A Retrospective Review of Revision and Re-revision Patella Osteosynthesis Performed for Failure of Fixation of Initial Comminuted Fracture Patterns: Very High Complication Rates

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Abstract

Literature on revision osteosynthesis for failed patella fracture fixation is extremely limited. This study reviews the treatment options and outcomes for revision and re-revision osteosynthesis at a Level 1 trauma center. All patella revision osteosynthesis cases between January 2021 and March 2024 were identified using Current Procedural Terminology codes at a single tertiary care academic center. Medical records, operative reports, and radiographs were reviewed to collect details regarding patient demographics, initial injury and fracture management, indications for revision surgery, revision construct, postoperative weight bearing and range-of-motion restrictions, and outcomes. The primary outcome was major failure defined as loss of fixation or further surgery for nonunion or infection. Ten patients underwent revision osteosynthesis for failed fixation. All fractures were initially comminuted fracture patterns (AO/OTA 34-C3), with nine (90%) initially treated with a 2.7-mm patella-specific variable angle locking plate (Synthes, Paoli, PA). Half ($n = 5$) of the patients were revised with the same patella-specific plate and half with an all suture transosseous fibertape tension band (Arthrex, Naples, FL). Additional fixation in the form of bony augmentation was performed in 20% ($n = 2$) of cases and soft tissue augmentation in 70% ($n = 7$). There was a 70% ($n = 7$) major failure rate, mostly due to loss of inferior pole fixation. There were four re-revision procedures performed with surgical fixation. Two of these subsequently developed infection, one united and the other had no radiographic signs of union and was lost to follow-up, but was without complication. Regardless of the chosen fixation construct, revision osteosynthesis for failed fixation of initial comminuted fracture patterns has an extremely high rate of failure. Complications increase with further revision surgery. Level of evidence: therapeutic level 3.

Keywords

- patella
- fracture
- knee
- comminution
- AO/OTA 34-C3

received
June 22, 2024
accepted after revision
October 23, 2024
accepted manuscript online
October 24, 2024

Thieme Medical Publishers, Inc.,
333 Seventh Avenue, 18th Floor,
New York, NY 10001, USA

DOI https://doi.org/10.1055/a-2451-6924.
ISSN 1538-8506.

Despite most cases healing without complication, there is a known failure rate for surgical treatment of comminuted and complex patella fracture patterns[1] and there is no clear indication of the type of surgical treatment or the postoperative course to be followed. Multiple studies have documented treatment options and outcomes for primary osteosynthesis of patella fractures, but limited literature exists for revision osteosynthesis performed for failed fixation. Achieving fracture healing in revision surgery is challenging due to patient factors, biological factors, bone loss from callus and/or fibrous tissue debridement, difficulty obtaining fracture reduction with adequate bone contact, and application of a fixation construct that can resist the deforming forces of the extensor mechanism for the prolonged time frame necessary for bony union. Ostensibly, the outcomes of revision osteosynthesis should be poorer than those of primary fractures.

Multiple surgical options have evolved to treat patella fractures.[2] Modern techniques for comminuted and complex fractures now often involve plates[3–15] and/or augmentation of bony and soft tissue fixation.[14,16–21] Primary fixation with plate constructs is supported by multiple studies demonstrating biomechanical advantages.[3,22–24] Given the challenges of fracture healing in the revision situation, plate constructs would seem reasonable for revision cases. However, the literature exploring revision fixation options and outcomes is sparse.[1]

This study sought to identify the treatment options and outcomes for revision osteosynthesis of patella fractures when using contemporary fixation constructs at a Level 1 trauma center. We hypothesized implant failure rates and complications would be high in the revision situation.

Patients and Methods

After obtaining institutional review board approval (approval number 2068782), Current Procedural Terminology code 27254 was used to identify all open reduction and internal fixation of patella fractures from January 2021 through March 2024 at a Level 1 trauma center. This time period correlated with the implementation of patella-specific plating at the hospital. All revision osteosynthesis cases were then identified through chart review. Details about the patient and initial fracture as well as its management were recorded using medical records, operative reports, and radiographs. This included whether the initial fracture was open or not, whether there was polytrauma involvement, fracture classification using the AO/OTA (AO Foundation/Orthopaedic Trauma Association) fracture classification,[25] and the initial fixation construct. Medical records, operative reports, and radiographs were then reviewed to collect details regarding patient demographics and medical history, the indications for revision surgery, the presence of infection, the revision construct including the use of bony and soft tissue augmentation as well as biological adjuncts, postoperative weight bearing and range of motion restrictions, and patient outcomes. The primary outcome was major failure defined as implant loss of fixation or further surgery for nonunion or infection.

Statistical Analysis

Descriptive analysis only was performed.

Results

A total of 10 patients were identified who underwent revision osteosynthesis for failed fixation, with one initially treated at an outside hospital. ►**Table 1** presents the patient characteristics as well as details about their initial injury and management. The mean age was 51 (range: 23–73), 60% ($n = 6$) were female, 80% ($n = 8$) were initially closed injuries, and 70% ($n = 7$) were isolated injuries. All patients initially experienced comminuted (AO/OTA 34-C3) fracture patterns and 90% ($n = 9$) had initial fixation with a patella-specific 2.7 mm variable angle (VA) locking plate (Synthes, Paoli, PA). There were no revision procedures of fracture patterns that were initially simple fractures.

►**Table 2** presents the revision fixation construct, including bony and soft tissue augmentation, biological adjuncts, postoperative weight bearing and range-of-motion restrictions, and the outcome. The mean follow-up was 16 months, and only one patient was not followed up to radiographically confirmed union or loss of fixation. Surgery was performed by four fellowship-trained trauma surgeons. Half ($n = 5$) were revised with a patella-specific 2.7-mm VA locking plate (Synthes, Paoli, PA) and half ($n = 5$) with an all suture transosseous fibertape tension band (Arthrex, Naples, FL) as their primary fixation method. Only 20% ($n = 2$) had augmentation of bony fixation and 70% ($n = 7$) had soft tissue augmentation mostly in the form of a transtibial cerclage suture. No patients received biological adjuncts. There was a 70% ($n = 7$) major failure rate following revision surgery. Of the seven major failures, five were loss of inferior pole fixation (three treated with further revision osteosynthesis and two managed nonoperatively), one loss of proximal pole fixation (treated with patellectomy), and one nonunion of the superior pole (requiring additional surgery with addition of transosseous sutures). There were two cases of union and one case without radiographic evidence of union or complication but no follow-up beyond 6 weeks as the patient was lost to follow-up. ►**Fig. 1** presents an example of failure of initial primary fixation and the revision construct with further loss of fixation.

►**Table 3** presents the details of the further re-revision surgery, including bony and soft tissue augmentation, biological adjuncts, postoperative weight bearing and range-of-motion restriction, and the outcome. Three cases used primary patella-specific plate fixation, with one (33%) having additional augmentation of bony fixation and two (67%) having soft tissue augmentation. The fourth case had debridement of the nonunion site and application of transosseous sutures with removal of hardware. One case had bone graft and bone marrow aspirate applied. Two of the cases had further loss of inferior pole fixation and the other

Table 1 Patient demographics and initial fracture characteristics

Patient number	Age	Sex	ASA	BMI	Medical problems/ comorbidities	Open injury	Polytrauma	Initial fracture classification	Initial fixation
1	52	M	2	31.0	Nil	No	Yes	34-C3	Patella-specific plate
2	48	M	2	26.7	Nil	Yes	No	34-C3	Cannulated screws
3	62	M	3	21.7	Alcohol abuse	No	Yes	34-C3	Patella-specific plate
4	41	F	2	22.6	Smoker	No	No	34-C3	Patella-specific plate
5	73	F	2	21.0	Osteopenia on risedronate, GERD	No	No	34-C3	Patella-specific plate with cannulated screws
6	23	M	2	25.1	Bipolar on Seroquel, smoker, marijuana	Yes	No	34-C3	Patella-specific plate
7	50	F	3	28.7	Alcohol abuse with cirrhosis, smoker	No	No	34-C3	Patella-specific plate
8	33	F	3	33.8	Spina bifida, shunted hydrocephalus	No	No	34-C3	Patella-specific plate
9	59	F	3	38.6	Diabetes, smoker, COPD, GERD, HTN, cholesterol	No	Yes	34-C3	Patella-specific plate
10	69	F	3	32.6	Hypothyroidism, GERD, HTN	No	No	34-C3	Patella-specific plate

Abbreviations: COPD, chronic obstructive pulmonary disease; GERD, gastroesophageal reflux disease; HTN, hypertension.

case did not have radiographic evidence of union but there was no complication. Two (50%) developed infection and remain on antibiotics, one related to the surgery site, and one non-local site that potentially may not be related to the surgery. Of the one case that went on to further revision fixation surgery, this also failed due to nonunion of the inferior pole and the patient required partial patellectomy and patellar tendon repair, which also failed and nonoperative treatment ensured.

Discussion

This study observed a high complication rate when revision surgery was required for failed fixation of initially comminuted and complex fracture patterns of the patella, despite the use of contemporary implants. The mode of revision failure was mostly due to further loss of fixation, predominantly at the inferior pole, but also of the proximal pole with lower rates of nonunion. There was a low rate of additional augmentation to bony and soft tissue fixation beyond a transtibial cerclage suture at the time of revision surgery. Outcomes of further re-revision surgery were poor with loss of fixation, nonunion, and infection becoming apparent. These findings suggest if revision surgery is required for failure of patella fixation (most likely with comminuted fracture patterns), then the construct montage should be biomechanically optimized and include both multiplanar bony and soft tissue fixation, with reinforcement of the patella tendon, to aid fixation of the inferior pole. This will aid in counteracting the deforming forces of the extensor mechanism and the delayed time to union in the revision setting. Consideration of biological adjuncts, more conservative postoperative protocols, and a review of indications for surgery for specific patient comorbidities could be considered to avoid the morbid outcomes that we have identified.

The high failure rates observed despite the use of contemporary implants was somewhat surprising. There is scant literature to guide treatment in the revision situation for failed fixation. This study found equally poor results with contemporary plate constructs, despite biomechanical studies to support their use,[3,22–24] and all suture fixation.[26] It is likely that biomechanical studies cannot reproduce the degree of comminution that occurs in complex patella fractures. Documentation of the management of failed fixation with revision surgery has been limited to a case report[27] and two small case series,[28,29] potentially indicating a publication bias. Bansal et al[27] presented a single case which supported the use of plate fixation in revision surgery. Xue et al[28] in six cases reported the use of a modified tension band wire technique with supplemental cerclage wire and iliac crest bone graft in all cases. Their mean time to union was 14.7 weeks, with all patients having good to excellent outcomes without any complication. Müller and Frosch[29] reported 10 patients with revision osteosynthesis after fixation failure, with 8 having initial AO/OTA C3 fracture.

Table 2 Revision constructs, postoperative protocols, and outcomes

Patient number	Revision fixation	Bony augments	Soft tissue augments	Biological adjuncts	Post-op weight bearing	Post-op ROM	Outcome
1	Patella-specific plate	Independent screws	Nil	Nil	Partial WB crutches	HKB locked in extension 2 weeks then ROMAT	Nonunion of superior pole requiring repair with transosseous sutures
2	Patella-specific plate	Independent screws	Transtibial cerclage fibertape	Nil	WBAT in extension	HKB 0–45 6 weeks	No follow-up beyond 6 weeks, nil complication
3	Transosseous fibertape tension band	Nil	Nil	Nil	WBAT in extension	HKB locked in extension 6 weeks	Loss of fixation of distal pole with nonunion managed nonoperatively
4	Transosseous fibertape tension band	Nil	Transtibial cerclage fibertape	Nil	WBAT in extension	HKB locked in extension 6 weeks	Loss of fixation of distal pole requiring revision surgery
5	Transosseous fibertape tension band	Nil	Transtibial cerclage fibertape	Nil	WBAT in extension	HKB locked in extension 6 weeks	Union
6	Transosseous fibertape tension band	Nil	Transtibial cerclage fibertape	Nil	WBAT in extension	HKB 0–45 6 weeks	Loss of fixation of proximal pole treated with patellectomy
7	Patella-specific plate	Nil	Nil	Nil	NWB 6 weeks	ROMAT	Loss of distal pole fixation and wound dehiscence treated with revision surgery
8	Transosseous fibertape tension band	Nil	Transtibial cerclage fibertape	Nil	TWB in extension	HKB locked in extension 6 weeks	Loss of distal pole fixation requiring revision surgery
9	Patella-specific plate	Nil	Patella tendon fibertape reinforcement	Nil	25% WB in extension 6 weeks	HKB 0–30 6 weeks	Loss of distal pole fixation treated nonoperatively
10	Patella-specific plate	Nil	Transtibial cerclage fibertape	Nil	NWB 6 weeks	Cast in extension 6 weeks	Union

Abbreviations: HKB, hinged knee brace; NWB, non-weight bearing; ROM, range of motion; TWB, tension-band wiring; WBAT, weight-bearing as tolerated.

This series included a mixed group of cases including malunion and refracture diagnoses. Specific management was not provided for the fixation failure cohort, but half of the patients were treated with plate fixation and half with revision tension band wiring. Clinical outcomes were also not provided for the fixation failure cohort, but the authors report that no patient had an extension deficit, although flexion was lost. Overall functional outcomes were good. Given failure rates for fixation of complex patella fracture patterns can be as high as 38%,[13] it is surprising that not more literature has been published on revision surgery given the relative amount of these procedures being performed.

The most common mode of failure that we identified was further loss of inferior pole fixation. Clearly, augmentation of the patella tendon fixation must be considered in revision cases and in primary comminuted fracture patterns involving the inferior pole. Comminuted fracture patterns involving the inferior pole should be considered as a patella

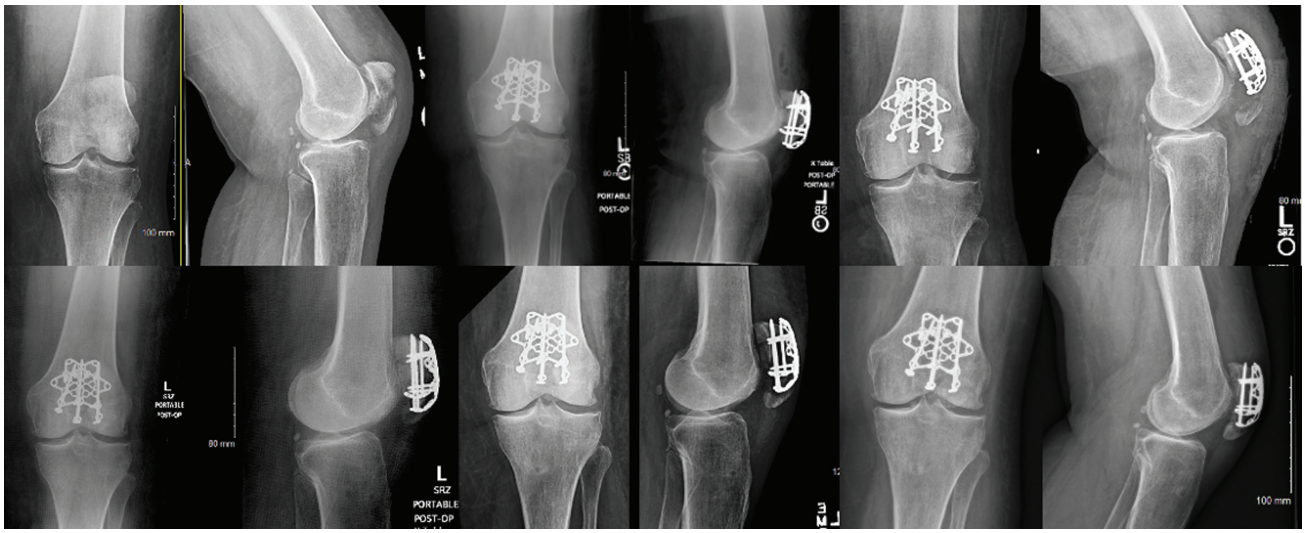

Fig. 1 Example of loss of primary and revision fixation eventually managed nonoperatively in a full leg cast for a further 6 weeks until union. Left to right (row 1): initial fracture, fixation, and failure. Left to right (row 2): revision fixation, failure, and follow-up.

Table 3 Re-revision constructs, postoperative protocols, and outcomes

Patient number	Revision fixation	Bony augments	Soft tissue augments	Biological adjuncts	Post-op weight bearing	Post-op ROM	Outcome
1	Transosseous sutures	Nil	Nil	Nil	WBAT in extension	HKB locked in extension 6 weeks	Union
4	Patella-specific plate	Cannulated screws	Transtibial cerclage fibertape	Nil	WBAT in extension	HKB locked in extension 6 weeks	Loss of fixation of distal pole and wound infection managed nonoperatively
7	Patella-specific plate	Nil	Nil	Bone graft; bone marrow aspirate	WBAT in extension	HKB 0–40 6 weeks	No confirmation of radiograph union, hardware remains intact, remains on suppressive antibiotics
8	Patella-specific plate	Nil	Transtibial cerclage fibertape; patella tendon suture reinforcement	Nil	NWB 2 weeks then 50% partial WB	HKB locked in extension 6 weeks	Loss of distal pole fixation requiring revision surgery

Abbreviations: HKB, hinged knee brace; NWB, non-weight bearing; ROM, range of motion; WBAT, weight-bearing as tolerated.

fracture with tendon avulsion. A fixation construct should address both elements of this injury to restore the extensor mechanism. The optimal technique to augment the patella tendon needs to be identified, and a reliance on screw fixation or all suture techniques is clearly inadequate. A transtibial cerclage suture as used in many cases in this series is also not adequate, given the failures that occurred. Other authors have used augmentation with hamstring tendon autograft in failed fixation.[30] In the primary setting, augmentation of comminuted inferior pole fractures has included additional cable[16] and wires[17] used in addition to plates[18] as well as suture[21] and additional anchors.[15] Given the ease of use and relative low cost of these implants and constructs, all could be considered, but the fixation must be biomechanically optimized. Fracture union in revision surgery is delayed.[28] Given the predictable outcome for repeat

failure, consideration could be given to increased use of bone graft and other biological adjuncts.[28] This study noted that outcomes worsen with every revision surgery, so it may be reasonable to be more aggressive with both constructs and adjuncts for healing to help prevent further reoperation. Additionally, despite increased biomechanical fixation with modern fixation constructs, a conservative approach to postoperative recovery including prolonged periods of range-of-motion restriction needs to be considered. Revision surgery cannot be considered as a repeat primary procedure.

This study is limited by size, but currently to our knowledge is the largest series on revision and re-revision surgery. Given the relative number of revision procedures occurring, a multicenter study seems best suited to further explore the topic and expand on the findings. Publication of additional series may refute our findings and is warranted to compare fixation strategies to identify an ideal construct for revision surgery. There are issues with loss of follow-up, but only one patient did not follow up to successful union or identified failure. However, 6 weeks of follow-up was still achieved. It is unlikely that a complication occurred that was managed elsewhere given the hospital being a tertiary care center. Other limitations include the lack of functional or patient-reported outcome measures, as others have recorded.[27,28] These were not recorded for the patients in our series and could not be considered in our retrospective study design. As such we do not have a secondary outcome measure. Presumably these outcomes would be poor with the complication rates documented and the results of patient-reported or functional outcomes would not change the recommendations from this research which aim to avoid further revision surgery. A final limitation is the association of a patient's medical comorbidities with outcome. Significant medical comorbidities related to alcohol abuse and psychological and neuromuscular conditions were present in 4 of the 10 revision cases. Such medical conditions may impact compliance with postoperative restrictions, and they are likely associated with the initial and subsequent failures of fixation. The association of medical conditions and outcomes is important knowledge as such patients may require different indications for surgery and different postoperative restrictions. Clearly the postoperative course should differ for patients not willing or not able to be compliant with the desires of the surgeon, and the risk–benefit ratio of surgery needs to be carefully considered.

Conclusions

The outcomes of revision osteosynthesis for failed fixation of comminuted patella fractures is extremely poor, and outcomes worsen with additional revision surgery. The success of revision osteosynthesis for simple fracture patterns is unknown given we had no cases included in this series. Revision surgery should not be considered repeat primary surgery. We recommend when performing revision surgery to have multiplanar bony fixation with augmentation of both bony and soft tissues in the form of tendon augmentation to prevent an otherwise predictable outcome and loss of fixation. Biomechanics must be optimized to restore the extensor mechanism. A similar strategy is recommended in primary fixation of complex comminuted fracture patterns to avoid revision surgery in the first place. Bone graft and biological adjuncts could be considered given the mechanical and biological challenges of achieving fracture union in the revision setting, and postoperative protocols may need to be more conservative. Future research should better quantify the best form of fracture fixation to optimize outcomes in the revision setting.

Conflicts of Interest and Source of Funding

No funding was received for this study. W.H. has given paid educational presentations for Smith & Nephew and Zimmer Biomet. S.D. is a speaker for AO North America, is a consultant for Stryker, receives royalties from Elsevier, and has received research support from Arthrex and Stryker. For the remaining authors, none were declared.

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