The clinical outcomes and complications of combined fixation with cannulated screws and the modified Pyrford technique for the treatment of transverse patellar fractures: a case series study

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Research Article

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Abstract

Background: Transverse patellar fractures can be fixed using various techniques. The purpose of the current study was to assess the clinical outcomes and complications rate of a combined fixation technique using cannulated screws and the modified Pyrford technique with non-absorbable polyester sutures.

Methods and Patients: Between January 2015 and February 2021, 26 transverse patellar fractures were fixed with this combined technique. Pre-operative data were collected from patients with transverse patellar fractures and the patients were followed up for at least 12 months. At each follow-up visit, plain radiographs were taken. At the 12-month post-operative follow-up, range of motion of the affected knee joint and clinical outcomes, as evaluated by the Bostman scoring system, were recorded.

Results: The average Bostman score at the 12-month post-operative follow-up was 28.3±1.5. Further, the average extension and flexion of the knee joint were 1.2±2.1 and 125.6±6.7 degrees, respectively. One patient experienced delayed bone union and one experienced superficial wound infection. There were no other post-operative complications. One patient required removal of the device for social-psychological reasons.

Conclusions: The combined fixation technique with cannulated screws and the modified Pyrford technique with suture materials produced excellent clinical outcomes and a low rate of complications in the treatment of transverse patellar fractures.

Background

Patellar fractures constitute about 1% of all adult skeletal fractures [1]. The patella is a key point of the extensor apparatus, which transports the contraction force that originates in the quadriceps to the tubercle of the tibia to achieve extension of the knee joint. Further, the patella increases the monument arm of the quadriceps tendon by 30% to facilitate extension of the joint [2]. Interruption of the extensor apparatus due to a patellar fracture necessitates surgical fixation due to the key role of the patella in the extensor apparatus. Surgical fixation is required in order to achieve anatomic reduction and stable fixation, allowing for early rehabilitation and a lower rate of post-traumatic osteoarthritis [3].

The modified tension band was composed of a looped figure-of-eight metallic tension band wire and double K-wires [4]. Although this technique can be applied in any type of patellar fracture, the rate of post-operative complications after the modified tension band technique ranges from 21–53% [5, 6]. Complications include Kirschner wire migration, tension band breakage, fixation failure, pain, symptomatic hardware, and infection [5, 6]. Biomechanically, transverse patellar fractures fixed with parallel cannulated lag screws and a metallic wire are more stable [7]. However, secondary surgeries to remove the internal fixation device are required in 23% of patients who undergo this surgical treatment [8]. To avoid the high rate of internal fixation device removal, a variety of patellar cerclage or tension band fixation techniques with suture materials, in place of a metallic device, have been introduced over the past several decades; these have dramatically decreased the post-operative device removal rate to 0[9–12]. However, the fixation failure rate after fixation involving patellar cerclage or tension bands with suture materials is reported to range from 6.3–7.7%[9, 12]. The

Pyrford technique is a technique for treating patellar fractures that involves fixation with a metallic circumferential cerclage wire and a metallic anterior tension band [13]. Camarda et al [11]. modified this technique by substituting the metallic wire with suture material for the treatment of patellar fractures. The authors reported good clinical outcomes and high post-operative secondary displacement of fractures [11]. In the current retrospective case series study, transverse patellar fractures were fixed with a combination of cannulated screws and the modified Pyrford technique with non-absorbable polyester sutures to achieve sufficient stable fixation and a lower rate of device removal. The purpose of the current retrospective case series study was to assess and report the clinical outcomes and complications rate of this combined fixation technique.

Patients And Methods

This retrospective clinical study was approved by the medical ethics board of our medical institute. Written or verbal informed consent was obtained from all patients. The indications for patellar fractures were as follows: congruity of the patellar surface > 2 mm, a gap between the patellar fragments > 3 mm, or inability to extend the knee due to tearing of the extensor retinaculum. Between January 2015 and February 2021, 94 displaced transverse (OTA/AO 34C1) patellar fractures were confirmed by radiography in our emergency room. All these fractures were surgically treated in our institute. Patients who met the below exclusion criteria were excluded from the current study: lost to follow-up before the 12-months post-operative follow-up (n = 2); impaired extension or flexion function of the ipsilateral knee joint before surgery (n = 2); unable to undergo rehabilitation at the medical instruction or unable to complete the final function evaluation due psychopathy or brain injury (n = 4); presence of an open patellar fracture (n = 1); previous fracture surgically treated on the ipsilateral lower extremity (n = 3); presence of a pathological patellar fracture (n = 0); aged less than 18 years (n = 1); treated with a technique other than the novel combined fixation technique described in this study (n = 47); presence of an old fracture (more than 14 days between the fracture and the surgery) (n = 3); did not provide written informed consent (n = 2); presence of a concomitant fracture or concomitant neurovascular injury on the ipsilateral lower extremity (n = 3). Thus, in total, 26 adult patients diagnosed with transverse patellar fractures treated with this combined fixation technique were included in this study. All surgeries were performed by one experienced orthopedic surgeon.

Each patient was placed in the supine position and a tourniquet was applied under anesthesia. An incision was made along the midline of the patella. After exposure of the fracture line, the hematoma in the fracture gap was removed. Then, several irrigations were performed to remove bone debris and fluid in the knee joint cavity. The anterior aponeurosis on the patella within 2 mm of the fracture line was elevated for exposure of the fracture line during reduction. Tight suture of the aponeurosis on the patellar surface was performed to facilitate and simplify the anatomic reduction. The reduction was checked to ensure it was satisfactory, and then temporary fixation was performed with a reduction clamp. After implantation of two longitudinal Kirscher wires, reaming in the smaller fragment was performed along the Kirscher wires in a monocortical fashion. Then, two cannulated screws were inserted. The length of each screw was shorter than the measurement to ensure that the tip of the screw would not protrude from the cortical bone or cut the suture. Then, cerclage and tension band wiring with non-absorbable polyester sutures (5 Ethibond-Ethicon Ltd., Edinburgh, UK) were performed in accordance with the Pyrford technique. During suturing, the knee joint was kept in extension. Every stitch was pulled forcefully and as close to the patella as possible. When suturing was completed, the stability of the fracture fixation was evaluated several times by full rotation of the knee joint; this was recorded in the surgical record and the physiotherapist was notified so as to inform individual rehabilitation. Before wound closure, the retinaculum was repaired, and the holes caused by reaming were sutured (see Figs. 1 and 2).

Post-operative rehabilitation was similar for all patients. Each patient had a cast applied with their leg in full extension for wound healing. Isometric quadriceps exercises and partial weight-bearing with crutches were encouraged immediately after surgery. The cast and stitches were removed simultaneously. Thereafter, active and passive knee flexion of 20 or 30 degrees, depending on the stability of the fixation, was instructed. If needed, the affected knee was supported by an adjustable knee brace. With tolerable pain, active knee flexion gradually increased 30 degrees every two to three weeks after progressive knee flexion training. At eight weeks post-surgery, the knee brace was removed, and the full range of knee motion was allowed. Importantly, knee rehabilitation was supervised by a physiotherapist to avoid secondary displacement of the fracture or failure of fixation. When bone union was confirmed by radiological examination, full weight-bearing without crutches was allowed.

The electronic medical records for all included patients were reviewed. The collected pre-operative data included body mass index (BMI), affected side, age, diagnosis of diabetes mellitus, gender, cigarette use, mechanism of injury, and the interval between injury and surgery. The included patients were followed up at one, two, three, six, and 12 months post-surgery, at a minimum. At each follow-up visit, plain radiographs were taken to assess the bone union time and post-operative complications. Further, the requirement for secondary surgery was recorded. The clinical evidence of patellar bone union included no tenderness with local palpation and the ability to continuously walk for three minutes without the aid of a crutch. The radiological evidence of patellar bone union included skeletal trabecula across the fracture line. Delayed bone union was defined as clinical and radiological evidence of bone union between three months and six months post-surgery. If the patient experienced delayed bone union, they were required to attend follow-up appointments every month until bone union was observed. The plain radiographs for all patients were assessed by two orthopedic surgeons. At the 12-months post-operative follow-up, the range of motion (ROM) of the affected knee joint was recorded and clinical outcomes were evaluated by the Bostman scoring system.

Results

In the current study, 15 out of 26 patients were female. The average age of the patients was 55.5 ± 20.6 years. A total of 16 left sides and nine right sides were affected. Twenty-one patellar fractures were caused by falling, two by sports, and three by traffic accidents. The average BMI of the patients was 24.5 ± 3.1. Out of the 26 patients, five were diagnosed with diabetes mellitus and four had a history of smoking before surgery. The average interval between the injury and surgery was 4.1 ± 1.6 days (see Table 1).

Table 1
The Demographic Data, interval between injury and surgery of the Patients

Number	Gender	Age (years)	Affected Side	Injury Mechanism	BMI (kg^2/m)	Diabetes Mellitus	Cigarette Use	Interval Between Injury And Surgery (day)
1	Male	19	Left	Sports	22.4	No	No	3
2	Female	62	Left	Fall	25.1	No	No	5
3	Female	33	Left	Fall	18.7	No	No	7
4	Male	21	Left	Traffic Accident	23	No	No	1
5	Female	69	Right	Fall	26.8	No	No	2
6	Female	75	Left	Fall	23.6	No	No	5
7	Female	46	Right	Fall	21.4	No	Yes	4
8	Male	73	Left	Fall	25.5	No	Yes	4
9	Female	58	Left	Traffic Accident	18.2	No	No	4
10	Female	72	Left	Fall	27.9	Yes	No	3
11	Male	47	Right	Fall	29.5	No	No	6
12	Female	78	Right	Fall	24.4	No	No	3
13	Male	45	Left	Fall	24.7	No	No	2
14	Male	28	Left	Sports	23.2	No	No	3
15	Female	82	Right	Fall	27.9	No	No	5
16	Male	39	Right	Fall	27.8	No	No	7
17	Female	28	Left	Fall	17.4	No	No	5
18	Male	20	Left	Traffic Accident	22.6	No	Yes	5
19	Male	54	Left	Fall	28.8	Yes	Yes	3
20	Female	77	Right	Fall	22.9	No	No	7
21	Male	71	Left	Fall	26.3	Yes	No	2
22	Female	80	Right	Fall	25.3	Yes	No	4
23	Female	66	Right	Fall	24.6	No	No	4

Number	Gender	Age (years)	Affected Side	Injury Mechanism	BMI (kg^2/m)	Diabetes Mellitus	Cigarette Use	Interval Between Injury And Surgery (day)
24	Male	64	Right	Fall	26.1	No	No	5
25	Female	69	Left	Fall	26.3	Yes	No	2
26	Female	68	Left	Fall	26.8	No	No	5

BMI: body mass index.

The average bone union time was 3.0 ± 0.34 months. The follow-up period ranged from 12 to 27 months. The average Bostman score was 28.3 ± 1.5 (excellent, n = 21, 80.8%; good, n = 5, 19.2%; fair, n = 0, 0%). The average extension and flexion of the knee joint were 1.2 ± 2.1 and 125.6 ± 6.7 degrees, respectively(see Figs. 3, 4 and 5).

Among the 26 patients, one patient (Number 17) experienced delayed bone union; this patient had pre-operative chronic kidney disorder and hypoalbuminemia, and bone union was achieved four months post-surgery. Another patient (Number 19) experienced abrasion of the patella and was diagnosed with a superficial wound infection; this resolved after treatment with oral antibiotics and removal of the stitches. There were no failed fixations, secondary displacement of the fracture, migrated cannulated screws, or soft tissue irritation in the current study. One patient (Number 4) experienced no post-operative discomfort but required removal of the device for social-psychological reasons. For this patient, removal of the device was performed one-year post-surgery; no further complications occurred during the later follow-up period (see Table 2).

Table 2
The data of follow-up periods, functional outcomes, complications and the requirement for secondary surgeries

Number	bone healing time (month)	follow-up periods (month)	Bostman score (points, grading)	range of motion (extension—flexion, degree)	complications	requirement for secondary surgeries
1	2	12	30, Excellent	5—135	No	No
2	3	16	30, Excellent	5—125	No	No
3	3	14	29, Excellent	5—135	No	No
4	3	18	29, Excellent	5—135	No	No
5	3	15	28, Excellent	5—125	No	No
6	3	27	26, Good	0—120	Pain after long distance walking or stair-climbing	No
7	3	18	28, Excellent	5—125	No	No
8	3	16	28, Excellent	0—125	No	No
9	3	12	28, Excellent	0—130	No	No
10	3	19	29, Excellent	5—125	No	No
11	3	13	29, Excellent	5—125	No	No
12	3	18	28, Excellent	0—125	No	No
13	3	16	30, Excellent	5—130	No	No
14	2	12	30, Excellent	5—135	No	No
15	3	26	25, Good	0—110	Pain after long distance walking or stair-climbing	No

Number	bone healing time (month)	follow-up periods (month)	Bostman score (points, grading)	range of motion (extension—flexion, degree)	complications	requirement for secondary surgeries
16	3	12	30, Excellent	5—130	No	No
17	4	16	29, Excellent	0—125	Delayed bone healing	No
18	3	24	28, Excellent	0—130	No	removal
19	3	17	28, Excellent	0—130	Superficial infection	No
20	3	12	28, Excellent	0—125	No	No
21	3	14	28, Excellent	0—125	No	No
22	3	19	26, Good	0—110	No	No
23	3	15	28, Excellent	0—125	No	No
24	3	12	29, Excellent	5—125	No	No
25	3	23	27, Good	0—105	Pain after long distance walking or stair-climbing	No
26	3	12	30, Excellent	5—125	No	No

Discussion

Transverse fractures of the patella are the most common type of patellar fracture [14]. In a cadaveric biomechanical study, Carpenter et al. [15] analyzed the stability of transverse patellar fractures fixed with three different techniques: modified tension bands, two parallel interfragmentary lag screws, and two cannulated lag screws with a tension band wire through the cannulations. The authors reported significantly better stability after fixation with cannulated screws and a tension band wire. Therefore, this technique was regarded as the "gold standard" for treating non-comminuted transverse patellar fractures. However, Hoshino et al. found that 30 out of 133 (22.6%) patients who received surgical treatment of transverse patellar fractures with metallic tension bands through double cannulated lag screws had to undergo secondary surgery to remove the device due to device irritation or wound infection [8]. In China, Buddhism is the most popular religion [16]. For Buddhists, the daily religious ritual of kneeling makes device irritation intolerable and results in a strong desire for device removal. The results of a systematic review conducted by Camarda et al. in 2016 indicated that fixation of patellar fractures with non-metallic devices is associated with a lower secondary surgery rate (1.6%) for device removal[17]. Gosal et al. [9] fixed 16 patellar fractures with non-absorbable polyester sutures in accordance with the modified Pyrford technique and reported one fixation failure (6.3%). Similarly, Egol et al. [12] fixed patellar fractures in a Krackow-type fashion with non-absorbable sutures and reported an initial failure rate of 7.6%. Therefore, increasing the strength of the low-profile construct of sutures seems essential for treating patellar fractures and achieving satisfactory clinical outcomes as well as lower rates of complications and secondary surgeries.

In the current study, transverse patellar fractures were surgically treated with two cannulated screws plus the modified Pyrford technique with polyester sutures. No cases of post-operative failure of fixation or secondary displacement of fractures were observed. In the biomechanical study conducted by Carpenter et al. [15], the load to failure of transverse patellar fractures after fixation with screws only was lower than that after screws with a tension band; though, the difference was not significant ($p = 0.06$). Due to the better stability of transverse patellar fractures compared with comminuted patellar fractures, Gwinner et al. [18] reported that screw fixation without a tension band can be considered for such fracture types, although the strength of this technique is lower than the strength of cannulated screws with metallic tension band wire. Given the high stiffness and minimal tissue reaction to polyester sutures, Qi et al. fixed patellar fractures with polyester suture tension bands through two cannulated screws and reported a mean Lysholm score of 95.7[19–21]. In their study, Qi et al. [21] found no failure of fixation, secondary displacement, infection, or device migration or breakage. Similarly, Busel et al. [22] conducted a retrospective case series analysis in 2019 and found that the secondary surgery rate for device removal after fixation with non-absorbable sutures through cannulated lag screws was 8%; all device removals were due to hardware irritations. However, Kumar et al. [23] reported that the tension band technique with non-absorbable polyester sutures through cannulated lag screws was difficult, and even impossible to perform for small-diameter screw cannulation. The thickness of the needle required to hold the suture and the thickness of the folded suture when passing the cannulated screws were usually too large for screw cannulation. As an alternative to polyester suture tension bands through cannulated screws, a variety of fixation techniques using non-absorbable polyester sutures have been introduced for treating patellar fractures; these techniques provide sufficient stability for early rehabilitation after surgery[11, 24–27]. Until now, there was no consensus as to the best fixation technique with non-absorbable sutures for the treatment of patellar fractures. Camarda et al. [11] fixed patellar fractures with FiberWire following the Pyrford technique and reported a high rate of ‘excellent’ Bostman scores (76.4%) and an absence of failure of fixation. However, 11.8% of patients experienced secondary displacement of fractures [11]. Furthermore, this study defined secondary displacement as a fracture gap less than 4 mm, which might be larger than the indication for surgery (gap > 3 mm) in the current study[11]. In the biomechanical study conducted by Burvant et al. [28], the displacement rate of fractures fixed with screws plus the Pyrford techniques was dramatically smaller than the displacement rate of fractures fixed with the Pyrford technique only. Therefore, the superiority of the combined technique in this study over the modified Pyrford technique may be due to the more stable fixation.

In terms of the Bostman scores and gradings, our findings are consistent with those after fixation with cannulated screws and metallic tension bands as reported by Tan et al. [29] and with those after fixation with the modified Pyrford technique as reported by Camarda et al [11]. The ROM in the current study was comparable, though somewhat smaller, than the ROM reported in previous studies that used tension band fixation with suture materials[11, 21, 30]. This is perhaps due to the concern of less stable fixation without metallic wires and the subsequent individual rehabilitation. In the current study, the post-operative infection rate was 3.8%, which is consistent with the post-operative infection rate of 3.6% after metallic tension band wire fixation for patellar fractures reported by Hoshino et al[21]. However, the infection in the current study was resolved by oral antibiotics and no further surgery was required. In the clinical study conducted by Hoshino et al. [21], 43.8% of the infections required intravenous antibiotics administration or further surgical interference.

The relatively small sample size is the main limitation of this study. Thus, there is a need for treatment of more cases with the combined technique in order to improve the reliability of the research. Because of the absence of inclusion criteria in this case series study, the fixation technique decision for each patient was made by the surgeons, resulting in selection bias. Further, the nature of a case series study means that this study lacked a control group and may not be as reliable as a case-control study. This study may have also been affected by recall biases. Therefore, the conclusions of this study should be confirmed by a prospective randomized controlled study in the future.

Conclusions

Our combined technique for fixation of transverse patellar fractures with cannulated screws and the modified Pyrford technique using suture materials had excellent clinical outcomes and a low rate of complications. This technique may be considered a better treatment approach for common transverse patellar fractures due to the lower rate of device removal.

Abbreviations

OTA/AO: Orthopaedic Trauma Association/ Arbeitsgemeinschaft für Osteosythese; BMI: body mass index; ROM: range of motion.

Declarations

Acknowledgements

Not applicable.

Authors’ contributions

QXT and YHL carried out the design of the study and reviewed the literatures. KPL and MG followed up the participants and collected all the data and images of the participants. YHL, KPL and MG were responsible for the radiographs assessment. YHL drafted the manuscript and TQX revised the manuscript. TQX gave the final approval of the version to be published. All authors read and approved the final manuscript.

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Availability of data and materials

The data supporting the conclusions of current study are included within the article, tables and figures. The datasets generated and/or analysed during the current study are not publicly available due to restrictions on ethical approvals involving patient data and anonymity but are available from the corresponding author on reasonable request.

Ethics approval and consent to participate

This retrospective clinical study was approved by the medical ethics board of Beijing Chao-Yang Hospital, Capital Medical University. The written informed consent was obtained from all included patients. All research methods were performed in accordance with the Declaration of Helsinki.

Consent for publication

Not applicable.

Competing interests

The authors declare that they have no competing interests.

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Figures

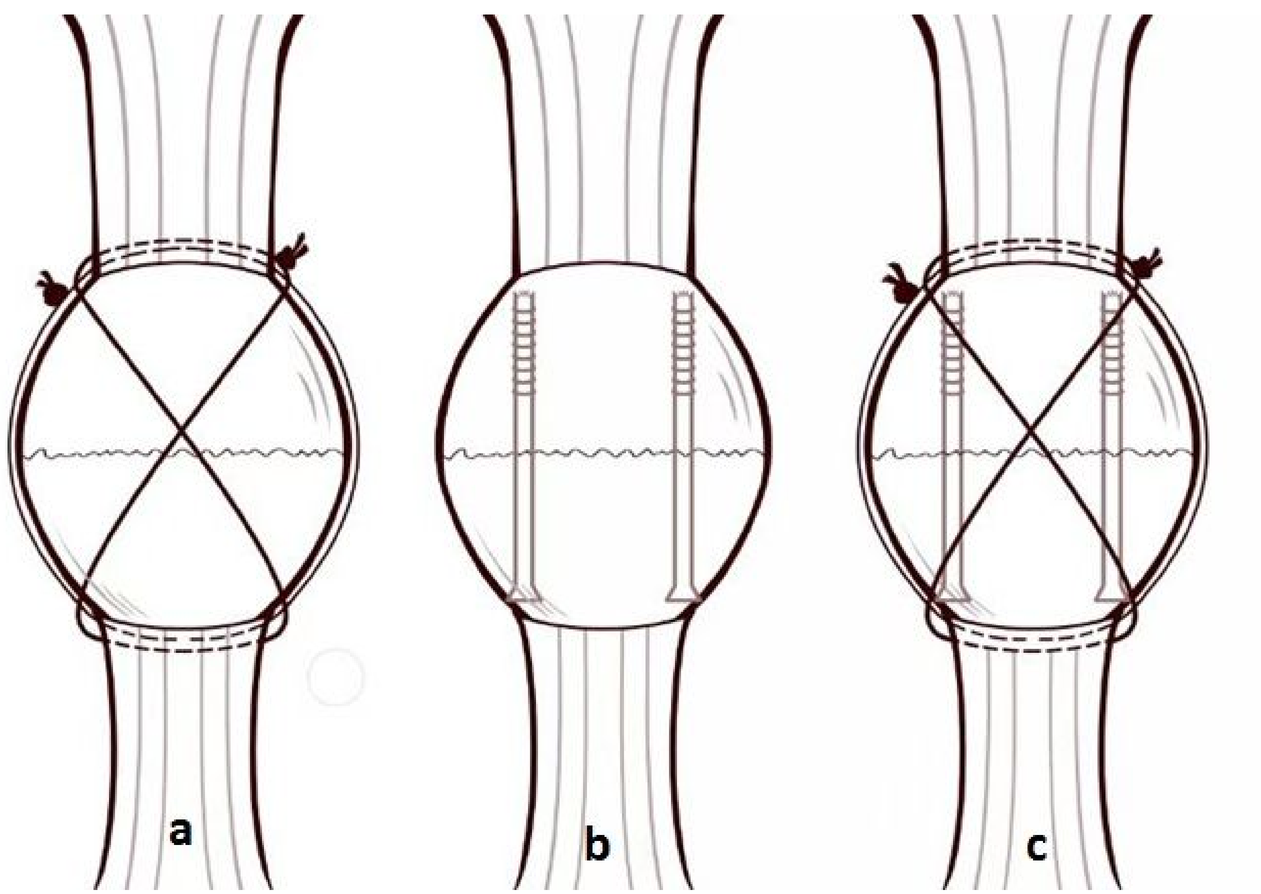

Figure 1

The combined fixation with cannulated screws and the modified Pyrford technique. (a) modified Pyrford technique; (b) cannulated screws fixation; (c) the combined fixation.

Figure 2

The image of transverse patellar fracture fixed with combined fixation during the surgery.

Figure 3

The plain radiographs of patient (number 12). (a) before surgery; (b) before surgery; (c) at 1 day post-surgery; (d) at 1 year post-surgery.

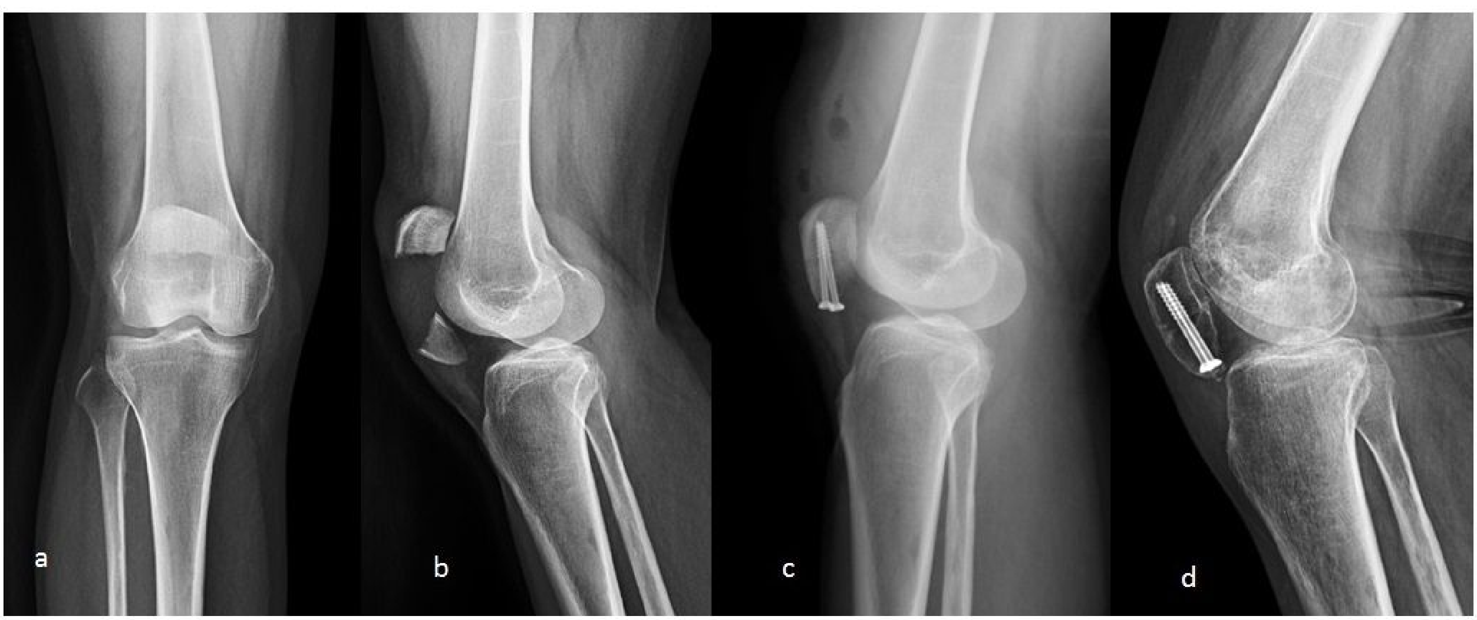

Figure 4

The plain radiographs of patient (number 23). (a) before surgery; (b) before surgery; (c)immediately after surgery; (d) at 1 year post-surgery.

Figure 5

The patient showed the range of motion of the affected knee joint at the final follow-up.(a) extension; (b) flexion.