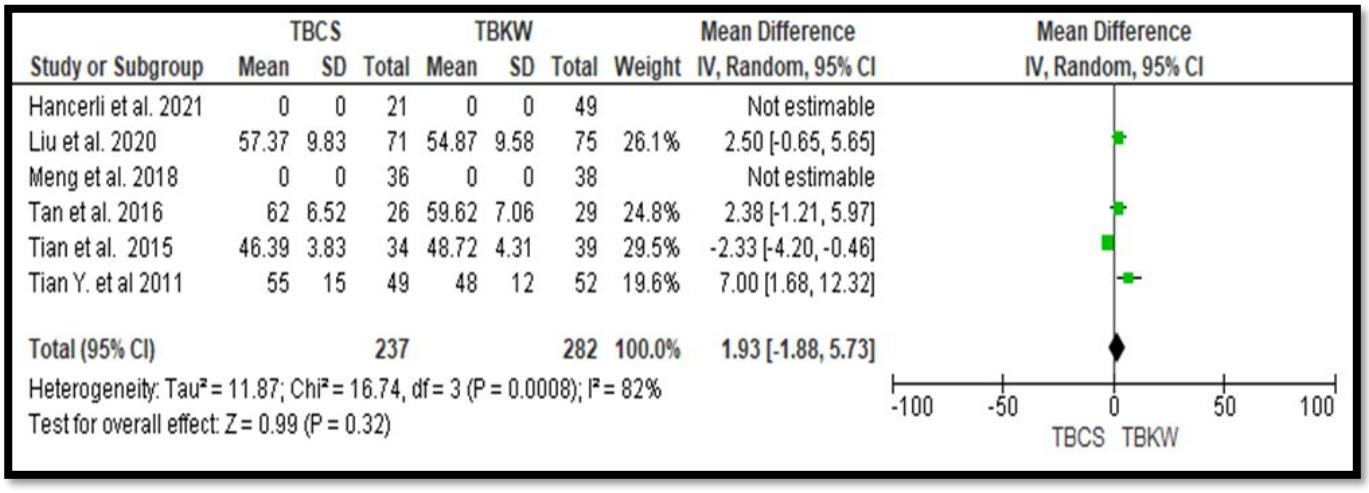

Figure 2: Forest plot of operative time scores.

Healing time: Patients undergoing TBCS had statistically more favorable outcomes than those treated by TBKW with a very highly significant difference (P<0.00001) (OR = -0.36, 95% CI: (-0.48, -0.25)). The shortest period (mean 1.72 months)was related to the TBCS group in the **Hancerli** study[22]. the longest period for union (mean3.3 ±0.7 months) was related to the TBKW group in the **Liu** study (**figure 3**) [23]

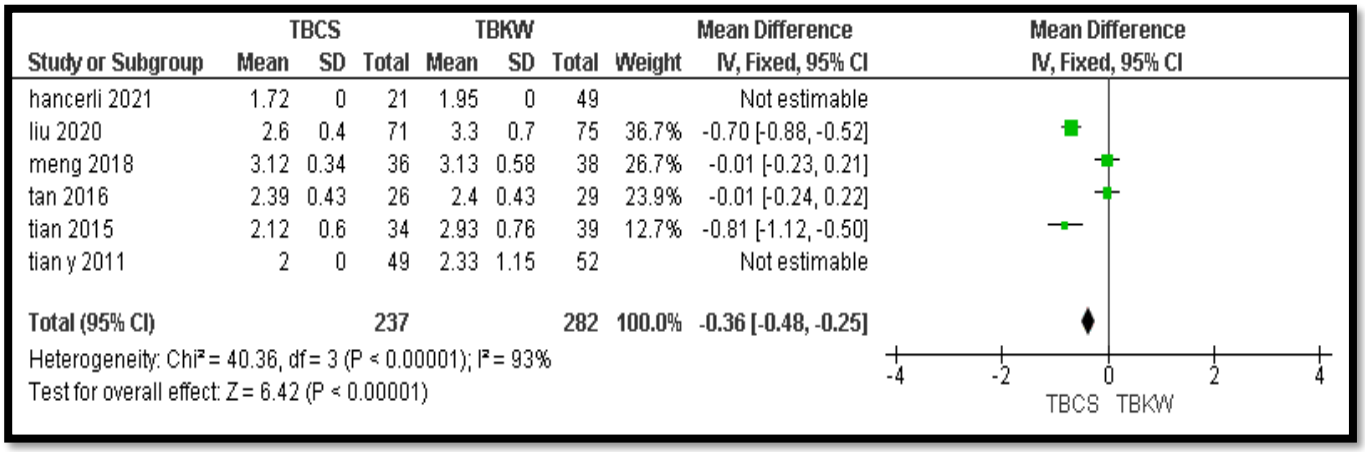

Figure 3: Forest plot of healing (union) time.

Range of Motion; regarding angles of ROM, the pooled analysis of the included studies showed no significant difference between TBCS and TBKW (p=0.06) **Figure 4**.

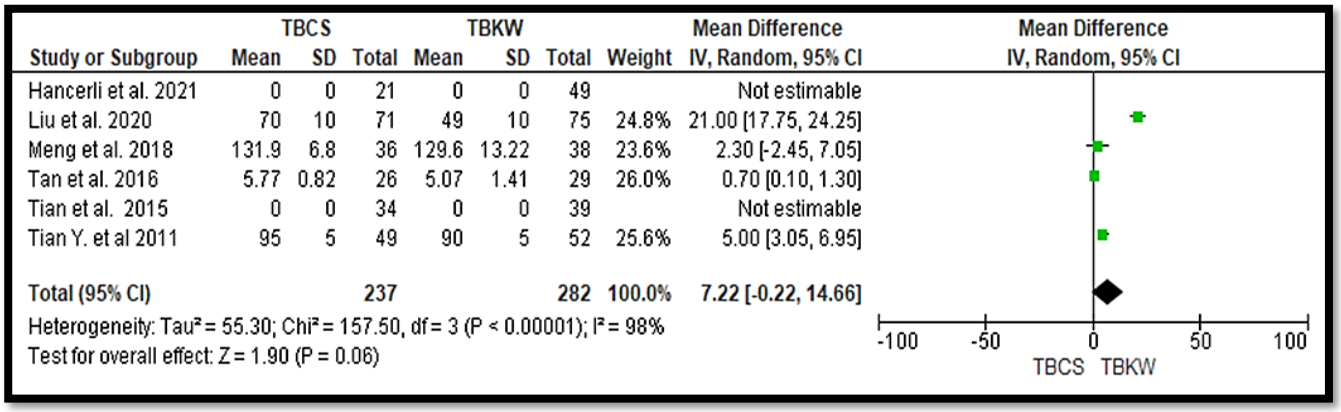

Figure 4: Forest plot of range of motion scores.

Complications and Hardware Failure; Non-favorable outcomes were reported in all studies. The risk of complications with TBKW was statistically higher than that with TBCS (OR = 0.26, 95% CI) (p=0.004) figure 5. A further meta-analysis of complications showed that hardware failure was more persistent with TBKW than TBCS (OR = 0.09; 95% CI) (p=0.004) **Figure 6**.

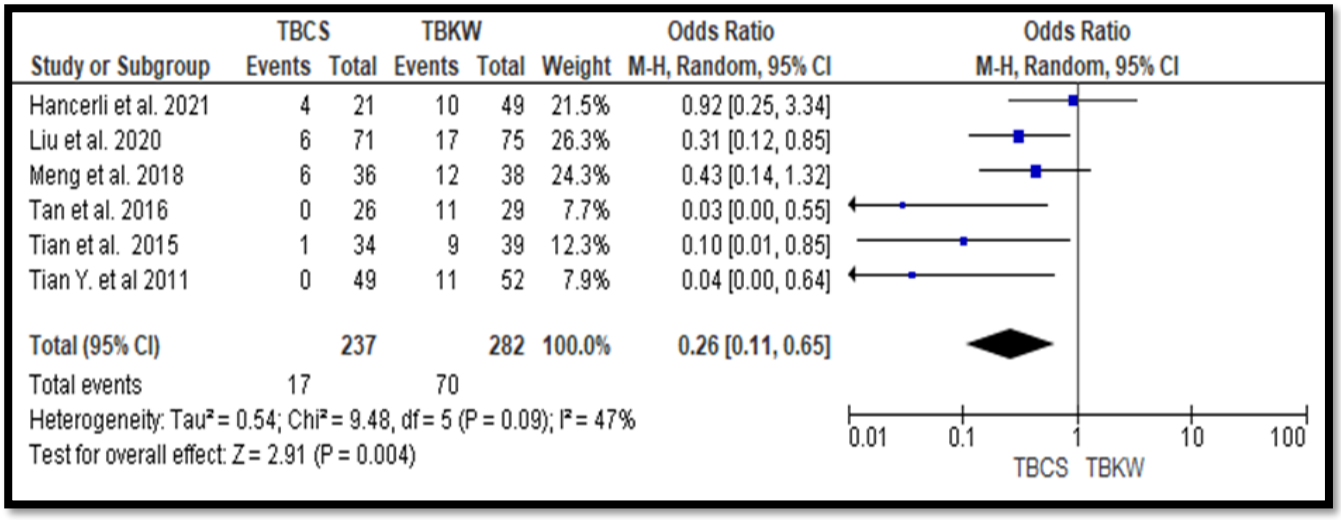

Figure 5: Forest plot of range of motion scores of complication rates.

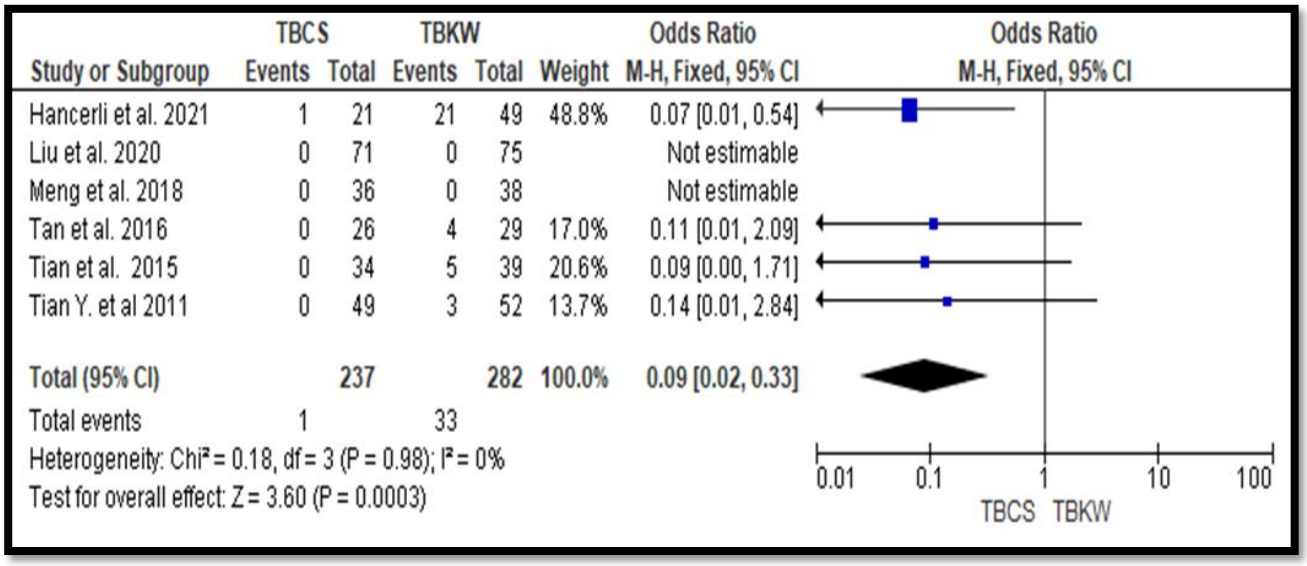

Figure 6: Forest plot of hardware failure rates.

DISCUSSION

In this meta-analysis, the management of displaced simple closed transverse patellar fractures in adults by the tension band and cannulated screw (TBCS) technique had a lower risk of hardware failure and complications than the tension band and Kirschner wires (TBKW) technique. Nevertheless, other radiological and clinical outcomes were comparable in both groups. Other methods of metallic implants reported good outcomes; however, we could not analyze them due to the limited number of studies.

.Surgical management is necessary for displaced fractures of the patella that affect the articular congruity and/or extensor mechanism. Rigid fixation with anatomical articular surface reduction is required since the patella is subjected to high tensile forces, with an ongoing need for the early mobilization of the knee joint[24].

Many treatment methods were used in the surgical treatment of simple transverse patellar fractures in adults. TBKW was the most commonly used method[24]. Other methods such as cannulated screws, TBCS, plates and non-absorbable suture osteosynthesis, arthroscopy-assisted reduction, and non-metallic implants (absorbable screws, sutures) were also reported[11]. Patellectomy, partial or total, can be done in highly comminuted fractures where fixation is not applicable [24].

Operative time, ROM, functional outcome scores, healing time, hardware failure, and complications were investigated and compared. In this meta-analysis, only metallic implants were included (TBKW, TBCS, interfragmentary cannulated screws, and plates). Two methods (TBKW and TBCS) were thoroughly reported in the literature. Although TBKW was commonly used, soft tissue irritation was constantly problematic. TBCS was found to overcome this issue and provide less irritation and need for implant removal [25,26].

A total of 19 articles (1264 patients) that reported the treatment of closed, simple transverse patellar fractures in adults were included in this meta-analysis. The tension band with Kirshner wires method was the most used method in the studies, followed by tension with cannulated screws, plates, and lag interfragmentary screws, respectively.

Meng *et al.* retrospectively compared three methods (TBKW, TBCS, and X plate). The three groups had comparable patients, and all methods had favorable outcomes. However, the rate of implant complications was higher in TBKW than in TBCS and X plate (31.6 %,16.7 %, and 5.9%, respectively). Hardware migration was only reported in TBKW (39.5%)[19].

Hoshino *et al.* analyzed 448 patients retrospectively (70% received TBKW, and 30% received cannulated screw) with mixed fracture patterns. The overall incidence of fixation failure was slightly lower with TBKW than CS (7.5% and 3.5 %, respectively), yet that was not statistically significant (P 0.065). Symptomatic hardware irritation that led to removal was frequently reported in TBKW than CS (P 0.002)[26]. In another study that compared TBKW versus CS. **Wang *et al.*** reported that the TBKW group had more complications (wire migration, skin irritation, and need for revision surgery)[18]. Cannulated screws (without tension bands) were reported in a few studies; we could not investigate their outcomes in this meta-analysis due to the limited number.

Our pooled analysis showed a significant difference between post-operative complications in TBCS and TBKW (P 0.004). The TBCS had lower post-operative complications than TBKW. **Liu *et al***. prospectively compared TBKW (75 patients) to TBCS (71 patients); all had displaced non-comminuted closed fractures. They concluded that TBCS had better functional scores, quality of life, post-operative pain, and lower complication rate than TBKW. However, operative time was not significantly different[(23)].

In a retrospective study by **Tan *et al.***, they compared TBCS (26 patients) and TBKW (29 patients). All had transverse patellar fractures. 92% of patients in the TBCS group had a ROM of >120° compared to 69% in the TBKW. The Mean scores of ROM were significantly better in the TBCS group (5.77±0.82) than in TBKW (5.07±1.41) (P=0.031) [(21)]. However, in our metanalysis, ROM was still better in TBCS than TBKW with no statistical significance (P=0.06).

A prospective study by **Hao *et al.*** reviewed 29 patients with simple transverse fracture patella treated by claw-like plate. They reported a good range of motion (5° extension/145°flexion) at 12 months postoperatively[(13)]. **Yan *et al.*** retrospectively compared 45 patients treated with an Adjustable patella grapple plate (APG) to 33 patients treated with TBCS. All had transverse patellar fractures. Outcomes were comparable except for the short operative time in the APG group. However, 24% of patients in the APG group reported metalwork irritation symptoms that necessitated removal[(20)].

At last, this study tried to give an overview of all types of metallic implant fixators on the patella on the literature provides another alternative method of fixations other than the traditional tension band with less irritation and more rigidity. The lack of studies concerning rare, new, and costly methods of fixation, e.g., plate fixators, was an obstacle in our study, and lack of direct comparative results, so we were more concerning the two primary commonly used methods with partly numerous data (TBCS vs. TBKW) trying to find out which is better regarding the outcome.

CONCLUSION

TBCS technique had a low risk of hardware failure and complication compared to the TBKW technique, while no superior method regarding ROM and operative time. On the other hand, plate osteosynthesis and isolated interfragmentary screws may provide other choices for the fixation of transverse patella fractures, but it needs more studies to prove their safety and effectiveness.

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