

Outcome of Transverse Patella Fractures Fixed With Cannulated Screws and Stainless Steel Tension Band Wiring

Haytham Abdel-Moneim Abdel-Moneim (✉ haa08@fayoum.edu.eg)

Fayoum University Faculty of Medicine <https://orcid.org/0000-0003-4819-0715>

Mohammed Ahmed Moussa

Fayoum University Faculty of Medicine

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Abstract

Background: Tension band supplemented by K-wires has long been the definitive technique for patellar fractures fixation. However, it is not without drawbacks. The stainless steel cable-cannulated screw tension band technique, may shorten healing time, decrease the complications and provide early range of knee motion. Herein, the current study evaluates the clinical and radiological outcome of this surgical modality.

Methods: This prospective study was conducted on 21 patients (13 males and 8 females) with transverse fracture patella from June 2017 to April 2021. The surgical fixation consisted of two 4.0-mm parallel partially threaded cannulated cancellous screws with a figure-of-eight stainless steel tension band wiring. Follow-up was at least 10 months. Assessment criteria included the Lysholm score for knee function, ROM, VAS for pain, fracture reduction, fracture healing time, and complication rates. After 3 postoperative weeks, slab was removed and immediate rehabilitation were commenced.

Results: The average Lysholm scores were 82.9 ± 4.4 SD, 87.8 ± 5.3 SD, and 92.7 ± 3.6 SD after 3, 6, and 10 months, respectively. VAS scores for pain were 2.6 ± 3.0 SD, 1.4 ± 2.6 SD, and 0.5 ± 2.3 SD at 3, 6 and 10-month, respectively. The patients had gained total ROM after 3, 6 and 10 months. The mean fracture healing time was 2.1 months (range, 1.5 - 3.1 months). Two patients experienced skin irritation by wire tails.

Conclusion: The stainless steel cannulated screws and tension band construct provides a good alternative in treatment of transverse patellar fractures. It could yield stable fixation, low complication rate while providing early mobilization and accelerated rehabilitation.

Introduction

Patellar Fractures are severe injuries that comprise about 1% of all skeletal fractures and are common within the age group of 20–50 years [1]. Transverse fractures, are the commonest type and usually happen through indirect trauma [2].

Selecting the ideal modality for managing patellar fractures represents a serious task [3, 4]. Fractures with displacement more than 2 mm or articular step off can be treated either closed or open with complementary fixation. It has been globally accepted that fractures with less than 8 mm displacement are the only ones that are suitable to the closed reduction and fixation techniques [5–7].

Tension band supplemented by longitudinal K-wires has long been the definitive technique for fixation of patella. However, it is not without drawbacks, such as bad reduction, loosening, and skin irritation [1, 3]. So the stainless steel cable-cannulated screw tension band technique could be alternative fixation method. Depending on the fact that the addition of the screws to the tension band technique provides compression throughout the ROM and by resisting the tensile loading force during terminal extension.

This technique shortens the fracture healing time, decreases the complications and provides early range of knee motion [8, 9], low rates of anterior knee irritation and implant failure [10].

Previously conducted biomechanical studies have revealed that the cancellous screws alone or in combination with tension band wiring provides stable fixation as long as the fracture is well reduced with less than a 1-mm gap between the fracture fragments [7]. As such, Benjamin et al. have recommended screw fixation for transverse patellar fractures in patients with adequate bone stock [11]. Similarly, studies by Dargel et al. and Carpenter et al. have demonstrated that, screw fixation is more stable and rigid than the modified tension band wiring technique [12, 13].

Herein, the current study evaluates the clinical and radiological outcome of the cannulated screws and tension band construct in fixation of transverse patellar fractures. Furthermore, it assesses the described technique while providing early mobilization and accelerated rehabilitation.

Material And Methods

This prospective study was conducted on 25 patients with transverse fracture patella from June 2017 to April 2021. The last case was operated upon on May 2020. The surgical fixation consisted of two 4.0-mm parallel partially threaded cannulated screws with a figure-of-eight tension band made using a 1.25-mm stainless steel wire. Four patients were lost to follow-up. So, we had reviewed 21 patients, with AO/OTA 34-C1 fractures in 15 patients and 34-C2 fractures in six. The study included 13 males and 8 females, aged 20 to 69 years (mean, 44 years). Follow-up was at least 10 months (range, 10-19-months).

Mechanism of injury included fall accidents (18 patients) and car accidents (3 patients). Operations were considered when the articular displacement was greater than 2 mm or fragment separation was greater than 3 mm on radiographs. The injury-operation interval was 1 to 8 days (mean, 2 days).

The inclusion criteria were (1) AO/OTA 34-C1 fractures, ie, patellar fractures primarily with a transverse fracture line; and (2) AO/OTA 34-C2 fractures, ie, transverse fractures with a single additional fragment created by a longitudinal fracture line. Assessment criteria included the Lysholm score for knee function, ROM, pain score using VAS, fracture reduction, fracture healing time, and complication rates.

Surgical technique

The operations were performed via an anterior longitudinal incision. Then routine dissection and reduction of the fracture were carried out. With a large towel clamp or Spanish clamp under intraoperative fluoroscopy, we drilled two K-wires (2.0-mm diameter) in parallel from the lower to superior pole of the patella, with a 2-cm space and a 5- to 10-mm articular surface. The K-wires penetrated the superior cortex. The position of the K-wire was determined using intraoperative fluoroscopy. One K-wire was first replaced by guide pin. We drilled along the guide wire with a cannulated bit and, after measuring its depth, screwed a 4.0-mm stainless steel cannulated compression screw along the guide wire. The screw head remained proud of the patella cortex, and the proximal end of the screw should be close to, or embedded within the

patella. We then screwed in the second cannulated screw and alternately tightened the screws. We removed the guide wire and threaded a 1.3-mm-diameter stainless steel cable through each of the cannulated screws. We then tightened the cable anterior to the patella to form the tension band, fixed the cable with cable clamps, and cut off the excessive cable (Fig. 1).

Postoperative protocol

Patients were put in a high above knee slab for 3 weeks with quadriceps femoris exercises soon after the operation, but without weight bearing. After 3 weeks slab was removed, and passive joint flexion and extension exercises were commenced. Then, active joint flexion and extension exercises were started 3 days later. Five weeks after the operation, patients were permitted to perform partial-weight bearing walking, and conventional radiographs were obtained, including lateral and AP patellar radiographs. Seven weeks postoperative, patients were permitted to perform full ambulation. Patients were reexamined at 1, 2, 3, 6, and 10 months after the operation to observe the fracture healing.

Statistical analysis

Results were analyzed by SPSS® statistical software (SPSS Inc, Chicago, IL, USA). Logistic regression was used to determine whether age, gender, fracture type and injury mechanisms had an influence on the postoperative general results, clinical improvement, implant evaluation and radiographic outcome. The impact of age, gender, fracture type, interval between injury and surgery, and health status on Lysholm scores and complications had been studied. The differences were considered to be statistically significant when p values were less than 0.05.

Results

Follow-up

The mean follow-up was 13 months (range, 10-17 months). The patients were followed up as follows; at immediate postoperative hospital stay, weekly during first postoperative month, every two weeks till the end of 3rd month, then every month till the last follow-up.

General results

The mean period between injury and operation was 16 hours (range, 5- 72 hours). The mean operation time was 70 min (range, 45 to 100 min), the mean fluoroscopy time was 0.5 min (range, 0.25 to 1 min), and the mean hospital stay was 2 days (range, 1 to 3 days). Tourniquet was applied during surgery, and no patient required blood transfusion postoperatively. No intraoperative complications had occurred.

Clinical results

The average Lysholm scores were 82.9 ± 4.4 SD, 87.8 ± 5.3 SD, and 92.7 ± 3.6 SD after 3, 6, and 10 months, respectively. After each follow-up period, analysis of the Lysholm score subgroups revealed that a lower mean difference of pain (25 points) and a lower mean difference of squatting scores (5 points)

didn't affect Lysholm scores. Furthermore, there were no differences in Lysholm scores based on the initial fracture type, mechanism of injury, age or gender (Tables 1, 2).

Table 1

Subgroup analysis showing correlations between different factors and the results.

| Factors | P value | | | |
|----------------------------|------------------------|-----------------------------|---------------------------|---------------------------------|
| | (Variables) | | | |
| | General Results | Clinical Improvement | Implant Evaluation | Radiographic Improvement |
| Age | 0.74** | 0.29** | 0.44** | 0.08** |
| Gender | 0.67** | 0.58** | 0.48** | 0.62** |
| Fracture type | 0.11** | 0.24** | 0.39** | 0.27** |
| Mechanism of injury | 0.34** | 0.59** | 0.26** | 0.54** |
| * Significant effect | | | | |
| ** Non significant effect | | | | |

Table 2

The functional outcomes among the study group were measured as regards Lysholm scores and complications, using univariate analysis.

| Factors | P value | |
|-------------------------------------|-----------------------|----------------------|
| | (Variables) | |
| | Lysholm scores | Complications |
| Age | 0.26** | 0.07** |
| Gender | 0.06** | 0.54** |
| Fracture Type | 0.04** | 0.09** |
| Interval Between Injury and Surgery | 0.91** | 0.85** |
| Health Status | 0.11** | 0.04** |
| ** Significant effect | | |
| ** Non significant effect | | |

VAS scores for pain were 2.6 ± 3.0 SD, 1.4 ± 2.6 SD, and 0.5 ± 2.3 SD at 3, 6 and 10-month, respectively. The patients had gained significant flexion and total ROM after 3, 6 and 10 months. The average flexion values were $109.0 \pm 10.5^\circ$ SD, $138.3 \pm 10.9^\circ$ SD, and $140.4 \pm 10.3^\circ$ SD, after 3, 6 and 10 months respectively. The average total ROM values were $105.0 \pm 11.8^\circ$ SD, $135.9 \pm 10.4^\circ$ SD, and $139.1 \pm 10.6^\circ$ SD, after 3, 6 and 10 months respectively.

The wounds had healed nicely in all patients at a mean time of 4 ± 2 SD weeks (range, 2-6 weeks). Moreover, there was improvement of symptoms and signs gradually during the regular follow-up. The knee pain, and oedema subsided gradually.

Radiological results

The mean fracture healing time was 2.1 months (range, 1.5 - 3.1 months) with adequate fracture reduction. All fractures had healed well, and the mean postoperative fracture spacing of the articular surface was 0.3 mm (range, 0–2 mm).

Implants evaluation

Fixation with proper rigidity was accomplished and confirmed with image intensifier. The two partially threaded cannulated screws with the tension band used for fixation were rigid enough throughout the bone union process in all patient, with no failure had occurred.

Complications

Complications rate was 2/21 (9.5 %). Two patients experienced skin irritation from wire tails, one of them required implant removal at 9 months postoperatively. There was no quadriceps atrophy, incomplete terminal extension of the knee, loss of fixation, or patient dissatisfaction with overall knee function at final follow-up.

Discussion

Furthermost patellar fractures are usually managed operatively. The tension band technique accompanied by longitudinal K-wires has always been the core way for fixation of such injuries [1, 3, 4, 8]. Numerous investigations have shown that the cancellous screws supplemented with tension band wiring yields constant fixation so long as the fracture is properly reduced [7, 15].

Cannulated screw tension band technique was applied for patellar fractures in some studies, in order to provide proper reduction, direct fracture compression and earlier ROM [1]. No loss of fixation had occurred among their patients [1]. Similarly, no hardware loosening, nor loss of fixation had been reported in the current study. The probability of cable-cannulated screw loosening is trivial owing to the dense cancellous bone of the patella and the fact that the distal end of the cannulated screw is threaded. In addition, the cable tightly attaches to the patellar surface to limit the separation of fracture fragments as a tension band technique [1].

In the present series, patients were put in a postoperative high above knee slab for 3 weeks, with quadriceps contraction exercises commenced soon after operation without weight bearing. After 3 weeks, slab was removed and immediate passive ROM were encouraged to decrease muscular atrophy and intra-articular adhesions. Besides, it may improve articular cartilage nourishment and fracture healing process.

Tian et al. permitted active joint flexion and extension exercises 7 days after the operation. One month later, their patients were permitted to perform partial-weightbearing. Patients were permitted to perform full ambulation after 8 weeks [1].

Bhati et al. encouraged patients to perform isometric knee extension and straight leg elevation exercises. Partial weight-bearing was permitted up to suture removal. Knee flexion was allowed to less than 45 degrees in the first week and gradually increased to 90 degrees in the 2nd week. The patients were provided with an exercise chart [16].

Posner et al. patients were put in a 24-hour hinged knee brace which was locked at full extension. Immediate weight-bearing as tolerated with the brace was allowed. At 2-week postoperative visit, formal physical therapy including progressive and controlled active knee flexion movements were commenced. At 8-week postoperative visit, full ROM and active knee flexion was allowed [17].

Lin et al. didn't apply any external immobilizers to any of their patients. Patients performed quadriceps contraction exercises soon after the operation. Unrestricted passive ROM was started early postoperatively, depending on the patient's pain tolerance. Active ROM was encouraged by 3 weeks postoperatively, and full weight-bearing was started by 8 weeks in their study [7].

Skin irritation is the main complication of the K-wire tension band. In some studies, symptoms attributable to wire irritation necessitated removal in approximately 15% of the cases [18, 19]. In our study two patients (9.5 %) experienced skin irritation generated by wire tails, and one of them required implant removal at 9 months postoperatively. With the cable-cannulated screw tension band technique, the tail of the cannulated screw tightly attaches at the superior or inferior pole of the patella, and the screw threads are not exposed to the patellar surface. Furthermore, the diameter of the cable is only 1.3 mm, and it closely attaches to the patellar surface after being tightened reducing the risk of skin irritation and postoperative activity discomfort [2].

An article reported that painful hardware was the most common complication which occurred in 30.1 % of patients, and tension band loosening and migration was the second major complication, seen in 11.5 % of patients [7]. Although symptomatic implant irritation is not a serious complication, but it delays rehabilitation and potentially leads to stiffness that may require a second intervention with additional hospitalization and cost [7].

According to Baydar et al. [20], cannulated screws are more resistant to distraction forces than the tension band techniques to manage patellar fractures. Additionally, the flexibility of K-wires can neutralize

a part of the force that should act on the fractured bone leading to reduced compressive forces on fracture site, unlike cannulated screws tension band fixation [21, 22].

A disadvantage of the screws tension band fixation method includes its technical difficulty [21]. For example, it has been noted that it can be difficult to place K-wires appropriately with a minimally invasive technique, and it may have a substantial learning curve [7].

Unfortunately, the current study had some limitations. First, the small number of patients. Second, the short duration of follow-up. Third, the lack of comparison to the traditional technique of tension band technique. A fourth limitation is the stainless steel material used in the study. Although it is cheaper, but it is weaker in comparison to titanium screws tension band system and interferes with MRI.

Conclusion

The stainless steel cannulated screws and tension band construct provides a good alternative in treatment of transverse patellar fractures. It could yield stable fixation, proper reduction and fracture healing, low complication rate while providing early mobilization and accelerated rehabilitation. A randomized, controlled trial with a larger number and longer follow-up is recommended.

Abbreviations

K-wire: Kirschner wire

mm: millimeter

ROM: Range of Motion

VAS: Visual Analogue Score

SD: Standard Deviation

AO/OTA 34-C1: A transverse fracture through the middle third, proximal third, or distal third of the patella, are classified by AO/OTA as a 34-C1.1, 34-C1.2 or 34-C1.3 fracture respectively.

AO/OTA 34-C2: Frontal/coronal, wedge fractures of the patella are classified by the AO/OTA as 34-C2 fractures.

AP: Anteroposterior

SPSS: Software Package for Statistical Analysis

MRI: Magnetic Resonance Imaging

Declarations

Ethics approval and consent to participate:

This study had been approved by the institutional (Fayoum University) ethical board review. Informed consent was obtained from all individual participants included in the study.

Consent for publication:

Not applicable.

Availability of data and material:

The datasets used and/or analysed during the current study are available from the corresponding author on reasonable request.

Competing interests:

The authors declare that they have no competing interests.

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Authors' contributions:

Abdel-Moneim contributions were; research concept and design, collection and assembly of data, writing the article, and final approval of the article. While Moussa contributions were; data collection, analysis and interpretation, writing the statistics and tables, and critical revision of the article.

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Figures



Figure 1

One-month postoperative lateral radiograph for a female patient 41 years old (case no. one), with a transverse fracture patella fixed with the technique described.



Figure 2

One-month postoperative AP radiograph of case no. one.

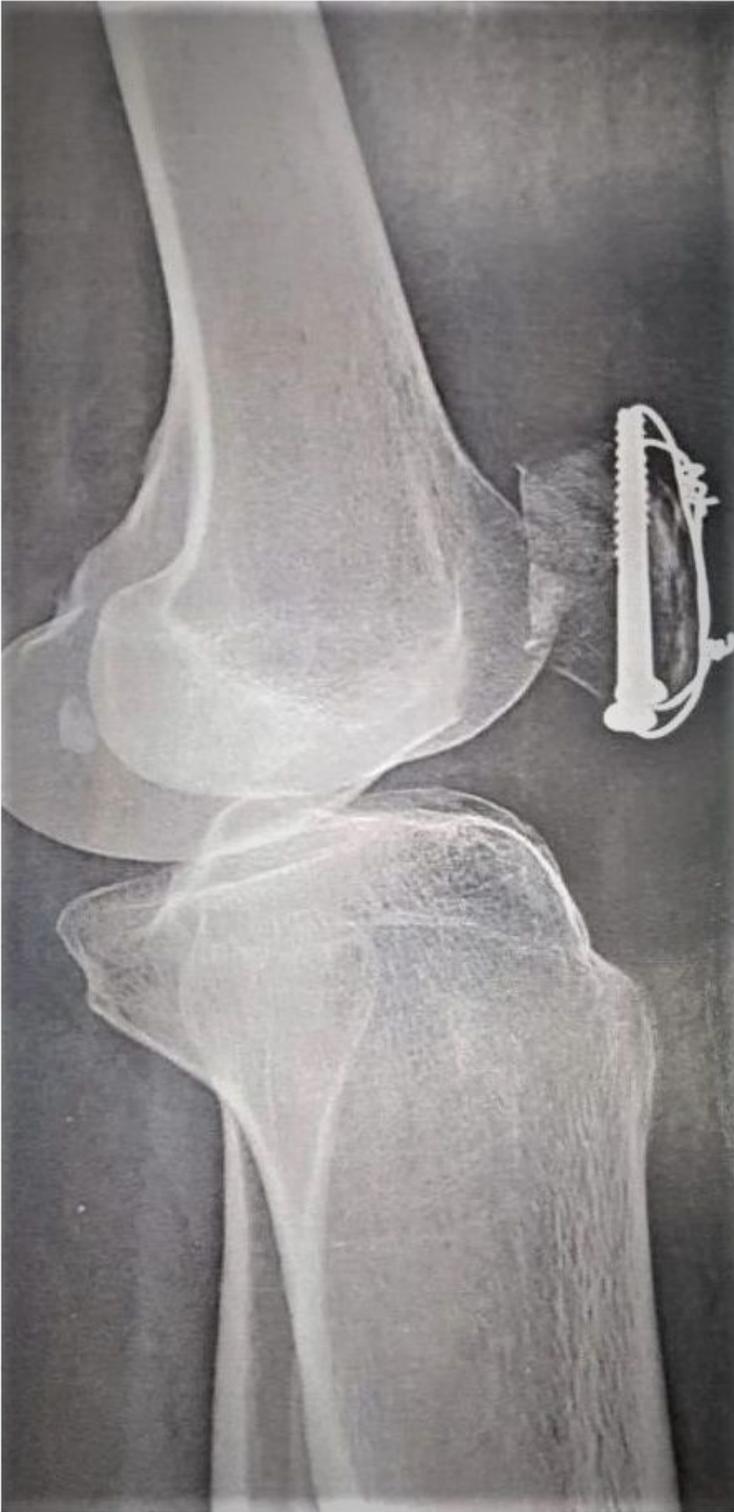


Figure 3

Six-month postoperative lateral radiograph of case no. one.



Figure 4

Two-month postoperative lateral radiograph for a female patient 50 years old (case no. two), with a transverse fracture patella fixed with the technique described.

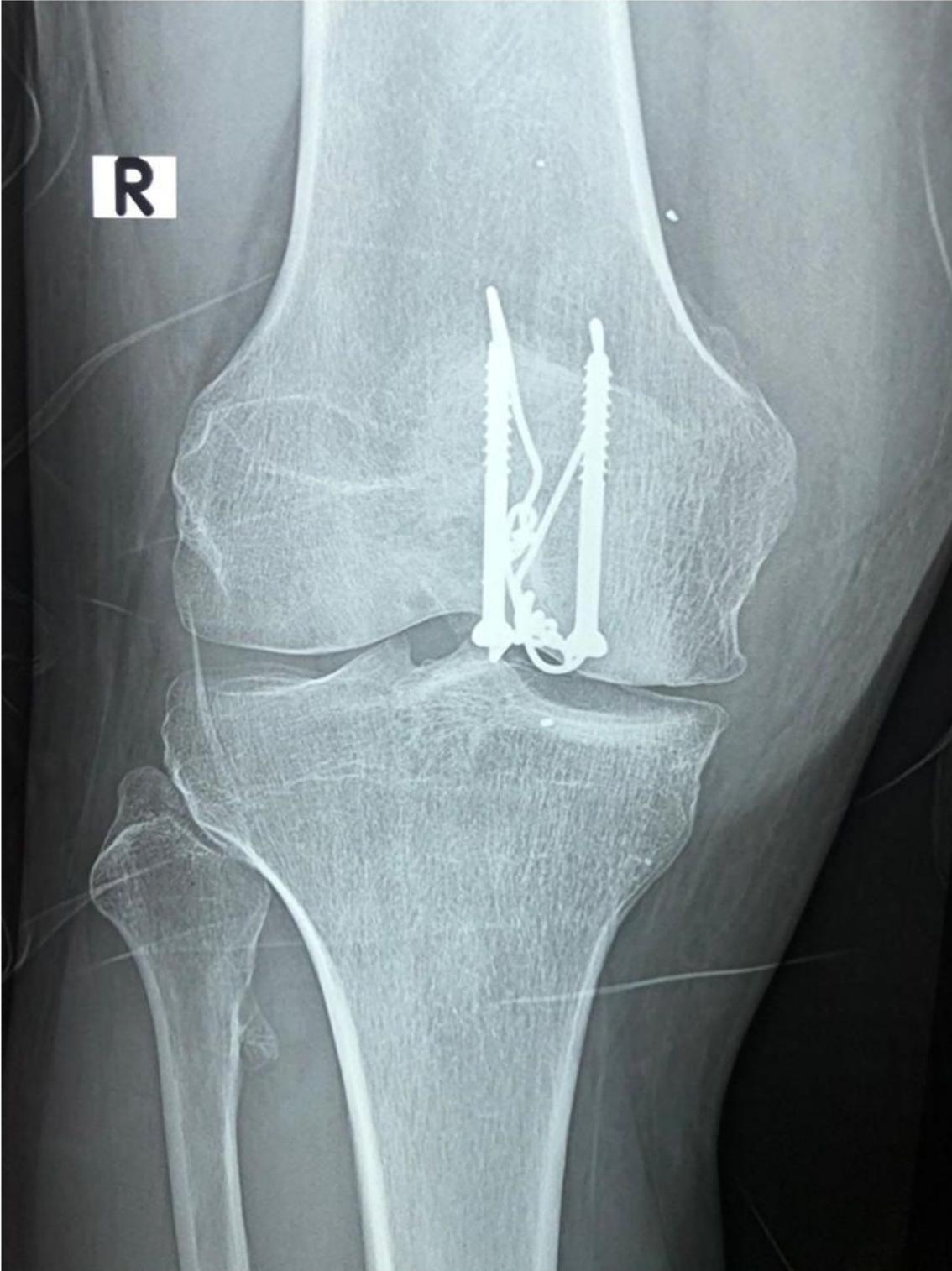


Figure 5

Two-month postoperative AP radiograph of case no. two.